Community Vulnerabilities to Climate Change and Local Coping Mechanisms in Khudi Watershed

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Letter of Recommendation

This is to certify that **Mr. Aseem Raj Sharma** has prepared this dissertation entitled

"**Community Vulnerabilities to Climate Change and Local Coping Mechanisms in Khudi Watershed**"

as partial fulfillment of the requirements for the degree of

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Majoring in

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and he had worked satisfactorily under my supervision and guidance.

This Master Degree Dissertation work embodies his own work and fulfills as per the requirement of Central Department of Environmental Science [CDES], Institute of Science and Technology, Tribhuvan University.

I therefore recommend this dissertation for approval and acceptance.

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Declaration

I, AseemRaj Sharma, hereby declare to the evaluation committee of this thesis that this thesis is a report based on primary information, and all the sources of information used are duly acknowledged. This work has not been submitted to any other university for any academic award.

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Aseem Raj Sharma

Abstract

Community Vulnerabilities to Climate Change and Local Coping Mechanisms in Khudi Watershed.

***A. R. Sharma*[1]**

The Khudi watershed lies in western Nepal within $28^0$03'-$28^0$30' north, $84^0$11'-$84^0$38' east and 823 m-3000 m above sea level. The agrarian watershed with seven hundred households was dominated by Bahun/Chettri (51%), Gurung (21%) and several others (28%). Temperature and precipitation data analysis between 1987 to 2006 and 1975 to 2006 respectively showed some changes. Temperature was in increasing trend. The maximum mean temperature was increasing at 0.81^0C/decade and the minimum mean temperature was increasing at 0.26^0C/decade. Seasonal temperature data also showed increasing trend, winter temperature was highly increasing trend (1.17^0C/decade maximum and 0.76^0C/decade minimum temperature trend). Average Precipitation of two trends of driest months, November and December, was decreasing by 0.58 mm/yr and 0.10 mm/yr respectively while that of wettest month, July showed the increasing trend of 1.91 mm/yr. Regarding the experience of local inhabitants, more than 90 percent respondents have experienced increasing temperature, and 91 percent respondents have experienced unusual rainfall events. Fifty percent respondents believed that rainfall amount was decreasing in recent past with direct impacts on agricultural production and water resources. Most of the farming communities experienced unusual weather patterns with negative impacts on agricultural production, increasing water scarcity and increased frequency of weather related disasters. Local adaptive capacity was poor. Knowingly or unknowingly some coping strategies like use of sprinkle irrigation, use of new varieties of crops, were adopted within the communities. There was an urgent need to formulate adaptive strategies for food securities and for dealing with water scarcities and climate change induced disasters.

Key Words: *Climate change, Disaster, Community, Vulnerability, Coping Mechanisms, Adaptive Capacity, People's perception.*

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Acronyms and Abbreviations

^0C	Degree Celsius
ACAP	Annapurna Conservation Area Project
ADB	Asian Development Bank
AR4	Fourth Assessment Report
CBO	Community Based Organization
CBS	Central Bureau of Statistics
CC	Climate Change
CO_2	Carbon dioxide
DAO	District Administrative Office
DDC	District Development Committee
DFID	Department for International Development (UK)
DHM	Department of Hydrology and Meteorology
FGD	Focal Group Discussion
GDP	Gross Domestic Product
GFD3	Ground Fault Display 3
GHG	Green Houses Gas
GIS	Geographic Information System
GoN	Government of Nepal
ha	Hectare
HDI	Human Development Index
HH/hh	Household
HMG/N	The then His Majesty's Government of Nepal
ICIMOD	International Centre for Integrated Mountain Development
IFRC	International Federation of Red Cross and Red Crescent
INGO	International Non-governmental Organization

IPCC	Intergovernmental Panel on Climate Change
ISDR	International Strategy for Disaster Reduction
KII	Key Informant Interview
km	Kilometers
MDG	Millennium Development Goal
MoFSC	Ministry of Forest and Soil Conservation
mm	Millimeter
MoEST	Ministry of Environment, Science and Technology
MoPE	Ministry of Population and Environment
NGO	Non-governmental Organization
NTNC	National Trust for Nature Conservation
ppm	parts per million
SDAN	Sustainable Development Agenda for Nepal
TAR	Third Assessment Report
UNEP	United Nations Environmental Program
UNFCCC	United Nations Framework Convention on Climate Change
UNSIDR	United Nations International Strategy for Disaster Reduction
VDC	Village Development Committee
WB	World Bank
WMO	World Meteorological Organization
Y2Y	Yellowstone to Yukon

Local Terms and Conversion

Ropani	Nepali land area equivalent to 0. 052 ha per *ropani*
Muri	Nepali unit of crop equivalent to 80 kg per *muri*.
Khet	Irrigated low land (in Nepali)
Bari	Rain fed upland (in Nepali)

INTRODUCTION

A. Background and Context

It has been universally accepted fact that world climate is changing more vigorously at present than any time period in the past putting greater threats to the wellbeing of human beings as well as earth system. According to IPCC (2007) summery report, eleven of the last twelve years (1995-2006) rank among the twelve warmest years in the instrumental record of global surface temperature (since 1850). The 100-year linear trend (1906-2005) of 0.74 [0.56 to 0.92] °C is larger than the corresponding trend of 0.6 [0.4 to 0.8] °C (1901-2000). The linear warming trend over the 50 years 1956-2005 (0.13 [0.10 to 0.16] °C/decade) is nearly twice that for the 100 years 1906-2005 (IPCC, 2007).This changed scenario in the earth climate is challenging both the developing and developed worlds.

The increasing temperature and unusual rainfall, drought, flooding, high rate of snow melting and sea level rise are threatening the sustainable continuity of the living earth. Recently, human activities have been identified as likely contributors to global as well as regional climate change (IPCC, 2006). Temperature is a good indicator of climate change. Precipitation may be of equal or greater importance in terms of monitoring global change in low and mid-latitude regions because of their vulnerability to both water shortages and quality (Shrestha & Wake, 2000). Extending the instrumental record with proxy data for the Northern Hemisphere indicates that over the past 1,000 years the 20th century increase in temperature is likely to have been the largest of any century, and the 1990s was likely the warmest decade Figure 1 from IPCC climate change synthesis report 2001. To understand climate variation and change it is essential to assess the climate sensitivity to a variety of factors both human and natural. The global and national data clearly show that the numbers of natural disaster events are increasing in recent years. Socio-economic and environmental losses caused by these natural disasters are also increasing. The increasing trend of all type of natural disasters noticeably reveals that

highest portion of natural disasters is contributed by climate related disasters compared to other kind of disasters (UNISDR, 2005).

Extreme weathers events have, in recent years caused heavy loss of life and extensive

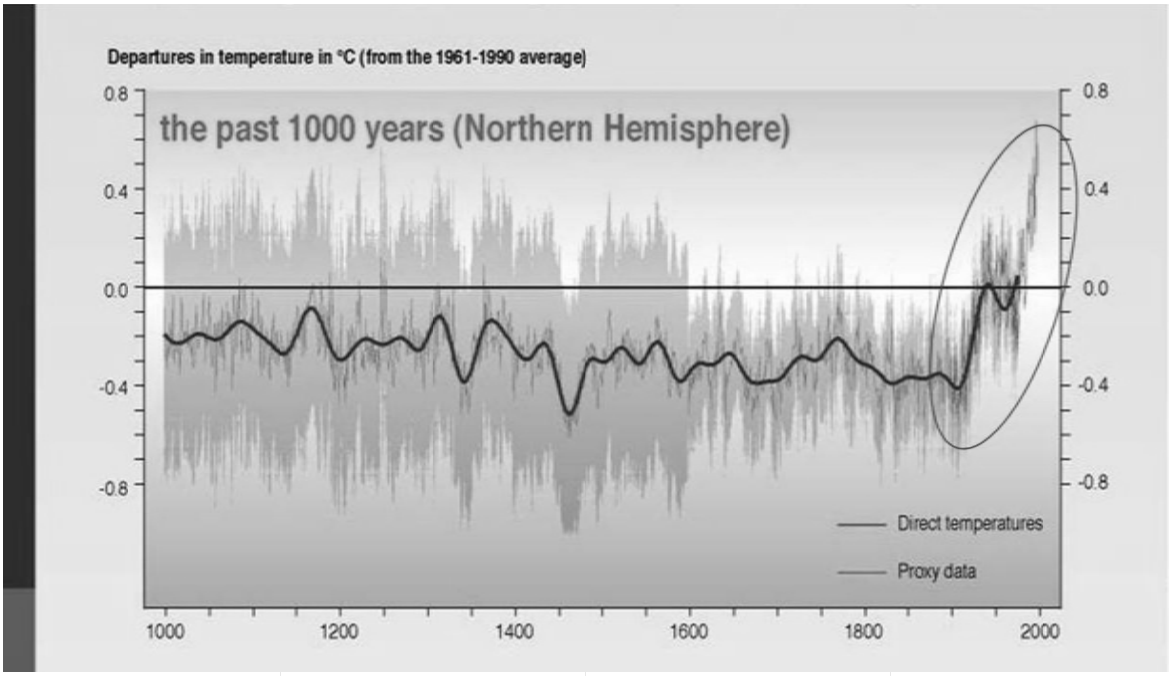


Figure 1: The past 1000 yrs temperature (Northern Hemisphere) (after IPCC 2001, the oval indicates increasing trend).

damages. As a famous Yiddish proverb *you can't control winds but can adjust your sails* it's time for us to work for the reduction of climate change risk.

The deaths in 5 years period of 2000 to 2005 by extreme weather events are shown in Figure 2 (Dow & Downing, 2006).

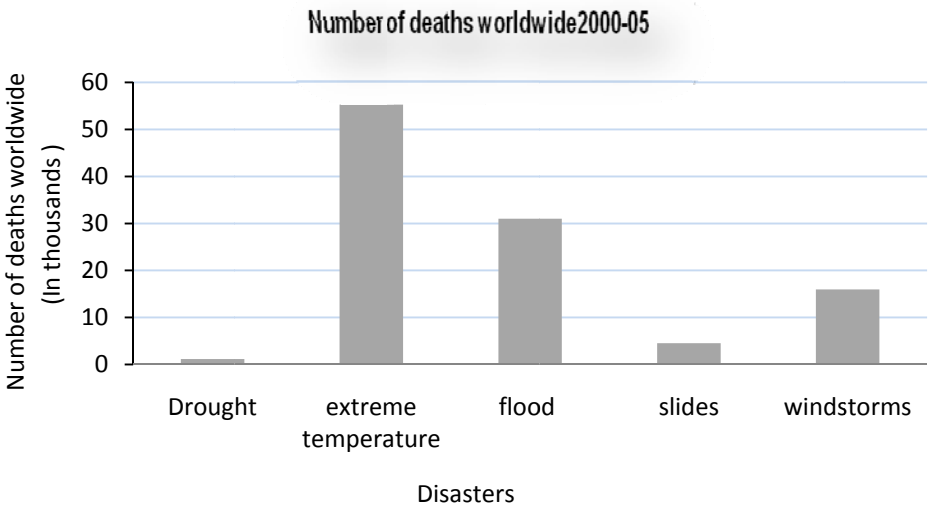


Figure 2: No of human deaths in 5 years time from 2000 to 2005 by different (Dow & Downing, 2006).

Similarly the following graph is the evidence for the increased number of disasters worldwide in recent years. These evidences clearly show that we are vulnerable due to changing climate.

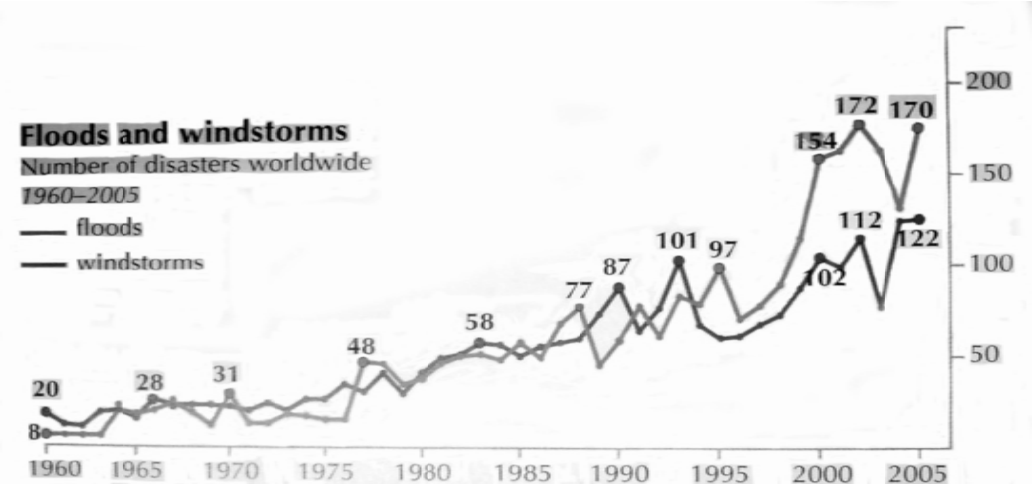


Figure 3: Number of disasters (Flood and windstorms) since 1960 -2005 worldwide (Dow & Downing, 2006).

Many natural systems are being affected by regional climate change and increased temperature (IPCC, 2007) putting the rural livelihood at risk. The earth's rising temperature has ultimately brought unavoidable climate change consequences. Widespread implications are predicted for agriculture, water resources, fisheries, forestry,

ecosystem and human health as well as social, economic and political systems (Reilly, 2001) making climate change more complex global issue of social, economic and political dimension.

Vulnerability is the degree to which a system is likely to experience harm due to its exposure to hazards (Tunner II, 2003). It is determined by the capacity of a system to anticipate, cope with, resist and recover from the impact of hazard. Exposure to natural hazards of the community is increasing day by day, making it more vulnerable with increasing global change and frequent extreme events.

Although it is difficult to link, with direct example, the dramatic power of the earth's meteorological system to climate change, however collected data shows response (Dow & Downing, 2006) with increasing extreme events. The international disaster database indicates that the incidence of flood and windstorm disasters has not only increased markedly since 1960s but also the events are more intensive, last longer and affect more people (Dow & Downing, 2006). Figure 2 shows the positive correlation of global change and vulnerability due to climate change. Researches over the climate change and global warming show that human-induced climate change is a tangible reality that affects human life triggering various disasters.

We are globally interconnected and climate change is considered to be problematic issue for many countries impacting various sectors and areas. Widespread implications of climate change indicate that climate change is a complex and cross-cutting issue. We know that dramatic changes are still to come and they will result in huge economic cost at community level to regional level. Along with the mitigation approach to climate change and associated risk, mainly for the developing countries, it is coping mechanism developed within the community that counts for risk reduction due to climate change.

According to IPCC report "Global atmospheric concentration of carbon dioxide methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. The global increase in carbon dioxide concentration is due primarily to fossil fuel use and land use change, while those of methane and nitrous oxide are primarily due

to agriculture." Human activities are increasingly altering the earth's climate (American Geological Union, 2003) changing it in such a way which is not good for the sustainable continuity of the living planet. Cumulative effects of the human activities on the concentration of the gases are increasing threat to increase disasters and unsustainable livelihood.

Global warming, the quicker warming of the earth enhanced by green house effect, has ultimately brought unavoidable climate change consequences. Warming of the climate system is now unequivocal. It is now clear that global warming is mostly due to man-made emissions of greenhouse gases mostly CO_2 (UNFCCC, 2007). In this context the adaptation is the best technique to minimize the risk of vulnerable communities.

Developing countries like Nepal are more susceptible to the climate change and its impacts due to their limited capacity to cope with hazards associated with changes in climate (Kates, 2000). Nepal has good reasons to be concerned about climate change. Over two million Nepalese people depend on climate sensitive sectors like agriculture and forestry for their livelihood (Garg, Shukla, & Kapshe, 2007).

Sharp variation of the climate with enormous range of elevation with in short span of North-South variation makes this country rich in biodiversity but at the same time it has the great impacts of even the slight change over the natural climate system.

B. Climate change, Vulnerability and Adaptation

Climate change refers to the variation in the Earth's global climate or in regional climates over time (UNFCCC, 2001) defines this as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere". Climate change impacts are the consequences of natural and human systems.

Vulnerability of the system is "a function of the character, magnitude, and the rate of climate variation to which a system is exposed (IPCC, 2007). In disaster planning, vulnerability is the social, economic and environmental exposure and sensitivity. Adaptation is the adjustment in natural and human systems to a new or changing

environment (Dow & Downing, 2006). For community and people adaptation is the process of social learning too. Adaptive capacity is the ability to understand climate changes and hazards, to evaluate their consequences for vulnerable peoples, place and economies and to moderate potential damages to take advantage of opportunities, or to cope with the consequences (Dow & Downing, 2006).

Yes, climate change is a reality and what we can do next is adaptation because mitigation for the country like Nepal is not so significant. As a developing country with very less contribute to emit GHGs in atmosphere, Nepal have to focus more on adaptation approach rather than control of the emission (Smit & Wandela, 2006). Vulnerability is a subjective concept that includes three dimensions: exposure, sensitivity, and adaptive capacity of the affected system

Adaptation is processes through which societies make themselves better able to cope with an uncertain future. Adapting to climate change entails taking the right measures to reduce the negative effects of climate change (or exploit the positive ones) by making the appropriate adjustments and changes (UNFCCC, 2006).

There are many options and opportunities to adapt. These range from technological options, behavior change at the individual level to other strategies including early warning systems for extreme events, better water management, and improved risk management, various insurance options and biodiversity conservation. What is required is the better adaptation strategy along with its proper implementation at community level.

C. Rationale of the Study

The research on community vulnerability within the country is very less. Although few national level study and reports have been published on community vulnerability, local level study are sporadic in spite of the fact that the micro-scale vulnerability assessment is more relevant than mega-scale in the country like Nepal which has high diversity in natural as well as human system within a short (of few kilometers) spatial variations. Hence local level study is important.

Researches over the climate change and global warming show that human-induced climate change is a tangible reality that affects human life triggering various disasters. The cumulative increase of Green House Gases (GHGs) concentration in the atmosphere has enhanced green house effect resulting in increasing rate of global warming. The reported global cost of natural disasters has risen even more, with a 15-fold increase between the 1950s and 1990s (IFRC, 2001), which shows more need of research based decisions to mitigate their impacts.

Climate change is considered to be problematic issue for many countries impacting various sectors and areas. Widespread implications of climate change indicate that climate change is a complex and cross-cutting issue. In these scenarios local level case studies are vital both for policy formulation and adoption, stir local people knowledge on present day's most challenging issue. Mountain regions of Nepal are more susceptible to climate change impacts and vulnerability. In this context study on community vulnerability due to climate change has great significance.

D. Objectives

The contribution in GHGs emission in Nepal is far below. So Nepal could not contribute much in mitigation of climate change, but the impacts are high- the high land mountainous region, landlocked political boundary, subsistence agricultural practices, poverty and low literacy rate all enhance increased vulnerability of community to climate change induced disasters.

The general objective of this study is to assess the nature of physical and socio-economic vulnerabilities, on the community due to climate change and its adaptation mechanisms.

The specific objectives of the study are;

a. identify the types, magnitude and recurrence interval of weather and climate related hazards/disasters based on local people's experiences in the study area,
b. assess their impacts in the past,
c. assess the pattern and trends of climate change based on recorded hydro-meteorological data and perception survey of experts and local people,
d. assess vulnerability and risk in terms of physical and socio-economic system in the changed context,
e. assess mitigation and adaptation techniques in context of changing climate,
f. recommend potential disaster risk reduction mechanisms,

E. Scope and Limitations of the study

The scope of this study is solely to carry out research on community vulnerability at Khudi watershed. The study has been carried out in the Khudi watershed of western hill of Nepal in Lamjung district. The scope of the work includes the following activities.

Major activities

The following key activities have been carried out under this work:

1. collection and review of literature and available maps,
2. collection of hydro meteorological data,
3. sharing of the ideas from national and international institutions and organizations,
4. filed observation and field survey(household survey, group discussions, key informant survey),
5. digital data base preparation processing and analysis,
6. Preparation of dissertation.

The work is, due to different technical constraints, limited to the followings.

- Only the community area of the Khudi watershed in lower zone has been considered.
- Only the single station data has been calculated for last 30 years,
- Detail physical vulnerability based on engineering tools was out of scope,
- Study is based on people perception. Its scientific verification is not carried out.

STUDY AREA

A. Country Background

1. Location and Physiography

Nepal, a Himalayan mountainous country, sandwiched between two large countries, China in north and India in South, East and West, occupy an area of 1,47,181 sq kilometers which is about 0.03% of Asia continent and 0.003% of world land mass. Situated on the southern slope of the Himalayas, it stretches in between the latitudes $26^0$22' and $30^0$27' north and the longitude $80^0$40' and $88^0$12' East (Chaudhary, 1998). With representation of about one third of the whole Himalayan range (2400 km), it shows unique climate with rugged topography and sharp altitudinal variation from 68 m in south to 8848 m, the world's highest peak in north within a short span of 145 km to 241 km with average of 193 km. Average east west length is about 885 km. About 83 % of the total land of the country is occupied by high mountains and wavy hills while remaining as flat land of Terai. Within this location of the country we can find tremendous climatic, biodiversity and cultural variation.

Wide altitudinal variation and diverse climatic condition make this country unique in the world in terms of physiography (Chaudhary, 1998).

T. Hagen (1969) first purpose the physiographic subdivision of Nepal on the basis of its physical and geological characteristics. Following are the physiographic subdivision of Nepal after T. Hagen with some modification given by Uprety (1999).

a) Terai (Northern Genetic Plain) and Dun valley (100-200 m)

b) Churia range(Siwaliks) (200- 700 m)

c) Mahabharata Range(1000-2500 m)

d) Himalaya and Mid lands:(300-2000 m)

e) Fore Himalaya (2000-4500 m)

f) Higher Himalaya (> 4000 m)

g) Inner Valleys (2500 – 4000 m)

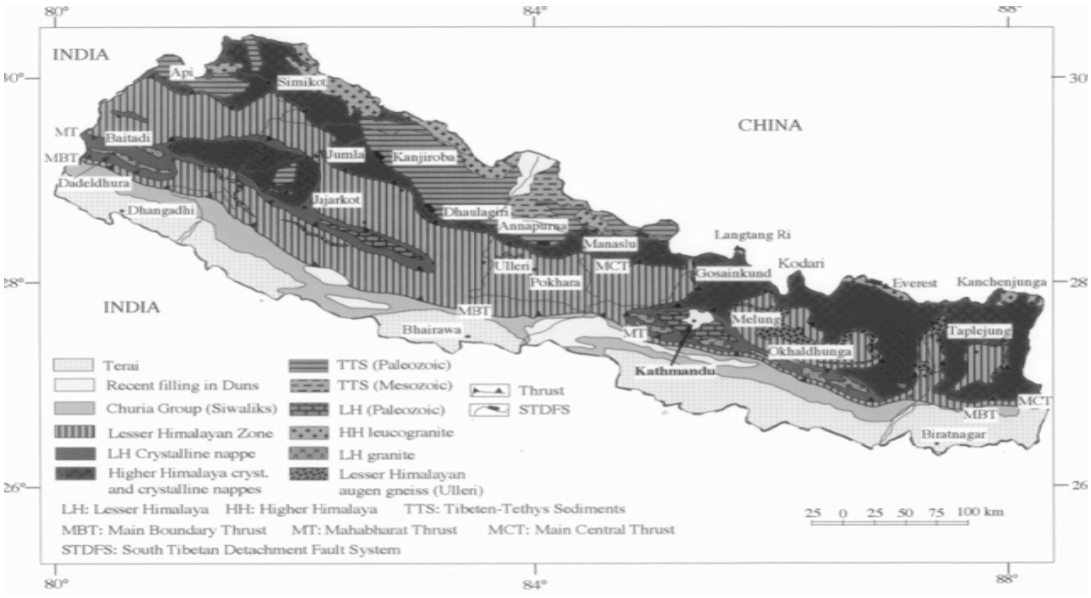


Figure 4: Physiographic subdivision of Nepal (Uprety, 1999).

2. Climatic variation

Within the short span of width, due to sharp altitudinal variation, a wide range of climatic conditions exist in Nepal. Climate of Nepal varies from tropical to arctic within the two hundred km span of from South to North largely being a function of elevation making the country more sensitive to climatic variation. Nepal has a monsoon climate, dominated by an extended wet season starting in June with the arrival of the South-west Summer Monsoon.

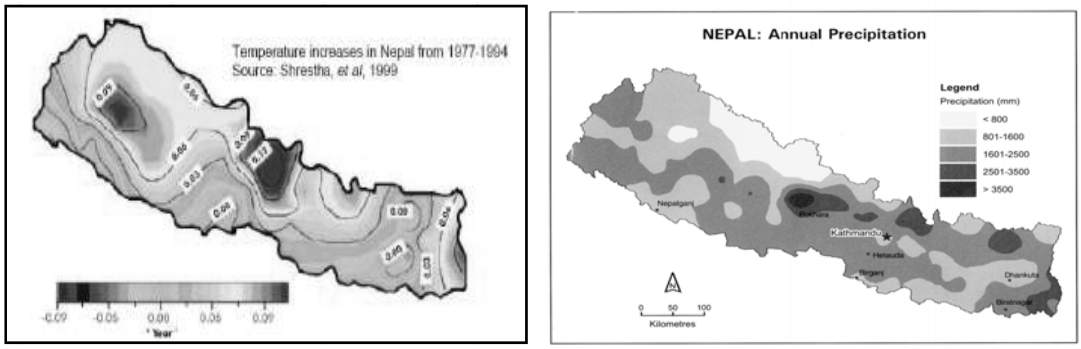


Figure 5: Temperature and Precipitation maps of Nepal.

The High Himalaya range retains the moist air masses of the monsoon, increasing precipitation in Nepal and keeping the areas to the north in deep rain shadow. These same mountains also act as a barrier to the cold fronts from central Asia, giving warmer winters to Nepal and northern India.

National mean temperature hover around 15^0C and increase from north to south with the exception of the mountain valleys. In the Terai the mean winter daytime temperatures are between 22 and 27°C, whilst summer temperatures exceed 37°C. Higher up in the Mid-Hills temperatures are between 12 and 16°C, with a general temperature decrease of about 6°C for every 1000 m gain in altitude.

Average rainfall is 1500mm with rainfall increasing from east to west (HMGN/MoFSC, 2002) creating diverse rainfall and temperature within the country. More than 80% rainfall is during the 4 months of monsoon and due to the great variation in the topography different parts of the country receive rainfall in varied magnitude and intensity, making different parts of the country more vulnerable to flood and landsides disaster.

Five climatic zones in Nepal based on altitude are the tropical and subtropical zone of below 1,200 meters; the cool, temperate zone of 1,200 to 2,400 meters; the cold zone of 2,400 to 3,600 meters; the subarctic climatic zone of 3,600 to 4,400 meters in altitude; and the arctic zone above 4,400 meters in altitude (Library of Congress, 2008). On the basis of precipitation the seasons of Nepal are pre-monsoon (the weather is dry and hot

receiving occasional rain showers), monsoon (very hot with about 80% of annual rainfall), post-monsoon (warm and humid) and winter (weather is cold and dry).

Rainfall varies greatly across the country with the general trend of wetter conditions in the east (Taplejung, 1,768 m altitude, receives an annual average rainfall of 2,024mm) and drier in the west (Baitadi, 1635 m, receives 1,037 mm). The average rainfall in Nepal is about 1,600 mm. The southern slopes of the Himalaya receive the highest rainfall (3,477 mm in Pokhara, 850 m; 5,550 mm in Lumle, 1,642 m), whilst the trans-Himalaya lands north of the main Himalayan range (Mustang, Dolpa, Manang and Jumla) are in rain shadow with a desert-like barren tundra, barely getting 250 mm of annual rainfall (Jomsom, 2,650 m, receives 255-295 mm (Agrawal et al, 2003). Precipitation is greatly influenced by the prevailing wind systems which are northeasterly in the winter and southwesterly in the summer. The winter winds bring cold, dry airstreams from Central Asia, in marked contrast to the warm, wet air masses from the south bringing the summer monsoon.

3. Population and its Distribution Pattern

Nepal with a population of about 23 million has a relatively low population density compared to other Asian countries such as India or Bangladesh; however, the population is overwhelmingly rural, with only 12% living in urban areas (Agrawal et al, 2003). Rural population density is relatively high at 686 people per square kilometer, a figure that exceeds that for most low income countries. This figure also indicates that rural to urban migration is high. At the time of 1981 census, the total population of Nepal was 15,022,839 the average family was made up of 5.8 persons, and life expectancy at birth was close to fifty years. As of 1991, the population was estimated at 18,491,097 persons (CBS, 2005). The Central Bureau of Statistics, as per 2001census, shows Nepal population as 22,736,934 persons with average household size 5.45 persons. The population density in 2002 was 162 per sq km. Population distribution is uneven, with about 45% of all Nepalese concentrated in the hilly central region, 47% in the fertile Terai plain, and only 8% in the mountains (Encyclopedia of Nations, 2007).

4. Socio-economic context

Nepal is a multi-cultural country with diverse livelihood of Aryan and Mongolian communities. Nepal has not rich economy. Despite its natural beauty and enormous potential for hydropower and tourism, Nepal is one of the poorest countries in the world, with 82.5% of the population living below the international poverty line of $2 per day. A Gini coefficient 2 of 0.37 indicates that income distribution is somehow uneven. Approximately 40% of the country's GDP came from agriculture in 2000, down from 52% in 1990. Agriculture also provides a livelihood to nearly 81% of the labor force. Any direct change in the climatic variables will affect the agriculture and hence the economy of the country too. A heavy reliance on tourism and agriculture makes Nepal's economy very sensitive to climate variability (Agrawal et al, 2003). It is difficult to determine Nepal's potential to adapt to climate change, but several key statistics may give some insight as to the state of its infrastructures and social and human capital.

B. Khudi Watershed

1. Location

Khudi Watershed of Lamjung District was selected as study area. Lamjung district lies in the Gandaki zone of Western Development Region of Nepal with geological extension from middle hill to northern Himalaya. Lying near to the middle of Nepal, Lamjung district, with its area of 1692 square kilometers, is one of biodiversity rich fragile hill region of Nepal.

Geographical location of the Lamjung district:

Latitude: $28^0$03'-$28^0$30' North

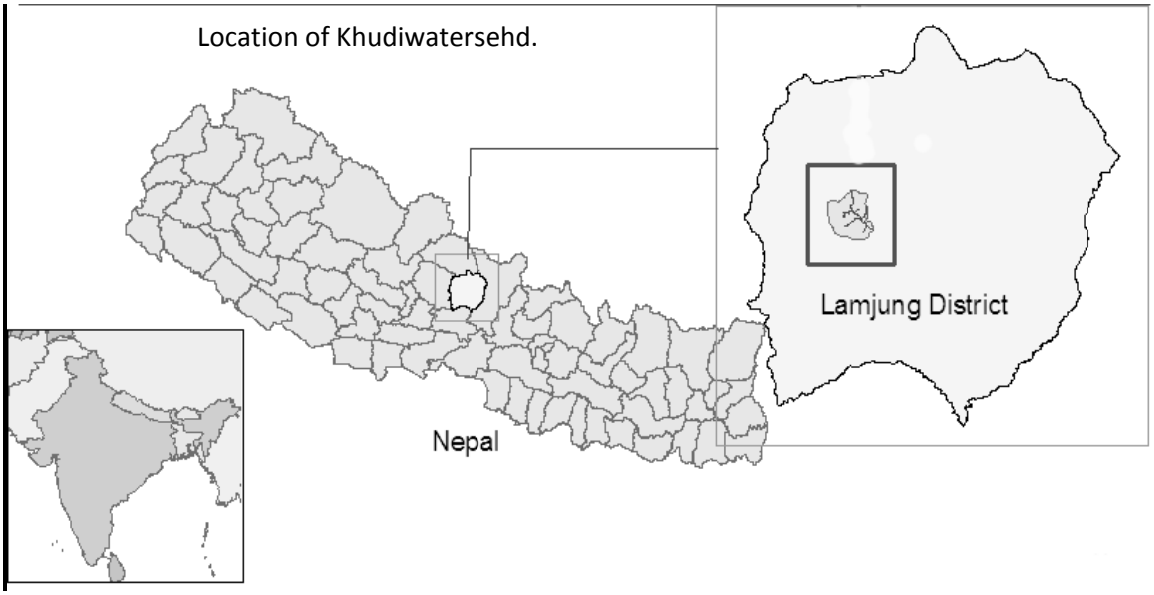
Longitude: $84^0$11'-$84^0$38' East

Altitude: Lowest 385 m and Highest 8162 m (From Sea Level).

The mean district minimum and maximum temperatures are 15.97^{0}C and 27.33^{0}C respectively (Narayani River Basin, Pokhra, DHM). Mean annual precipitation of the district is (only rain fall, as snow fall was not measure) is 2371.5 mm (Narayani River Basin, Pokhra, DHM). It is a typical hilly district with landscape of rugged topography of Northern Mahabharata range to Himalaya belt with Manaslu and Lamjung Himal.

According to CBS 2001 Census, the total population of Lamjung district is 177,149 with population growth rate of 1.42 per year and consists of 36,525 households with population density of 104.70 per square kilometer (CBS, 2006). There are 61 VDCs within the district. Lamjung is one of the tourist destinations within the country. Khudi is the entry point for ACAP.

Khudiwatershed of Lamjung is located in between latitude $28^0$17' and longitude $84^0$22' and elevation ranging from 823 m to 3000 m (Figure 6). Khudi watershed is a subsystem of Marsyandgi watershed. The watershed encompasses different wards of three VDCs namely Khudi, Simpani and Ghanpokhara. This area was selected as study site as western region of Nepal is considered as one of the highly temperature increasing region of country and because of the availability of hydrological and meteorological data since 1981.



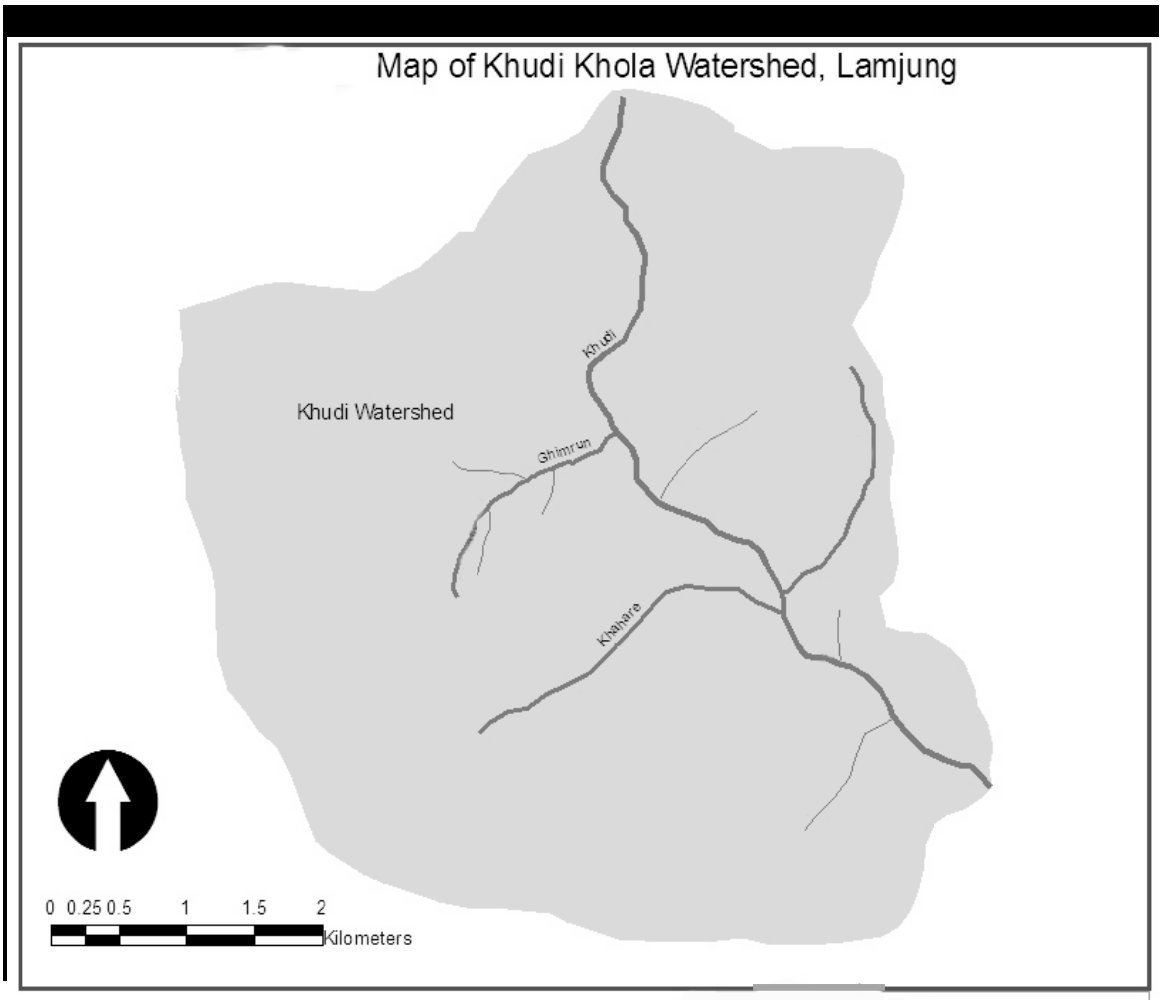


Figure 6: Location and Map of Khudi watershed.

2. Socio-economic condition

Total population of the three VDCs of the watershed area is 10,447 (4,890 male and 5,557 female) and total households are 2,099 with average population density of 133.54 (CBS, 2006). The watershed area is dominated by Indo-Aryan castes such as Brahmin, Chhetri, followed by Mongolian Gurungs. Agriculture is major occupation followed by foreign employment as *Lahure* mainly from Gurung community (Gurung, 2004). Almost all the household of Gurung has at least one Indian or British army or ex-army pensioner. Livelihood of most of the people is based upon the integrated system of farming, forests and livestock as in other hilly areas of Nepal. But recent years young generation is being more engage in foreign employment, tourism an

3. Biophysical condition

The watershed is a typical example of mid hill region of Nepal and lies in middle mountain ecological zone. Altitude rises from 823m to 3000 m. Generally watershed area is sloppy land with upper portion comprises of steep slope and lower belt gentle slope. Near to the Khudi River the area is flat too.

4. Climate

Climate of the area varies from sub-temperate at lower altitude to sub-alpine at higher altitudes with average annual rainfall 3345.755 mm and average maximum temperature 27.17°C and minimum temperature 15.50°C. More than 80% of total rain occurs between June to September i.e. during monsoon period.

Picture 1: Khudi watershed.

5. Vegetation

The area's forest is mostly hardwood forest dominated by Sal *(Sorea robusta).* It is common in the southern aspects and lower altitudes. In the upper parts of northern aspects *Schema-Catanopsis* forest is dominant with other associate species. Other associated species are *Rhus* sps. *Syzygium cumini, Teminalia alata, Phyllanthus emblica, Cleistocalyx operculat, Engelhardia spicata* etc. on lower altitudes and *Myrica Esculenta, Pinus* sps. *Madhuca indica, Lyonia ovalifolia,* etc on higher altitudes. At the top part of the Northern aspect of the Southern hills *Rhododendron* sps. *Pinus roxburgi* and other temperate species are recorded.

LITERATURE REVIEW

Climate change impact studies focus primarily on physical exposure to average climatic conditions. It attempts to identify the vulnerabilities of a system in different climatic conditions. There is need to conduct assessments on climate change in order to assist in evaluating vulnerabilities arise due to this.

Climate change and global warming

United Nations Framework Convention on Climate Change (UNFCCC, 2002) defines "climate change" as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere".

United Nations framework Conventions on Climate Change (UNFCCC) in its Article 1 defines climate change as *a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.* Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability which may be due to natural internal processes or external force, or to persistent anthropogenic changes in the composition of the atmosphere or in land use" (IPCC, 2006).

Global temperature is increasing by 0.3^0C to 0.6^oC since the last 19^{th} century and by 0.2^oC to 0.3^0C over the last 40 years (1960- 2000) (Xiaodong & Baode, 2000) with indication of more increase in the global temperature in coming days making earths sustainability more vulnerable.

According to the Intergovernmental Panel on Climate Change Synthesis Report (2007) there has been an unprecedented warming trend during the 20^{th} century. The current average global surface temperature of 15°C is nearly 0.6°C higher than it was 100 years ago - most of the increase has been the consequence of human activity. A further increase of 1.5-6.0°C is projected for the period to 2100. Forth Assessment Report of IPCC (2007) concluded that

"most of the observed increase in globally averaged temperatures since the mid 20th Century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations". The average atmospheric CO_2 concentration has increased from 280 ppm in 1850 to 365 ppm at present, and could exceed 700 ppm by the end of the present century if emissions continue to rise at current rates (IPCC, 2007).

Scientists predicted through the global climate models that the average global surface temperature increase from 1.4°C to 5.8°C due to presumed doubling of CO_2 concentration in the atmosphere by the end of the 21st century. In the northern hemisphere, precipitation has increased by 0.5% to 1.0% per decade whereas the increase in tropical countries has been 0.2% to 0.3% per decade. The trend over the course of the last century has been uneven, but in the period since 1976 the warming trend is roughly three times that of the past 100 years as a whole (WMO, 2004).

The increases in average global temperature (global warming); changes in cloud cover and precipitation particularly over land; melting of ice caps and glaciers and reduced snow cover; and increases in ocean temperatures and ocean acidity – due to seawater absorbing heat and carbon dioxide from the atmosphere (UNFCCC, 2007) clearly indicates the changing trend in climate. Over the last century, atmospheric concentrations of carbon dioxide increased from a pre-industrial value of 278 ppm to 379 ppm in 2005, and the average global temperature rose by 0.74° C (UNFCCC, 2007) which supports the fact the global increase in the temperature is mainly due to the excess emission of CO_2 from human induced sources.

The scenario of the global change impacts in the fragile mountains of Nepal and around is greater, the major impacts and threats of global warming are widespread. As a result of global warming, the type, frequency and intensity of extreme events, floods, droughts and heavy precipitation events, are expected to rise even with relatively small average temperature increases. Changes in some types of extreme events have already been observed, for example, increases in the frequency and intensity of heat waves and heavy precipitation events (Meehl, et al., 2005) and such events bring more risk to the people living near to riverside or the marginal community.

Vulnerability and Coping Mechanism

Future vulnerability depends not only on climate change but also on the type of development path that is pursued (IPCC, 2007) and for any development we must focus on the sustainable approach minimizing not only environmental hazard but also long term impacts on lifestyle, human behavior and associated effects. Although higher level of development creates higher coping capacity, it might also imply increased social exposure to climate hazards.

The developing countries are more susceptible to climate change impacts as they have limited capacity to adapt. The least developed countries are among the most vulnerable to extreme weather events and the adverse effects of climate change. They also have the least capacity to cope with and adapt to the adverse effects of climate change (UNFCCC, 2006).

Although Nepal's contribution to the GHGs emissions is very less, it is the country where its impacts are very high (Chalise, 1994).

IPCC summery report 2007 indicates that human beings are the main responsible for the increased amount of the green house gases. Developing countries are considered to be particularly susceptible to climate change due to their limited capacity to cope with hazards associated with change in the climate. The major risk reduction approach is adaptation to global change (UNFCCC, 2006).

Article 17 of The Marrakesh Accords UNFCCC (2001) said " the least developed countries are among the most vulnerable to extreme weather events and the adverse effects of climate change due to mountainous and landlockness". They also have the least capacity to cope with and adapt to the adverse effects of climate change. Considering this fact UNFCCC article 4.4 said "the developed country parties shall assist the developing country parties that are particularly vulnerable to the adverse effects of climate change in meeting cost of adaptation to those adverse effects.

Focusing on the preventive measures to control climate change UNFCCC Article 2 said *…stabilization of GHGs concentrations in the atmosphere at a level that would prevent*

dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change , to ensure that food production is not threatened and to enable economic development to proceed in sustainable manner……..…

Changes in land surface can result in emission or removal of CO_2 to the atmosphere and also change in the Earth's radiation balance by altering the Earth's surface albedo. In addition, changes in land surface can alter the fluxes of sensible and latent heat to the atmosphere and thus the distribution of energy within the climate system; and in so doing can alter climate at the local, regional, and even global scale. It is estimated that one-quarter of the anthropogenic contribution of carbon to the atmosphere is derived from land cover changes such as deforestation (IPCC, 2001). Scientific understanding and tools are increasingly becoming available to address the broader implications of land surface interactions within the climate system for national and international policy (IPCC, 2007).

A wide array of adaptation options is available, but more extensive adaptation than is currently occurring is required to reduce vulnerability to climate change. There are barriers, limits and costs, which are not fully understood (IPCC, 2006).

Adaptation can reduce vulnerability (IPCC, 2006). Adaptive capacity is intimately connected to social and economic development but is unevenly distributed across and within societies (IPCC, 2006). The greatest challenge in this century is rising temperatures which will have serious effects on rainfall, the strength and distribution of tropical storms, sea levels and glacier melt, thereby causing greater risks to life and livelihood and increasing damage-related costs.

The impacts of climate change increase, among other things, are associated with water and food shortages, coastal inundation, the distribution of vector-borne diseases such as malaria and dengue fever, and the rate of extinction for many species (up to 30 per cent with a 2°C rise in temperature) (IPCC, 2007).

IPCC (2006) concluded that increased global temperature since 20th century is very likely due to increased anthropogenic greenhouse gas emission from burning of fossil fuel and forest conversion. The planet is already experiencing climate change impacts on community and livelihood, water resources agriculture and disasters (WWF, 2007). Using current temperature trends, by 2100, the average temperature may rise by 1.4-5.8^{0}C (IPCC, 2006). This increases certainty of occurrence of disasters in fragile ecosystems (WWF, 2007).

Climate change is emerging as one of the most profound ecological and social concerns over our time (Y2Y, 2007). The ecological axiom "adapt, migrate or die" takes a particular relevance and urgency as scientists continue to study potential scope of climate change. In the face of warming temperatures many species, not leaving human beings, will be forced down one of the three paths (Y2Y, 2007) of adaptation, migration or die. Associated effects of climate change were already observed such as increase in dry period, intense rainfall, flood, landslides, forest fires, glacial threats etc (Shrestha & Wake, 2000). Because climate has an important role in determining the altitudinal zone of vegetation and life zones, it is possible that high altitude communities in mountain areas will be sensitive to the effects of long term climatic change (Grabherr, Gottfried, & Pauli, 1994).

Mountainous regions are characterized by sensitive ecosystems, enhanced occurrences of extreme weather events and natural catastrophes. These are also the regions of conflicting interests between economic development and environmental conservation. In context of Climate Change, significant perturbations can be expected to natural systems and these will inevitably have an influence on the economy of the mountainous region. Global change will probably exacerbate the present conflict situation between environment and economy. International conference on Adaptation to climatic variability and change (2006) mention that generalization of the climate in the Himalayas is largely due to the absence of long term data and extremely limited number of meteorological stations.

Dow and Dowing have published "The Atlas of Climate Change Mapping" the world's greatest challenge in 2006 from Earthscan. This provides essential background readings

on climate change impacts and coping mechanism. New records and observations around the world are consistent with scientists' expectations of climate change. Correlation between increasing uncommon weather events and observed changes in temperature, and in atmospheric composition led to conclude that global weather pattern are likely to be affected by climate change. Polar changes, glacial retreat, everyday extremes are the warning signs of the impacts of climate change. Trends or/and events of local temperature rise, extreme heat and/or drought, extreme precipitation and/or wind and changing animal and plant behavior are consistent with the theories of climate change since 1990s to 2005. It was predicted that global temperature will continue rising in coming days and expected to increase in average by 2 to 4.7 ^{0}C in 2000-2100. As a consequences of these changes, world biodiversity is at risk and many species and ecosystems, already at risk from human development, may not be able to adapt to new climatic conditions and stresses, increase water scarcity and induced conflict, threatens food security, human health, sea level rises and coastal cities at risk, cultural losses through damage to indigenous cultures, historical monuments etc will occur.

Nepal and Climate change vulnerability

The response for country like Nepal to these consequences is adapting to these changes. The capacity to adapt to climate hazards and stresses depends on a country's wealth, resource and governance (Kates, 2000).

The climate change risk can be traced by studying the rate of snowmelt, landslides, flooding and change of vegetation. For vulnerability assessment, the place based (micro scale) study is more relevant than larger area if we give due consideration to spatial variation of natural hazard and vulnerability (Tunner II, 2003).

Nepal demonstrates diverse geo-physical and climatic conditions within relatively small areas resulting vast biological diversity, therefore, it is an ideal place to study climate change impacts on natural and socioeconomic spheres. In context of Nepal, a few studies have been carried out on vulnerability and risk assessment of natural hazards. Some of them are (Chhetri & Bhattarai, 2001), (Dhital, Khanal, & Thapa, 1993), (Dixit, 2003),

(ICIMOD, 2002), (Khanal, 2005), (Khanal, 1999), (Mool, Bajracharya, & Joshi, 2001). However most of them are based on the available information of the past without or in only some extent to climate change and potential future risk of climate change related disasters.

Although Nepal is responsible for only about 0.025% of total annual greenhouse gas emissions of the world (Karki, 2007) it is experiencing the increasing trends and the associated effects of global warming.

Precipitation and temperature maps of Nepal have been constructed showing the regional variation in monsoon (maximum and minimum temperature's regional variation) with its trend.

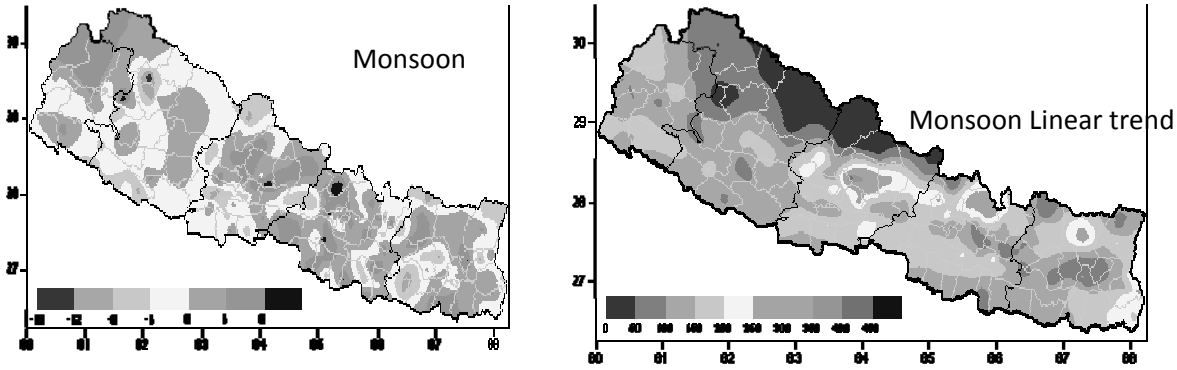


Figure 7: Monsoon precipitation in cm and its linear trend in percent of normal per decade. (After Baidhya, 2008)

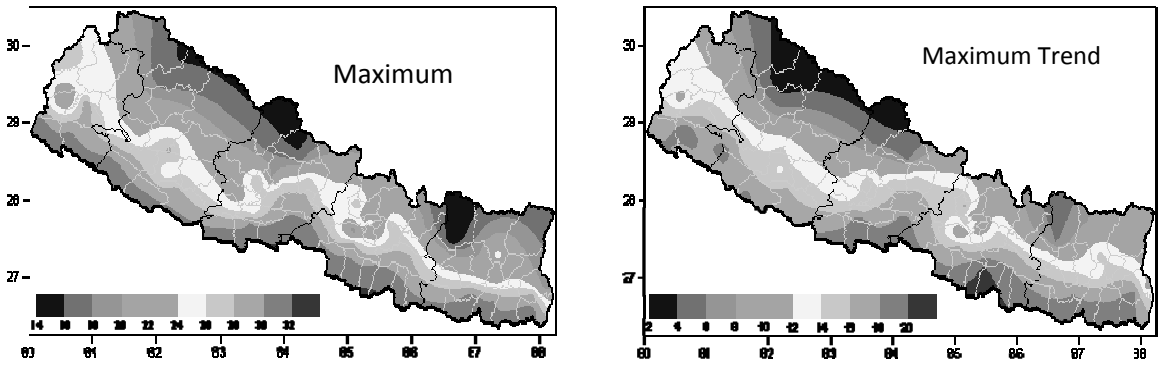


Figure 8: Annual mean maximum temperatures in ºC and their linear trend in ºC per decade.(After Baidhya, 2008).

Nepal Stocktaking report (2008) has mentioned the climatic scenario of Nepal. Climate of Nepal is characterized mainly by altitude, topography, and by the seasonal circulation system. Summer Monsoon contributes most of the annual

precipitation in Nepal during the rainy months, June through September. Spatial distributions of the total monsoon precipitation (cm) and its linear trend (% of normal/ decade) over Nepal for the period of 1971-2004 are depicted in Figure 8.

Spatial variation of surface air temperature in general follows the broad scale topography of Nepal and shows a variety of trends in seasonal patterns. The winter is the coldest period, generally due to the passage of north-westerly continental dry air. However, hottest period is just before onset of the monsoon. Cloudiness and precipitation during monsoon usually slightly reduced surface air temperature. The remaining periods are generally mild. The average warming in annual temperature between 1977 and 2000 was 0.06°C/yr, which was found more prominent at higher altitude regions of Nepal particularly during winter (Shrestha et al, 1999). The spatial distributions of the mean annual maximum temperature and their linear trend over Nepal for the period 1971-2004 are depicted in Figure 9. Similarly the spatial distribution of mean minimum temperature and their linear trend over Nepal for the period of 1971-2004.

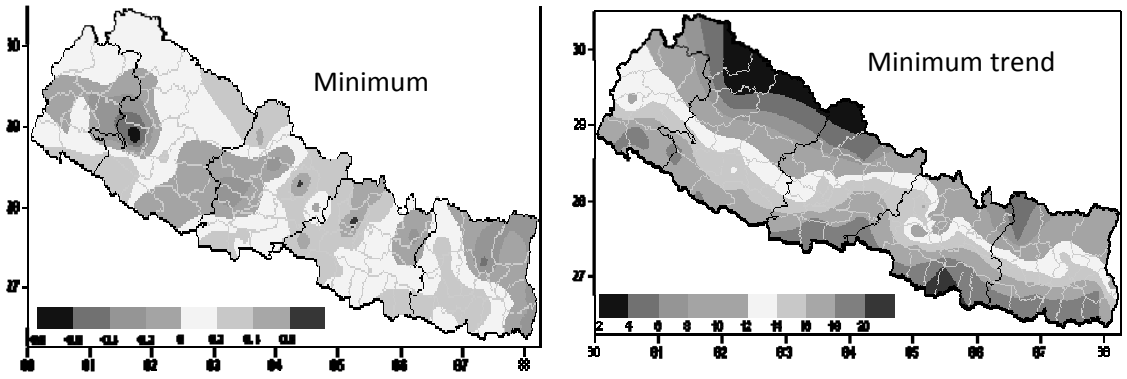


Figure 9: Annual mean minimum temperatures in ºC and their linear trend in ºC per decade.(After Baidhya, 2008)

These temperature analysis graphs clearly indicate the warming trend of total surface temperature of the country. The temperature differences are most pronounced during the dry winter season, and least during the height of the monsoon.

Analyzing the recent climatic trend, it is reported that there is significant warming trend in Nepal with more pronounced at higher altitudes. This finding is reinforced by observations of X. Liu & B. Chen (2000) on the other side of the Himalayas on the

Tibetan Plateau (Figure 10). They have predicted mean temperature increase by 1.2°C and 3°C by 2050 and 2100 respectively. It has been observed such as increase in dry period, intense rainfall, flood; landslides forest fires, glacial retreats and GLOF threats (Shrestha & Wake, 2000).

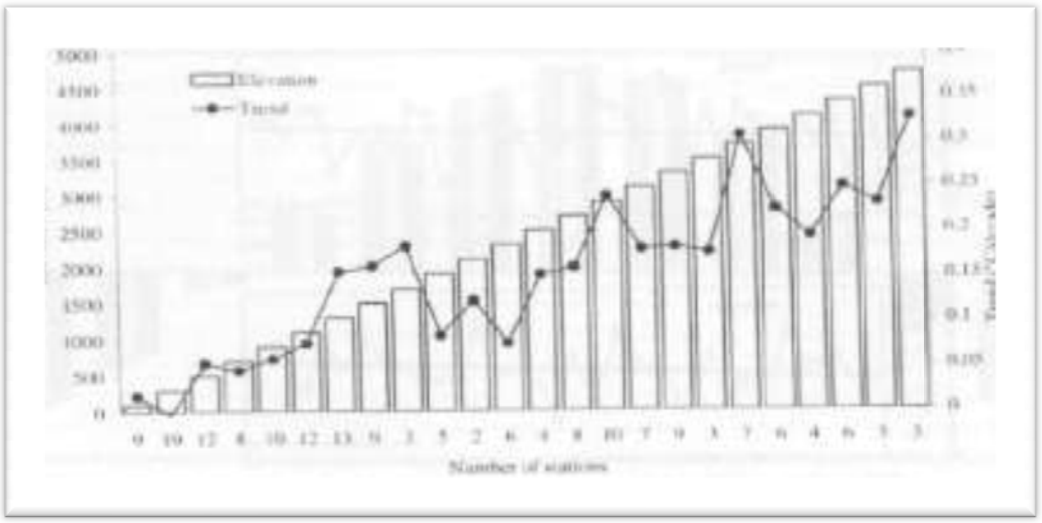


Figure 10: Temperature changes according to Elevation (Liu & Chen, 2000).

IPCC (2006) reports an increase in mean surface temperature in the range of 0.3°C to 0.8°C over the past 100 years in tropical Asia including Nepal.

However, (Shrestha et al, 1999) reported the temperature increase of 0.06°C to 0.12°C per year in most of the middle mountain and Himalayan regions, while the Siwalik and Terai regions shows warming trends of less than 0.03°C/yr from 1971-1994. Climate change scenarios across multiple general circulation models meanwhile show considerable convergence on continued warming, with country averaged mean temperature increases of 1.2°C and 3°C projected by 2050 and 2100.

Nepal's National Assessment Report for the World Summit on Sustainable Development (2002) recognizes the links between climatic circumstances and land degradation, erosion and landslides: "*in a nutshell, 'too much water' and 'too little water' is responsible for land degradation in different land uses in Nepal*." It also recognizes the increase in landslide risks due to the effects of paddy cultivation and livestock grazing in the hills and mountains. However, the fact that climate change might increase those risks is not discussed, and adaptation to climate change is not mentioned anywhere.

The SDAN lists Nepal's continuing vulnerability to climate change, natural disasters and environmental degradation are among the constraints facing Nepal's Sustainable Development. It also contains a separate section on climate change, which lists the potentially serious consequences for infrastructure, agriculture, drinking water, irrigation, hydropower, and biodiversity, and mentions the risk of GLOFs. Broader climate risks, including natural hazards such as floods and droughts, feature prominently, and concrete disaster mitigation measures are proposed including the establishment of a national disaster preparedness and management agency, the creation of village-level early warning systems for floods, landslides or earthquakes, building decentralized emergency response capacity, enforcing design standards for buildings and infrastructure that take into account site-specific risks etc. It also focus on broader perspective on Nepal's development patterns incorporating migration, watershed management, flood management, and disaster preparedness which will also help communities adapt to climate change.

One of the most important indicators of vulnerability to climate change and disasters is poverty. This is the unfortunate situation for most Nepalese living in mountainous and hill regions. Only 2% of the land is suitable for cultivation, and it can support only 8% of the population (Tianchi & Behrens, 2002). Human activities to build settlements, cultivate steep slopes, gather fuel wood, and construct other infrastructure have led to severe land degradation. Deforestation is another problem in the mountain areas, leading to increased landslides—up to 12,000 per year—and floods. From 1979-1998, forested area decreased by one third (Tianchi & Behrens, 2002).

Different reports from (IPCC, 2001), (IPCC, 2006), (IPCC, 2007), (World Bank 2005), and (DFID, 2006) gives in their reports options and ways to reduce the vulnerability in developing country like Nepal. A number of options can reduce vulnerability in all regions of Nepal to climate change and climate related disasters. Non-structural measures are particularly attractive as they generally involve lower costs than engineering measures and would go a long way towards building capacity for disaster preparedness and water resource management. Such measures include: Developing and implementing land use/zoning policies; maintaining up to date hazard and vulnerability maps; training

and capacity building for disaster and water resource management; working with the community to increase public awareness and develop early warning systems and evacuation plans; afforestation and reforestation programs (for reduction in flooding/landslide risk).

In Nepal, in between 1995 to 2002, the totals of 6854 lives were lost by the landslide and flood disasters (ADB/ ICIMOD, 2006) with billions of dollars economic lost of land and infrastructures. In total more than 500000 people were killed by landslides in the 20th century globally. In first 25 weeks of 2003, there were 2000 landslides fatalities in 139 large events, 95% of which occurred in less developed countries (ADB/ ICIMOD, 2006). Because of its location in the central part of the Himalayas and with its fragile geology, steep slopes, high relief, and intense monsoon climate, Nepal is prone to water induced disasters such as flood and landslides. Over the last twenty years from 1983-2002, flood and landslide caused 6466 deaths and more than US $200 million in damage. In 1993 alone there were more than 1300 lives lost and over US $ 2 million of property and infrastructure destroyed by an individual event recording the highest 24-hr precipitation of 540mm (ADB/ ICIMOD, 2006).

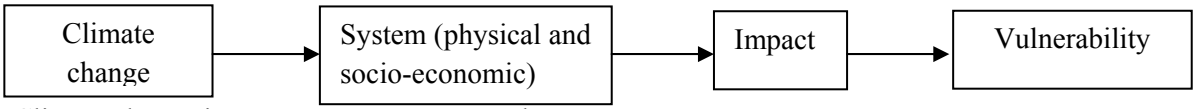
In Nepal, recorded 55 fatalities in 2000, 185 fatalities in 2001 and 345 fatalities in 2002, (Oven et al, 2008) reflecting a rising trend of disasters impact with the economic costs exceeding billions of dollar per year, with remote and rural communities being particularly affected.

There are many reports and case studies focusing on different aspects of climate change in Nepal. Local level vulnerability assessment studies are rare in context of hilly region of Nepal. Available literature has been reviewed before carrying the study.

THE METHODOLOGY

A. Research Approach

This research has followed climate change vulnerability approach (Desanker and Nassef, 2003; Kelly and Adger, 2001; Lim, 2003 as quoted in (Sutherland, 2004; Kelly & Adger, 2001). In this approach, the scientific data along with people participation and experience sharing are used to assess the vulnerability to better understand the nature of vulnerability of community to climate change and induced disasters. For the research purpose two major vulnerabilities viz. physical vulnerability and socio-economic vulnerability has been taken into account. The nature of a hazardous event or condition is a social construct and not solely a biophysical condition. Thus research on disaster related risk to climate change is performed by considering social and physical condition of the area (Kates, 2000). Following this approach the assessment was carried out.



Climate change impact assessment approach.

Using this approach, vulnerability will be determined using following equation,

$$V = I - A$$

Where, V= vulnerability,

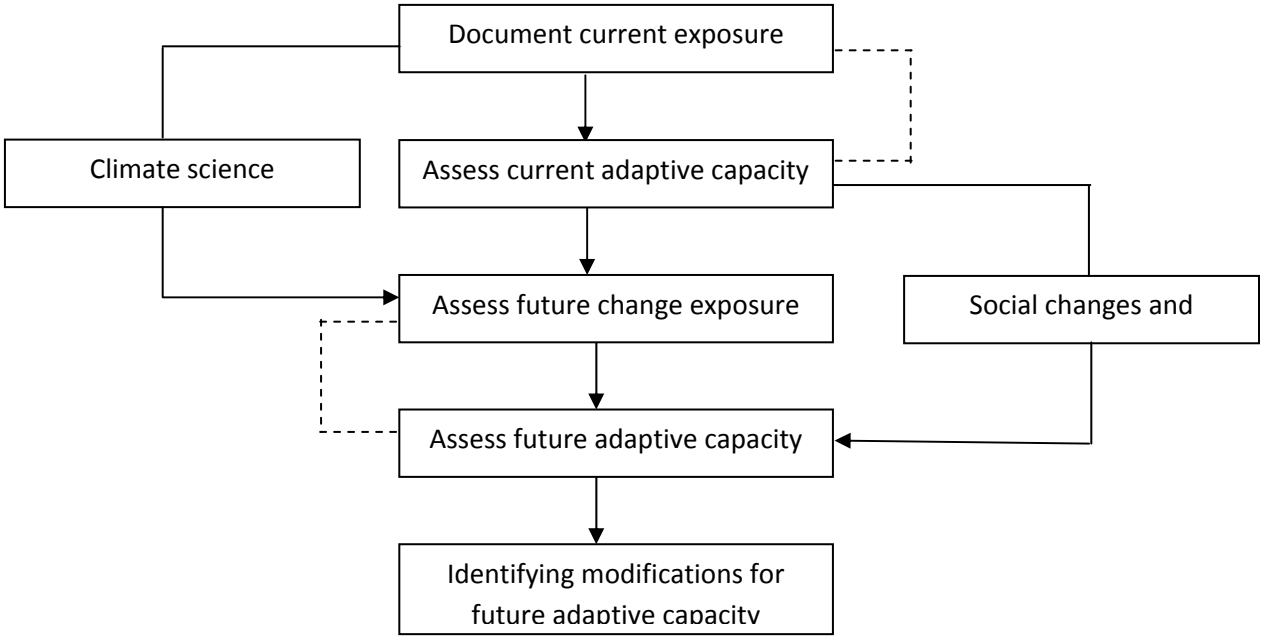
I = impact

A = adaptations

Physical vulnerability is often measured by considering the reference to physical indicators such as dampness of land, loss of vegetation, return period of storms or floods or length of severity of drought etc. Social vulnerability is often measured by threats to lives, infrastructures etc. to support basic needs. Participatory case-study methods were adopted for assessing vulnerability to better understand the nature of vulnerabilities of communities to climate change. The assessment begins with the system in questions and

examines the conditions of the community and of various stimuli that gives rise to its vulnerability and the interrelationship between them.

An assessment of vulnerability began with the documentation of the current exposure to climate change of a community. Exposure refers to both the physical conditions of the climate related risks, including its extent and magnitude. Consultation with local community helped to document the exposure of community and it was based on personal experience of the respondents. The settlement pattern, location of assesses and infrastructures in the community were based on field observation. The climate change vulnerability approach is as follows:



The climate change vulnerability approach. (Desanker and Nassef, 2003; Kelly and Adger, 2001; Lim, 2003 as quoted in (Sutherland, 2004; Kelly & Adger, 2001).

Future changes in the climatic attributes for which the community is sensitive have been estimated by reviewing the climate science literature with proper extrapolation.

B. Data Collection

Sources of Information

1. Primary Data

a) Reconnaissance survey

A reconnaissance survey was carried out in field to get the general understanding of the status of the study area before starting the detail work.

b) Sample Design

Stratified Random Sampling is often used when the population characteristics are heterogonous. This sampling technique gives a better cross-section of the population so as to gain a higher degree of relative precision. Here the entire population that is number of household within the watershed is divided into two strata considering that the altitudinal variation creates heterogeneity in the livelihoods of the local people, especially on the factors related to climatic variation (Weiss & Hassett, 1982). Therefore the entire watershed was stratified into two area one below 1000 m and another above 1000 m so that changes in the community at different altitude can easily be assessed.

c) Household Survey

A total of 63 households (each stratum consisting at least 30 households) were selected randomly for the purpose of household survey. Stratification was done based on the spatial distribution i.e. each settlement was taken as a stratum. During fieldwork similarity was observed in the socioeconomic condition within same settlement. The household survey structured questionnaire was prepared and interview was conducted incorporating different aspects of climate change, disasters, water resources and agricultural production. Other key socio-economic parameters such as income, expenditure, and landholding were also considered for household survey. Though selection was random, focus has been given to consider the elder people.

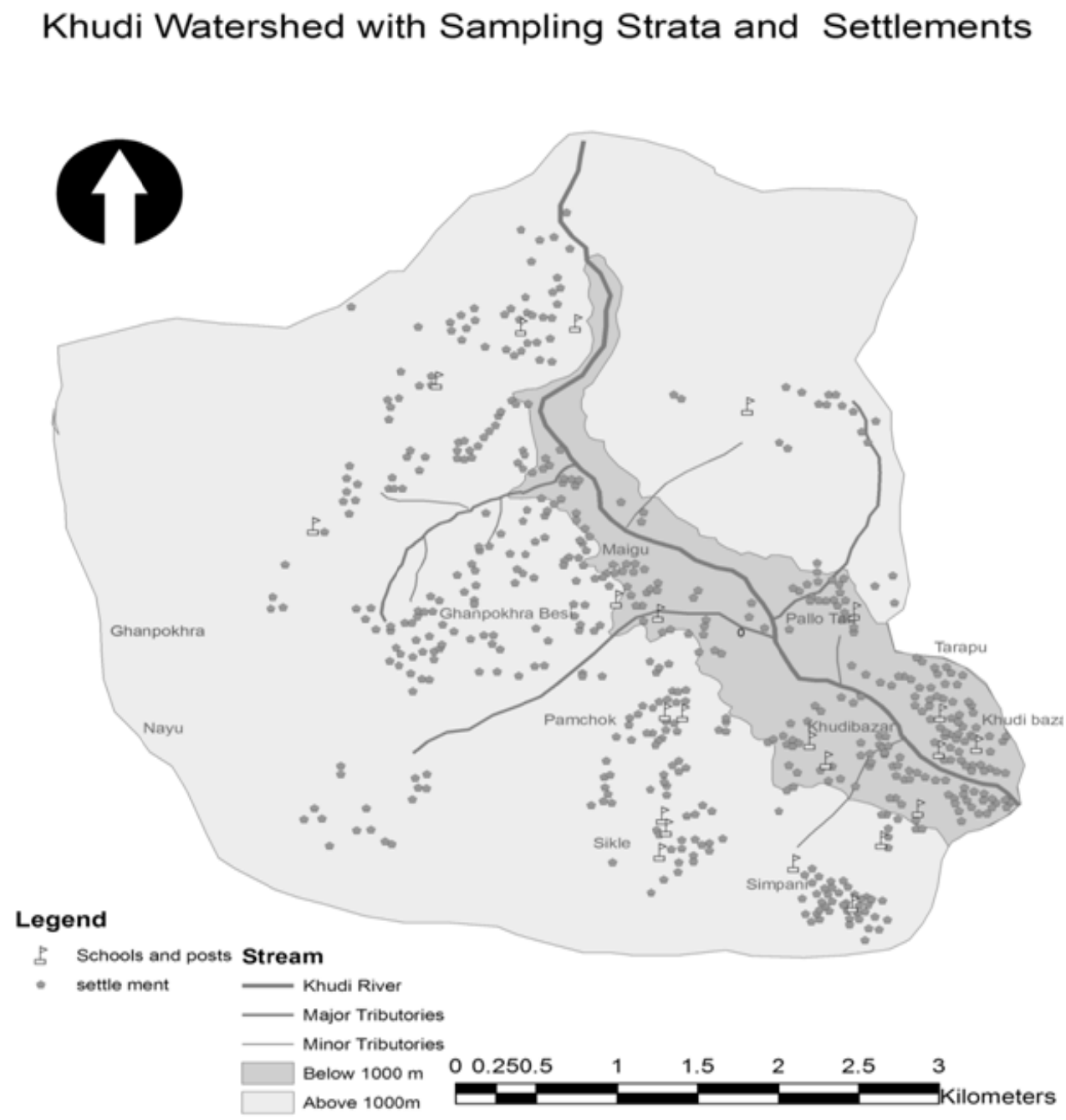


Figure 11: Khudi watershed with sampling strata and settlements.

d) Focus Group Discussion

Discussion was carried out with local stakeholders to get information about the past and present condition of climate, changes in the water resources, their economic shifting etc. People who have been residing in the study area for at least 15 years were selected for this purpose. Checklist has been prepared to include trend, impacts and mitigation measures on climate change and disasters and focus group discussion was carried among the concerned stakeholders. The major stakeholders involved in FGD includes,

1. *Ama Samuha*: Almost all the village bears *Ama Smuha* (Mothers Group), which is a community level most active organization of women from different sectors like agricultural, local business and teaching etc. These are highly interested in any project as they are involved in community adaptation, disasters preparedness and to bring the changes in community behavior.

2. Teachers: those are the well educated people who easily understand the climate change disasters issues and can disseminate the information to young students that spread to the overall community very easily.

3. Social workers/Local politicians: These are the leaders whom others listen and follow. They are the medium of change and also can influence decisions at the community.

4. Farmers: This is the dominant group in the community that is facing direct impacts in agricultural production.

5. Others: Representatives from district level government office including District Administration Office (Disaster Department), other district level offices such as Development Committee, Irrigation, Soil conservation, agriculture, and forest, Red Cross District Office, National Trust for Nature Conservation(NTNC)'s Annapurna Conservation Area Project Office (ACAP) which is working for the better environment in the study area and other local level organizations who have been involved in FGD and KII.

e) Key Informants Interview

To document the changes and vulnerability, informal interview with key informants was carried out about the climate change and agricultural change pattern, water availability, extreme climatic events etc. Perception of people about the role of climate change on following was collected: Climatic Hazards (flash floods, landslides, thunderstorms etc.), agricultural change pattern, cropping & harvesting time and duration between them, vegetation and crop shift, water source and its availability (quantity and duration). These changes were considered as indicator of community exposure to climate change and disasters.

f) Field observation

Field observation was carried out number of times. During field visit, observation was made about the disasters and vulnerability. Photographs of the area were taken to illustrate later. Important observed information was noted and noticeable changes had been marked in the maps also.

2. Secondary Data

a) Climatic data

Khudi Meteorological station's data of climatic parameters, temperature and rainfall, which are being generated from the Department of Hydrology and Meteorology(DHM) was collected as the major source of data to analyze the trend of climatic changes. Monthly maximum and minimum temperature from 1987 to 2006, monthly precipitation since 1975 to 2006's station data were collected. This gave the instrumental measurement of the changing climate change within the watershed area.

b) Socio economic and other data

Data published from CBS was used to analyze socioeconomic status of the study area. Relevant publications like books, journals, magazine, symposium, internet papers, newspaper, research publications etc were consulted and relevant data were used.

3. Ancillary

Ancillary data source including available maps on different aspects like geology, geomorphology, vegetation, drainage network; land uses etc were collected.

C. Data processing, analysis and interpretation

Data obtained through different sources were processed, analyzed and interpreted by using appropriate statistical tools, tables, graphs, charts and pictorial devices. All the statistical data were entered and analyzed using ***spreadsheets.*** Maps have been prepared using concerned computer software.

RESULTS AND DISCUSSION

A. Personal, Family and Ethnic Information

Out of 90 household surveyed in the study area in two ecological zones above 1000 m, upper belt and below 1000 m lower belt, most of the respondents were elder people. The ethnic diversity is high with about 67% of *Bahun* and *Chhetri* in lower belt and 47% in Upper belt. *Gurung (52%)* are more in upper belt and few *Magars* household along a few households of *Dalits* were surveyed in the area. Figure 12 indicates the ethnic composition of the area.

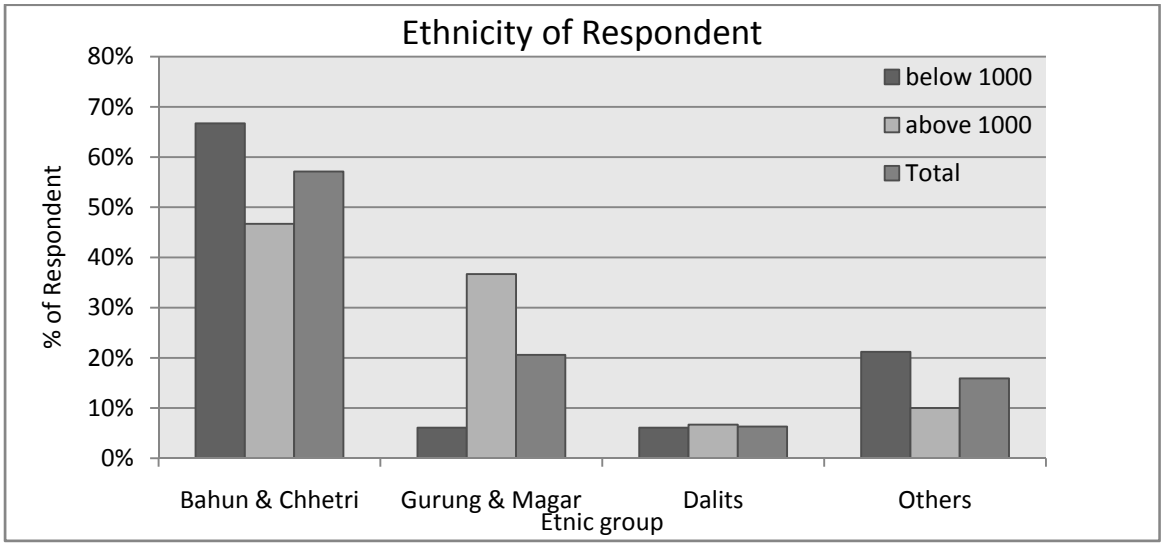


Figure 12: Ethnic composition of the study area.

The average family size of the area is found to be 4.73 numbers in lower belt and only 4 in upper belt with average of 4.38 which ranges from minimum of 2 to maximum of 12 family members per household. The average family size of study area (4.38 persons per hh) is below the national average of 5.45 (CBS, 2001).The male respondents are in majority with nearly 85% followed by only 15% of the female respondent. As research was focused on finding the people's perception on climate change based on their experience, interviewers were mainly conducted with elder persons of the community. The literacy rate (5 years and above) is high (about 93%) but majority are only literate

farmers, followed by teachers who used to stay in village and have acquired proficiency, bachelor and masters degree too. Figure 13 show detail on education level at that area.

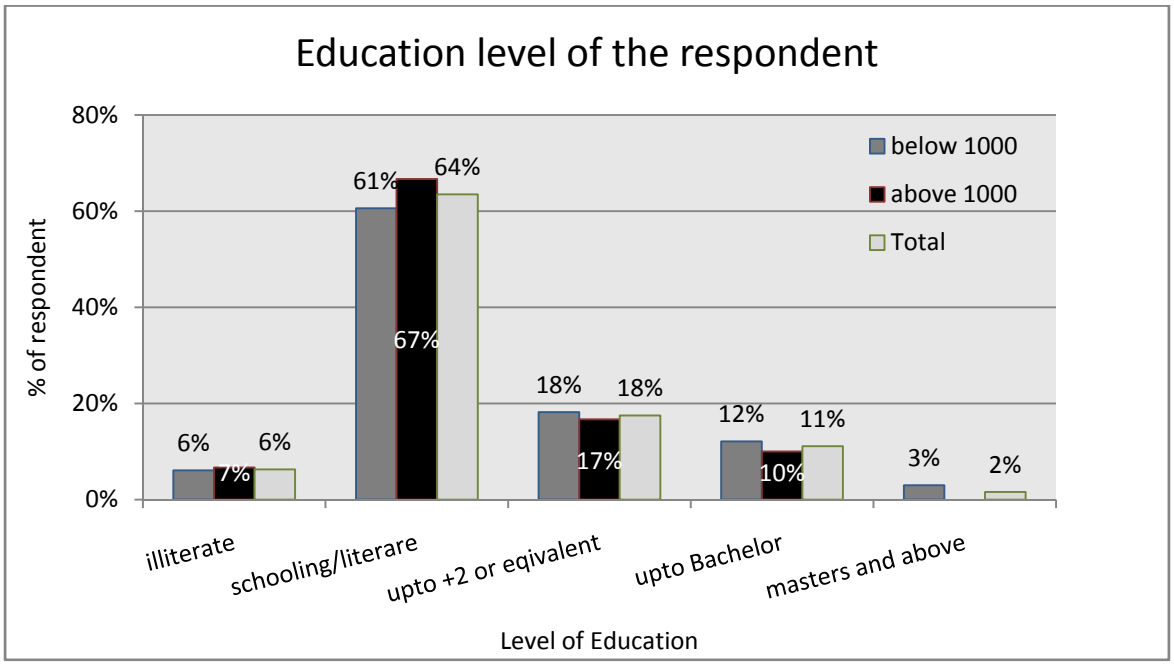


Figure 13: Education level of the respondents.

B. Socio-economic Context

It's a diverse society with *Bahun/Chhetri, Gurungs* and *Magars* along with small cluster of *Dalits (Mijar,Kami and Damai)*. Socially the study community is upper caste dominant, with people involved in job, service and agricultural activities. Most *Gurung /Magars* are *Lahure* (Foreign Army). Almost all family relies upon farming practices and dependent upon agricultural products solely or partially. The land is used as irrigated *khet*, rain fed *khet*, *Bari*, barren land and forest. Table 1 shows the distribution of household by size of landholding.

Table 1: Average landholding capacity of community.

Landholding *(in ropani)*	Percent of households
Almost Landless (< 1)	7.95
Marginal (1-4)	14.29
Small (5-10)	39.7
Medium (11-20)	25.4
Large (> 20)	12.7

Approximately 8% families are almost landless with landholding size less than 1 *ropani*. They have to depend on either others land or other sector such as in shops/business for basic needs, 14.25% families fall in marginal farmer group with landholding between 1-4 *ropanis*, about 40% are small farmers, 25% are medium farmers with land between 11 to 20 *ropanis*. Only 12% families have more than 20 *ropanis* of land for agricultural practice. On average, each household has 2.89 *ropani* of permanently irrigated *khet*, in lower belt its 4 *ro/hh* while in upper belt only 1.91*ro/hh*, and own rain fed irrigated *khet* is 4.97 *ropani/hhs* in average, upper belt 5.67 *ro/hh* and lower 4.17 *ro/hh*. Upper belt people have more barren land than people at lower belt (Table 2).

Table 2: Average size of landholding (in ropani).

Eco zone		Own permanently irrigated *khet*	Own rain fed irrigated *khet*	Own cultivated *bari*	Own barren land	Own forest
above 1000	Mean	1.91	5.67	1.73	2.21	0.82
	Minimum	0.00	0.00	0.00	0.00	0.00
	Maximum	11.00	20.00	5.00	30.00	16.00
	Std. Deviation	3.32	5.96	1.53	5.91	2.95
below 1000	Mean	4.00	4.17	1.97	0.76	0.97
	Minimum	0.00	0.00	0.00	0.00	0.00
	Maximum	25.00	30.00	10.00	10.00	6.00
	Std. Deviation	5.57	6.40	2.03	2.03	1.94
Total	Mean	2.89	4.97	1.84	1.53	.89
	Minimum	0	0	0	0	0
	Maximum	25	30	10	30	16
	Std. Deviation	4.60	6.17	1.77	4.55	2.51

Although agriculture is the main occupation, most of the family (67%) said that the food produced is not sufficient to feed them throughout the year. The annual yield of the area is about 3 *muri/ropani* of paddy, 1.45 *muri/ropani* of maize and 2 *muri/ropani* of millet *(*Table 3). Many of the houses depend upon the exported food to fulfill their needs.

Table 3: Productivity of the Major Crops in the Area.

	Paddy			Maize			Millet			Potato		
	Cultivated land (Ropani)	Production(Muri)	Yield (Muri/Ropani)	Cultivated land (Ropani)	Production (Muri)	Yield (Muri/Ropani)	Cultivated land (Ropani)	Production(Muri)	Yield (Muri/Ropani)	Cultivated land (Ropani)	Production(Muri)	Yield (Muri/Ropani)
below 1000	8.42	23.55	2.80	6.79	9.55	1.41	1.27	2.70	2.13	0.48	0.97	2.00
above 1000	8.76	23.52	2.68	6.76	10.34	1.53	0.66	1.03	1.56	0.28	0.59	2.07
Total	8.58	23.53	2.74	6.77	9.92	1.47	0.98	1.92	1.96	0.39	0.79	2.02

Income and Expenditure

The major sources of family income are agriculture, job/service, business, pension and remittance. Although agriculture does not give direct income, it's major factor to balance household budget. Other than agriculture, in the lower ecological belt major income sources are job and services and tourism business while in upper belt it is remittance. It indicates that there are job opportunities along with growing urbanization in lower Khudi while in upper mountain belt its remittance from the youth working outside the country, that support their livelihood. They are spending maximum amount of the money in education followed by agriculture and other sectors.

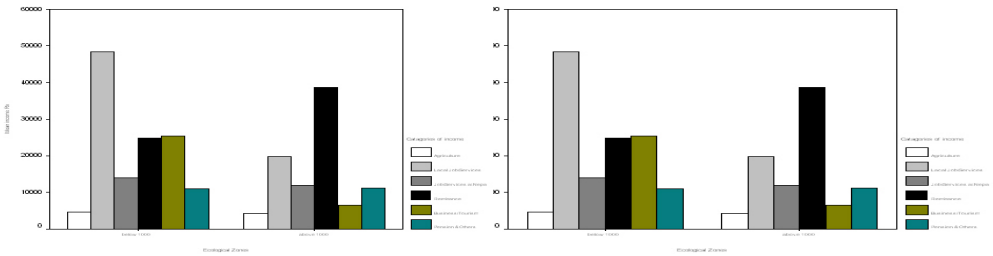


Figure 14: Sectored Income and Expenditure of households in the area.

C. Climatic Analysis

1. Temperature

The monthly temperature analysis shows that maximum temperature reaches its peak value in June while it's December when lowest minimum temperature was recorded. The highest and lowest value of the mean temperature reaches in July and January respectively.

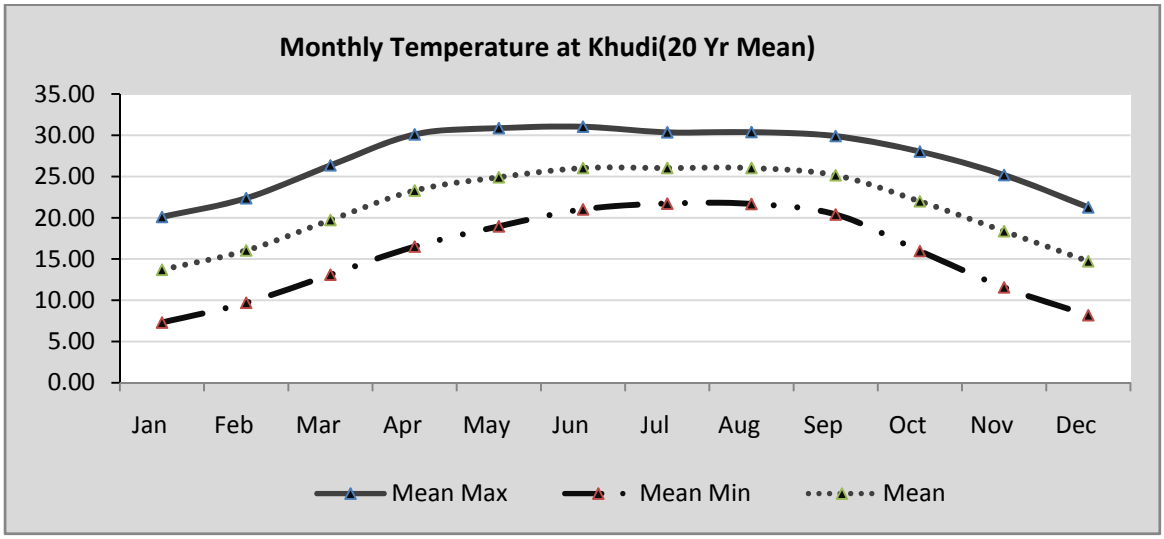
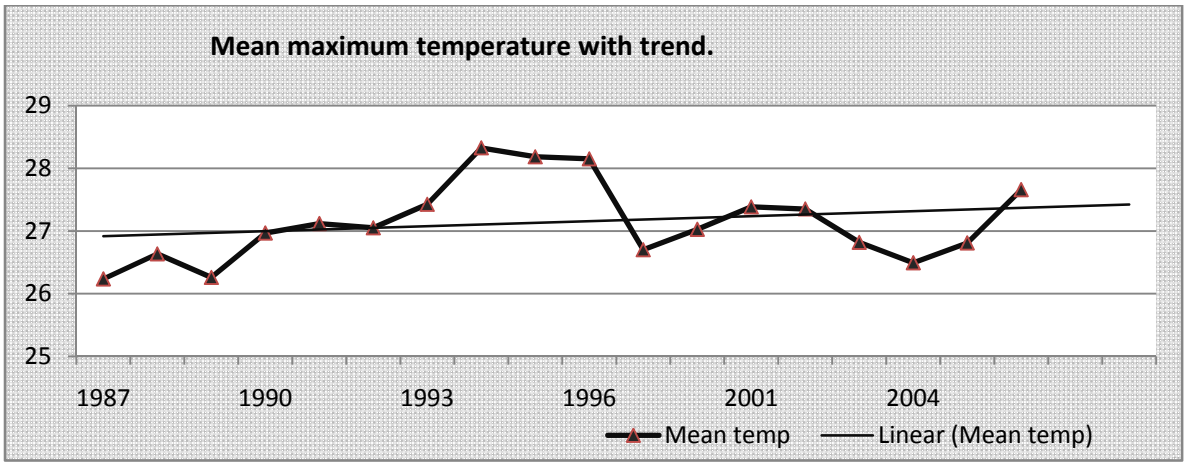
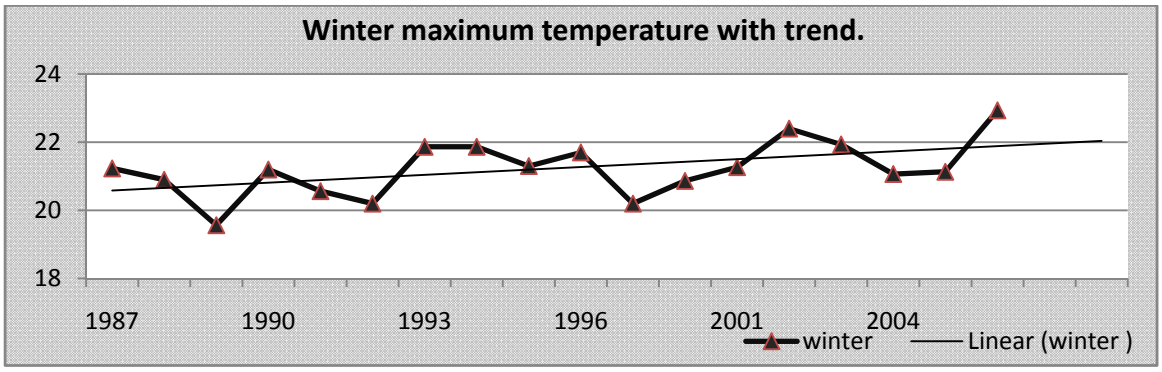
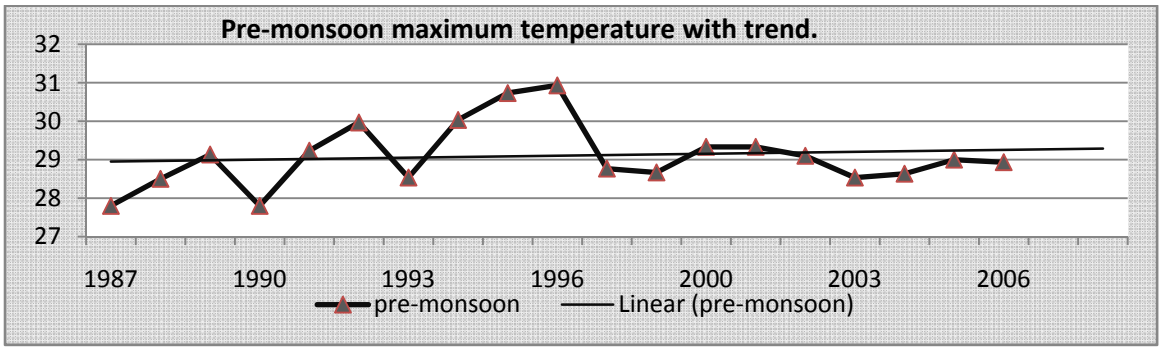


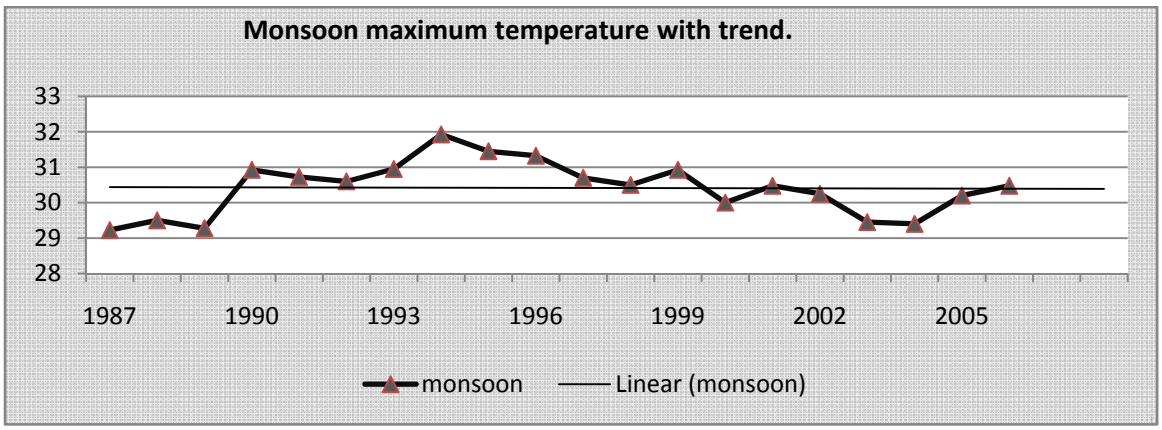
Figure 15: Mean monthly Temperature.

The recent IPCC Fourth assessment Report (2007) states that global warming is unequivocal and the linear warming trend over the last 50 years is 0.13°C per decade. Warming is also being observed in Nepal. Based on the records from 1979, the mean Nepal temperature is increasing at 0.41°C per decade (Baidhya, 2008). The Khudi station data shows that both maximum and minimum temperatures are increasing sharply, with maximum temperature increase of 0.23°C per decade and mean temp increase of 0.18°C per decade.


Mean maximum temperature with trend.
29
28
27
26
25
1987
1990
1993
1996
2001
2004
Mean temp
Linear (Mean temp)


Winter maximum temperature with trend.
24
22
20
18
1987
1990
1993
1996
2001
2004
winter
Linear (winter)


Pre-monsoon maximum temperature with trend.
32
31
30
29
28
27
1987
1990
1993
1996
2000
2003
2006
pre-monsoon
Linear (pre-monsoon)


Monsoon maximum temperature with trend.
33
32
31
30
29
28
1987
1990
1993
1996
1999
2002
2005
monsoon
Linear (monsoon)

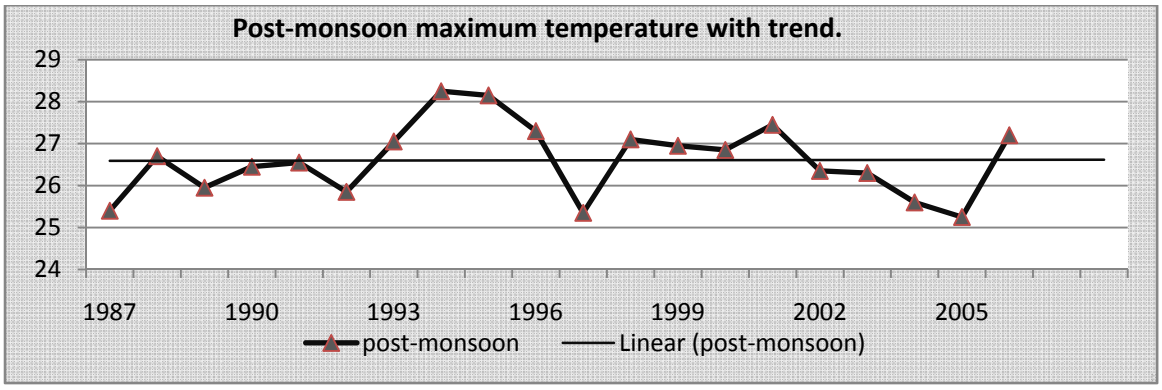
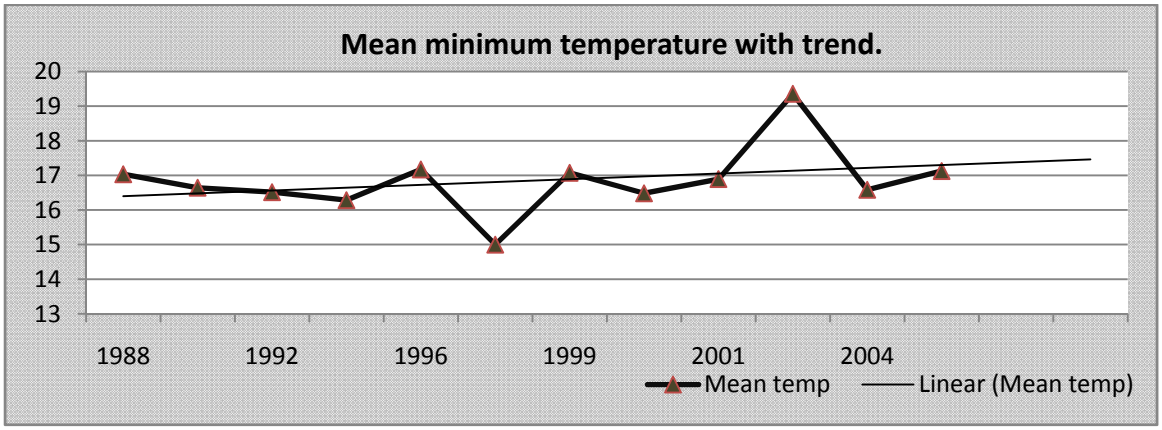
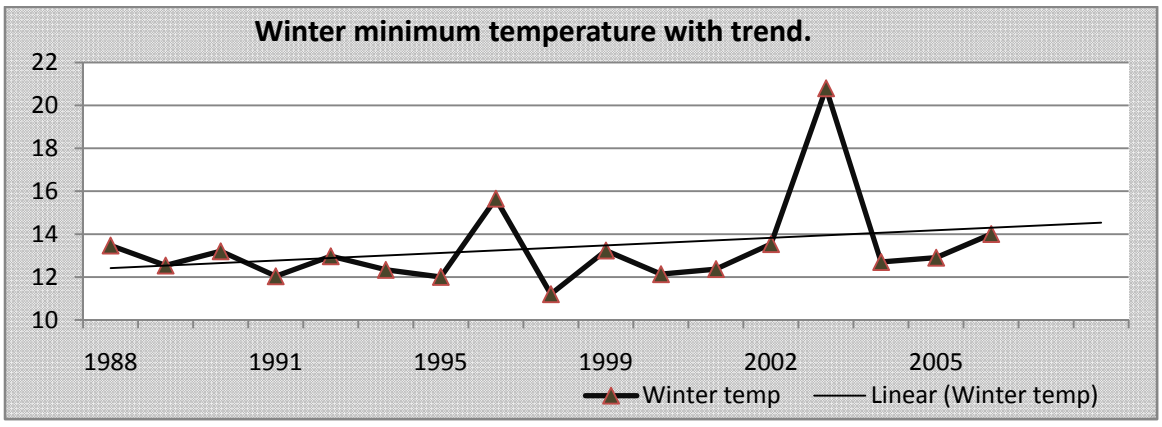
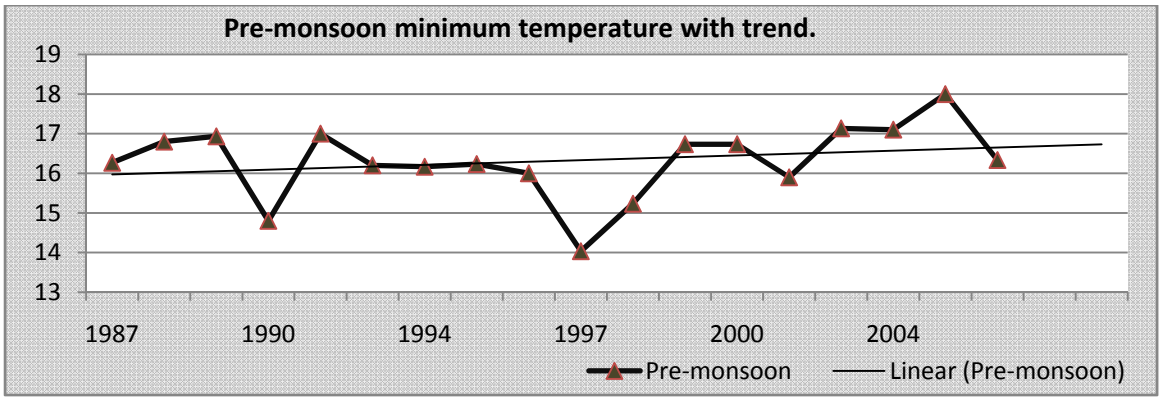


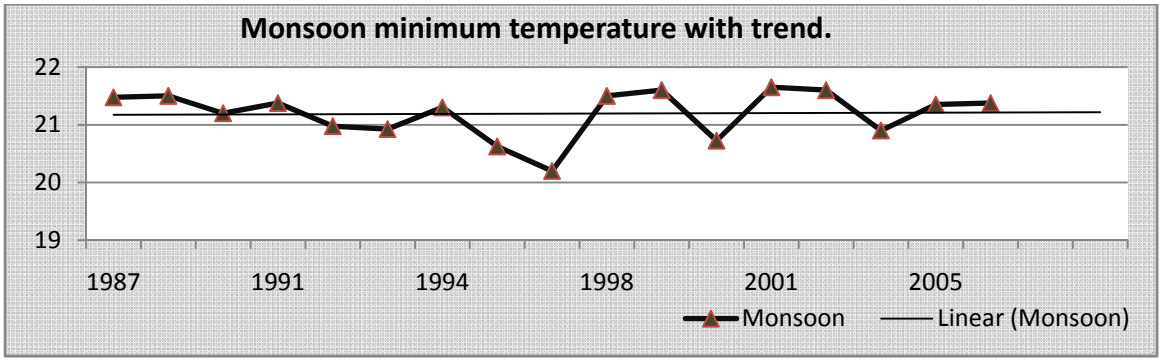
Figure 16: Maximum Temperature trend. (Mean, Winter, Pre-monsoon, Monsoon, Post-monsoon).

Trend in Maximum Temperature(Deg C/Year)*					
Khudi Station	Annual	Winter	Pre-Monsoon	Monsoon	Post -Monsoon
	0.026	0.076	0.016	0.00	0.001









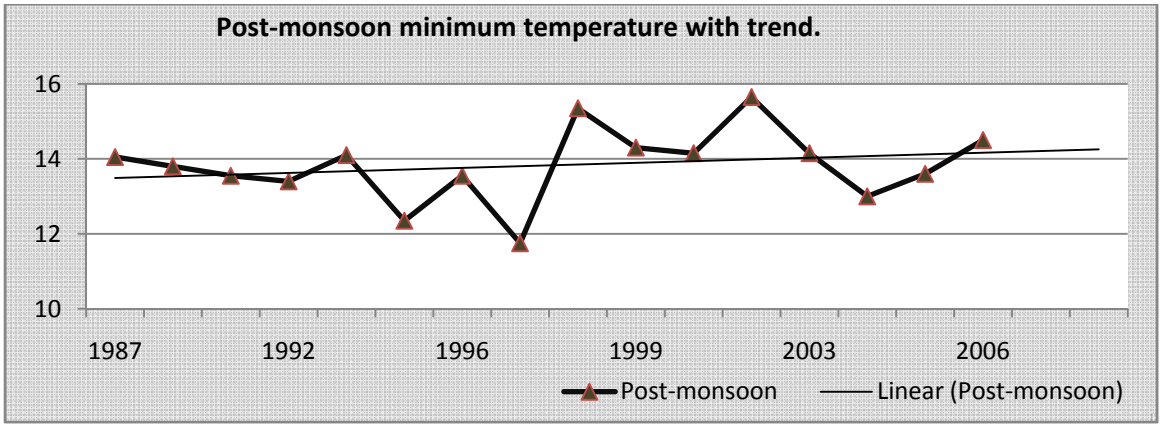
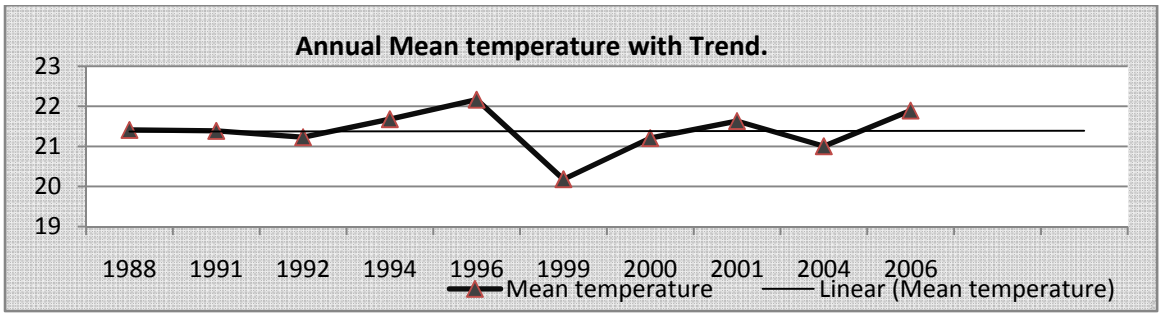
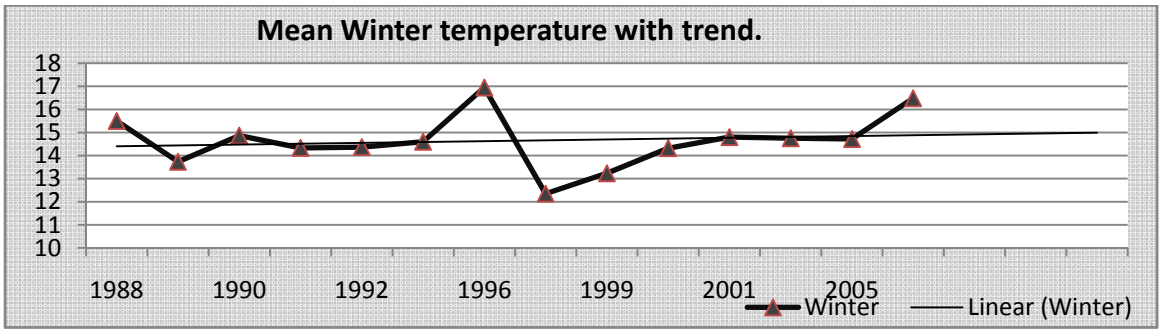
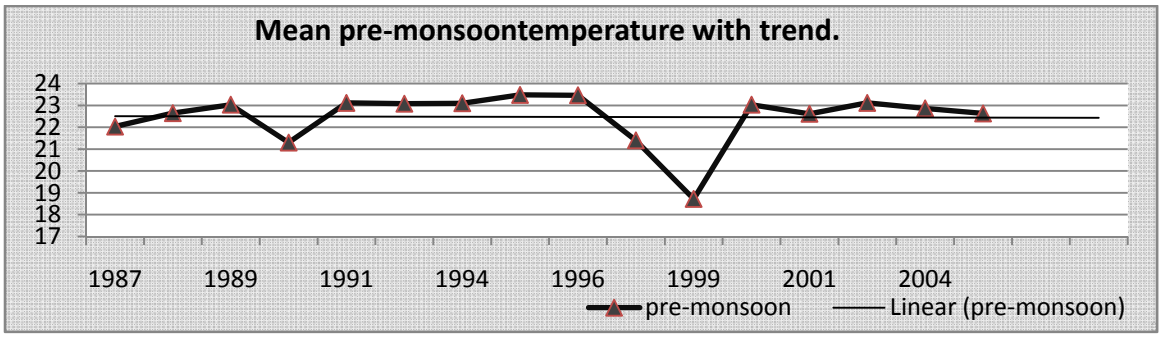


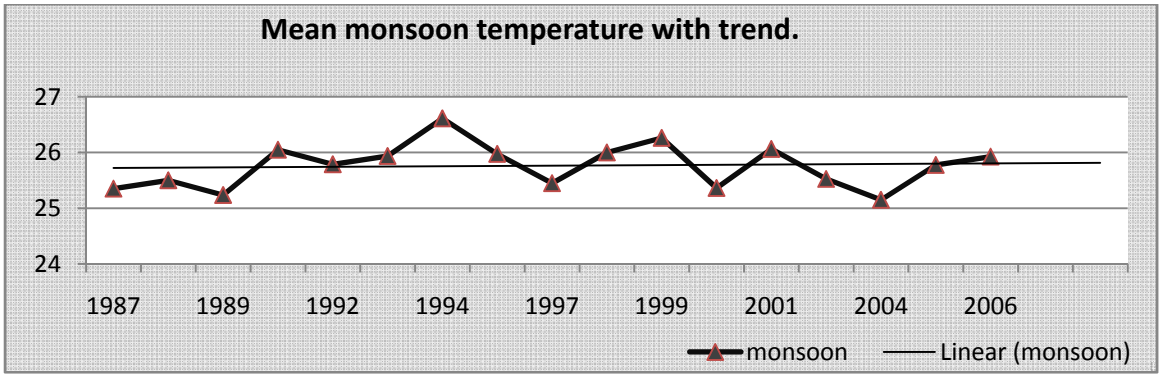
Figure 17: Minimum Temperature trend. (Mean, Winter, Pre-monsoon, Monsoon, Post-monsoon).

Trend in Minimum Temperature(Deg C/Year)*					
Khudi Station	Annual	Winter	Pre-Monsoon	Monsoon	Post -Monsoon
	0.081	0.117	0.039	0.002	0.044


Annual Mean temperature with Trend.
23
22
21
20
19
1988
1991
1992
1994
1996
1999
2000
2001
2004
2006
Mean temperature
Linear (Mean temperature)


Mean Winter temperature with trend.
18
17
16
15
14
13
12
11
10
1988
1990
1992
1996
1999
2001
2005
Winter
Linear (Winter)


Mean pre-monsoontemperature with trend.
24
23
22
21
20
19
18
17
1987
1989
1991
1994
1996
1999
2001
2004
pre-monsoon
Linear (pre-monsoon)


Mean monsoon temperature with trend.
27
26
25
24
1987
1989
1992
1994
1997
1999
2001
2004
2006
monsoon
Linear (monsoon)

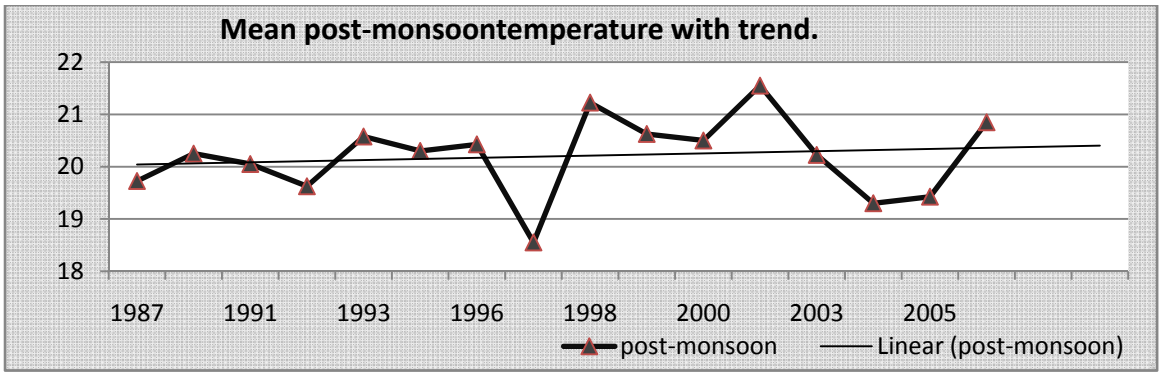


Figure 18: Mean Temperature trend. (Mean, Winter, Pre-monsoon, Monsoon, Post-monsoon).

Trend in Mean Temperature(Deg C/Year)*					
Khudi Station	Annual	Winter	Pre-Monsoon	Monsoon	Post -Monsoon
	0.001	0.037	-0.004	0.005	0.021

**Trend was calculated only for the months/years whose complete data were available.*

The 25 years temperature analysis shows that temperature in the area is in increasing trend. The average maximum temperature was increasing at 0.26°C/decade and minimum temperature increase was 0.81°C/decade, which is greater than national average increase of 0.4°C/decade. Winter temperature increase is alarming, the maximum temperature increases at 0.76°C/decade and minimum temperature increases at rate of 1.17°C/decade which indicates that the western mountain hill of Nepal is warming rapidly. The snow cover area of upper Khudi is decreasing each year, as winter temperature is increasing more, it's sure to increase the rate of melting in coming years. Pre-monsoon maximum temperature increases 0.16°C/decade and minimum temperature increase at rate 0.39°C/decade which hover around national average. Surprisingly the maximum monsoon temperature shows constant trend while that of minimum temperature shows very slow increase (0.02°C/decade). The post monsoon minimum temperature is also increasing significantly (0.44°C/decade) but that of maximum temperature is increasing very slowly (0.01°C/decade). Alarming increase in both maximum and minimum temperature both in average and season, especially in winter has great influence on the community's livelihood as it hampers cropping pattern and yield, water availability in the driest pre-monsoon months, chances of spread of diseases etc.

2. Precipitation (Rainfall)

The mean 30 years (since 1975) annual rainfall of the Khudi Watershed as measured at Khudi meteorological station is 3345.93 mm.

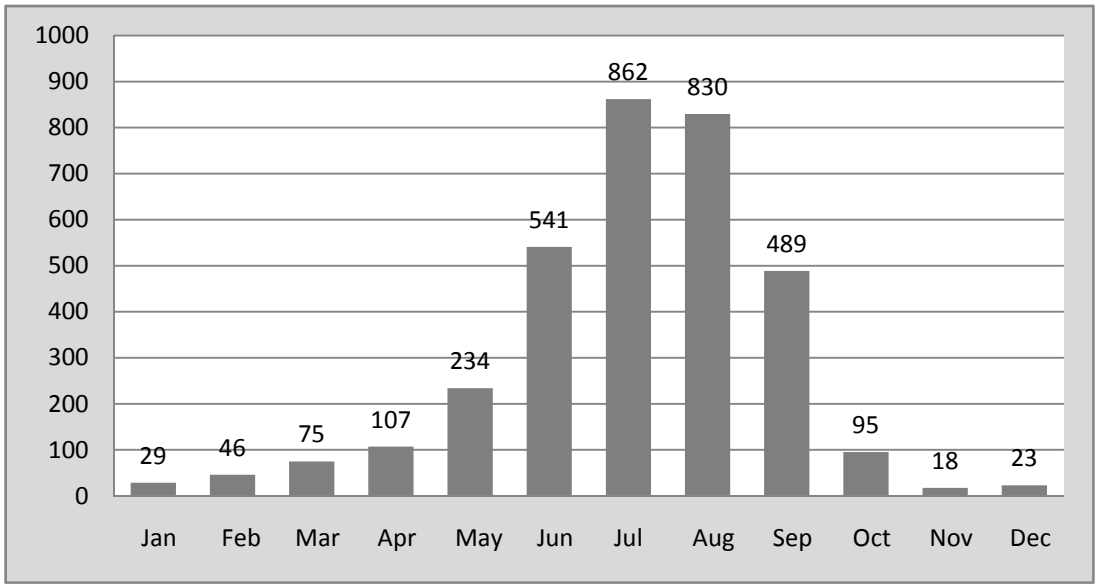


Figure 19: Monthly mean rainfall at Khudi Station.

The 30 years average monthly rainfall shows that November is the driest month with only 18mm of average rainfall while July is the wettest month with 860 mm of average rainfall. The four months of monsoon season from June to September contribute about 81% of the annual total rainfall. These four months are highly sensitive to the weather related disasters. Pre-monsoon (March-May) season accounts for 13% of the annual total rainfall. Winter (December-February) is the driest season followed by post-monsoon (October-November) season both contributing about 3% of the total annual rainfall (Figure 18).

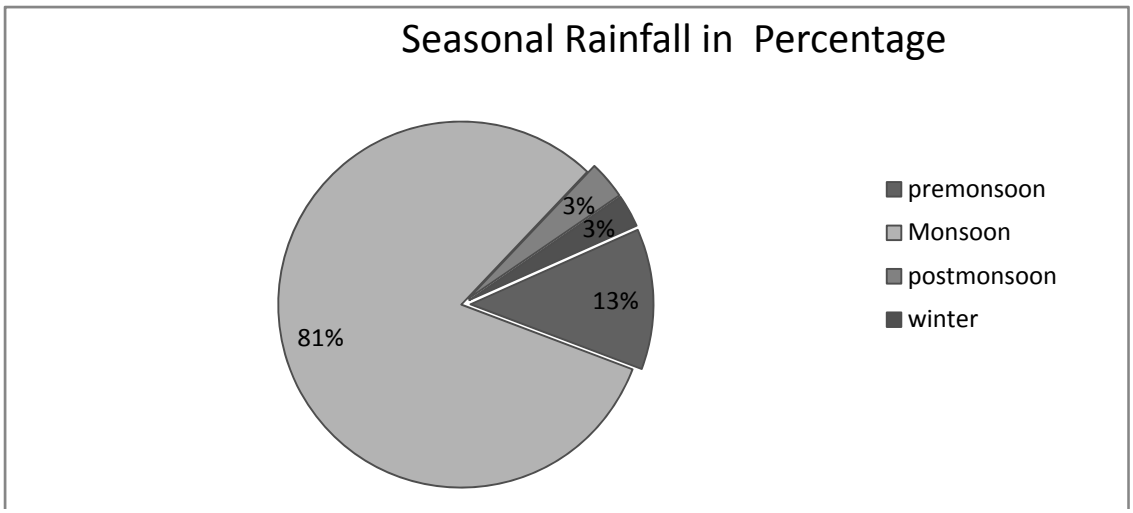


Figure 20: Seasonal Rainfall Contribution in %.

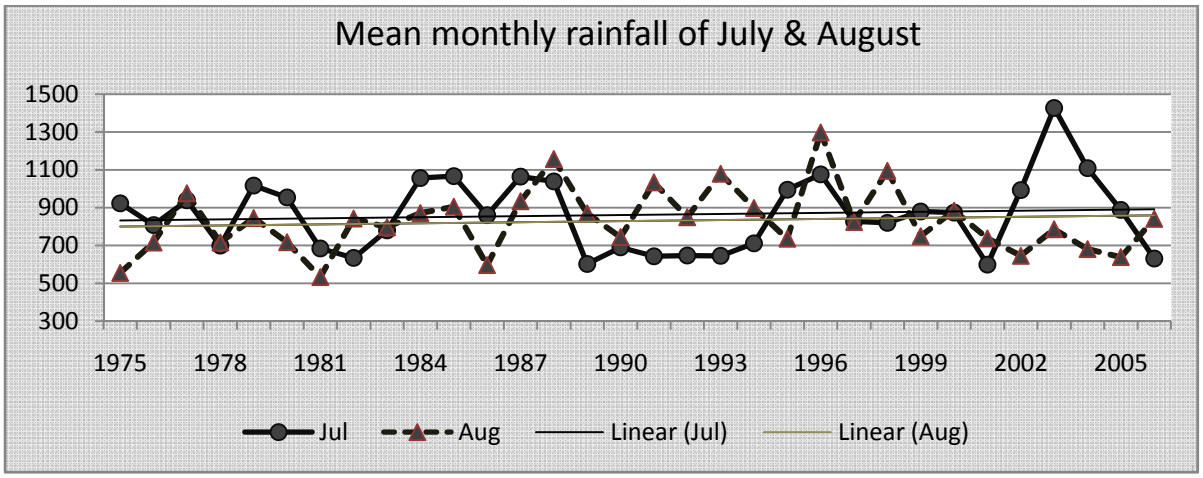


Figure 21: Mean monthly rainfall of two wettest months with trend.

Monthly rainfall for the two wettest months shows slight increase in rainfall (1.89 mm/yr in august and 1.91 mm/yr in July), in the period of 1975 to 2006 (Figure 19) but number of dry months are increasing and the rainfall in driest months in decreasing order supporting the fact of decrease total rainfall. November, December and January are the three driest months in which two of them, November and December shows decreasing trend of rainfall by 0.582 mm/yr in November and 0.096 mm/yr in November but in January it is slightly increasing with 0.0822 mm/yr (Figure 20).

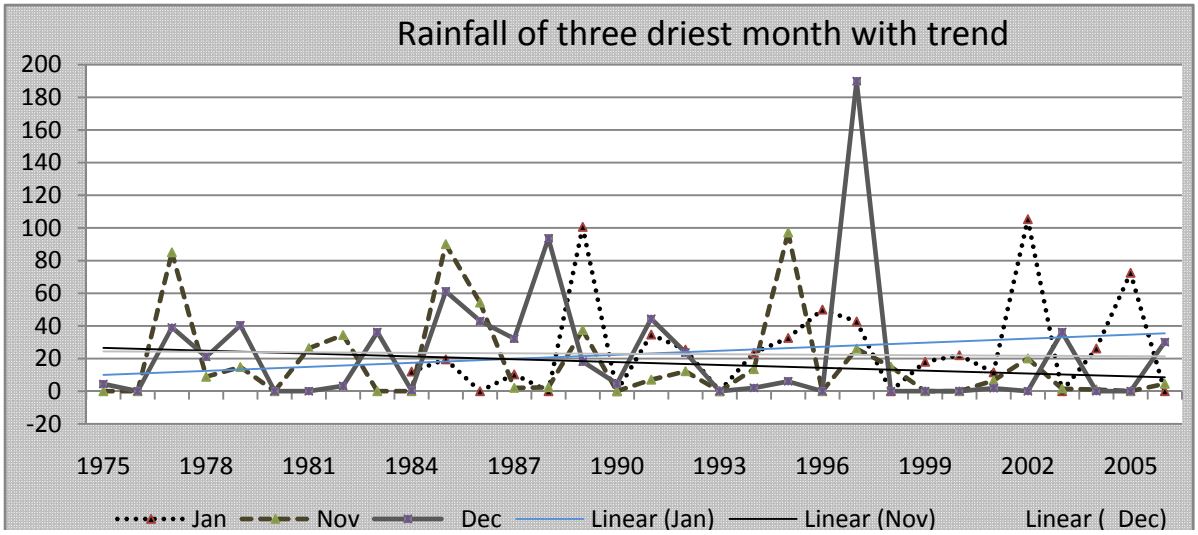


Figure 22: Mean monthly rainfall of three driest months.

The high fluctuation on the rainfall indicates the increasing uncertainty in the dry season rainfall in study area. It has great influence on agricultural practice and total production yield.

Seasonal rainfall analysis indicates increasing trend in pre-monsoon and monsoon rainfall but decreasing rainfall in winter and post-monsoon. Pre-monsoon and monsoonal heavy rainfall makes the area more prone to water related disasters. Seasonal rainfall trend analysis indicates uncertainty of the rainfall.

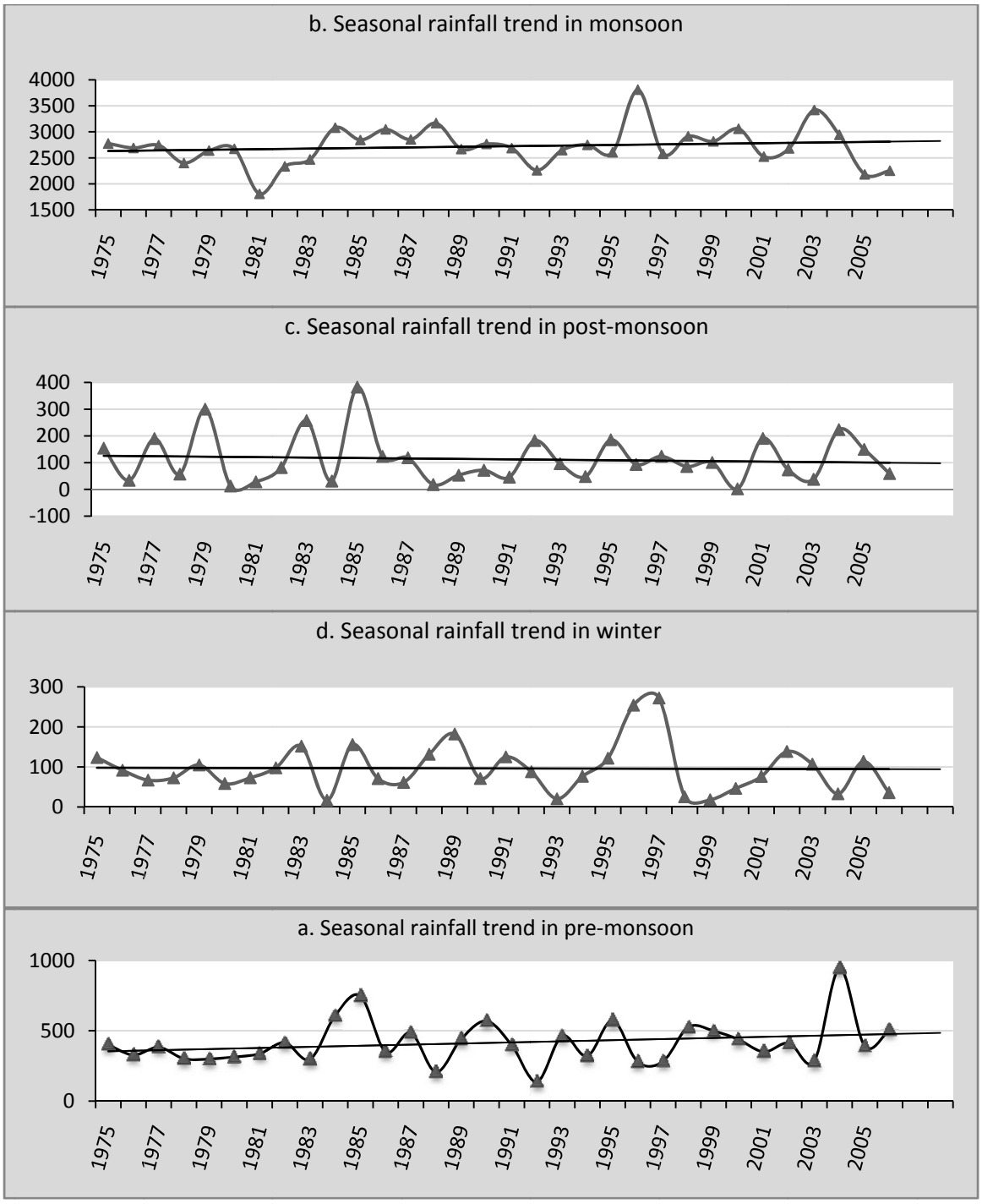


Figure 23: Seasonal Rainfall trend a. pre-monsoon, b. monsoon, c.post-monsoon & d. winter.

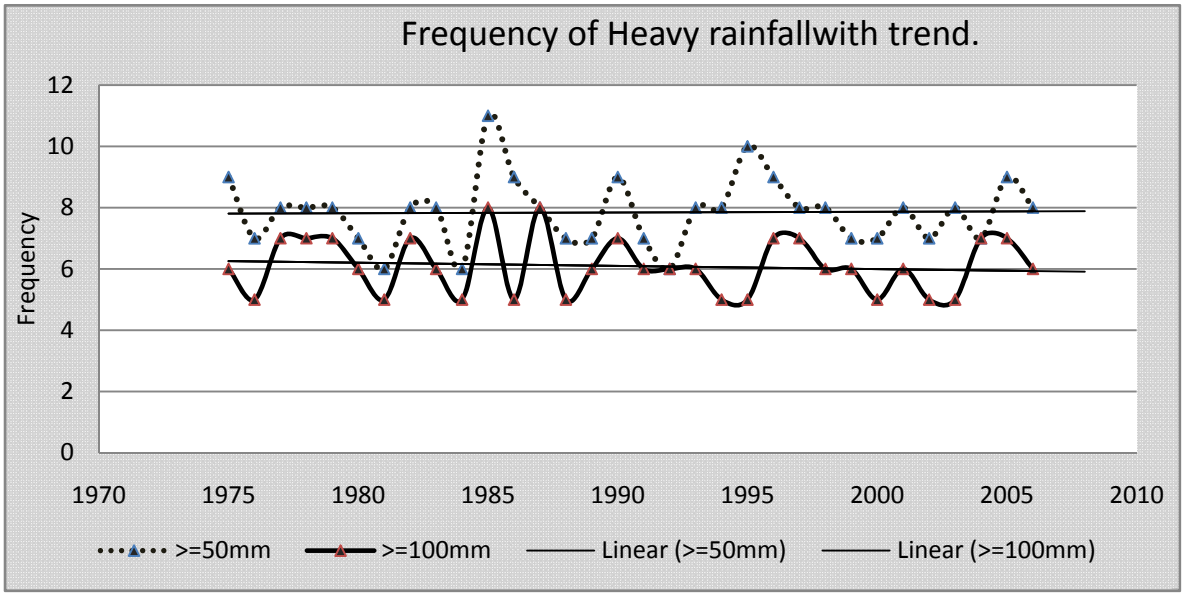


Figure 24: Frequency of occurrence of heavy rainfall with trend.

In the mountainous region usually the heavy rainfall is responsible for weather related disaster such as floods, landslides and erosion. So it is important to understand the trend of heavy rainfall in the area. Heavy rainfall analysis shows that it is in increasing trend for >=50mm and constant for >=100mm rainfall within 24 hrs.

The annual mean rainfall analysis shows high fluctuation in yearly rainfall but five year moving mean indicates the gradual increase in average rainfall from 1975 to 1985 (3199.94 to 3621.92 mm) then it shows decreasing trend for next 5 years then again it increases with 3644.26 mm in 1996. But in recent decade it's in decreasing trend with 3098.728 mm in 2006. The linear trend line (Figure 23) showed the decrease in the rainfall in recent years but average rainfall in recent years is fluctuating which explains the uncertain pattern of rainfall.

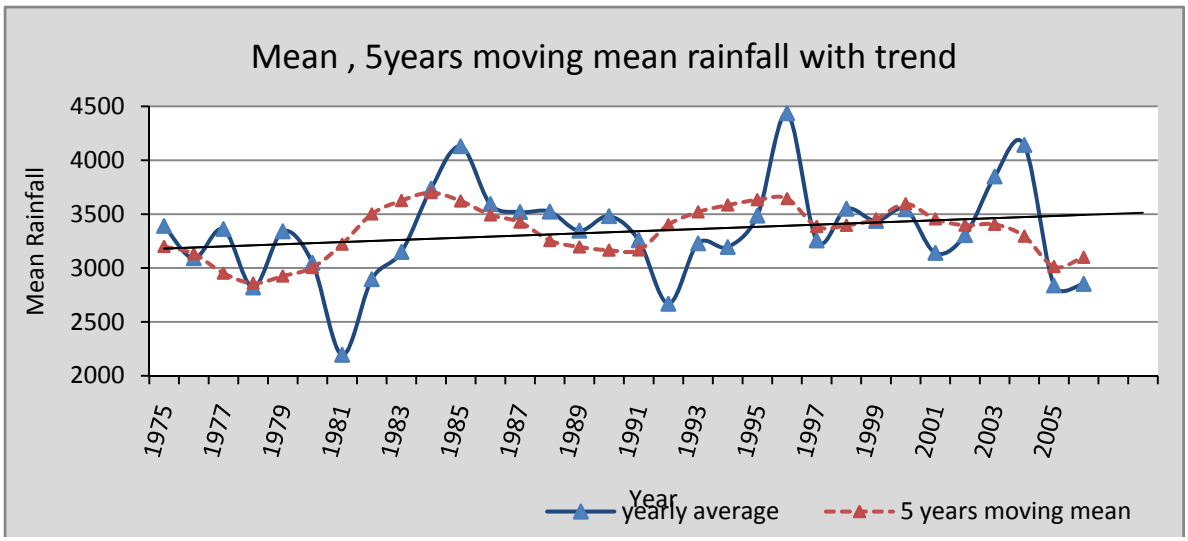


Figure 25: Annual mean and % years moving mean rainfall with trend.

D. People's Perception

1. Temperature, Precipitation, Cloudy days, Frost fall, Hailstorm and snowfall pattern

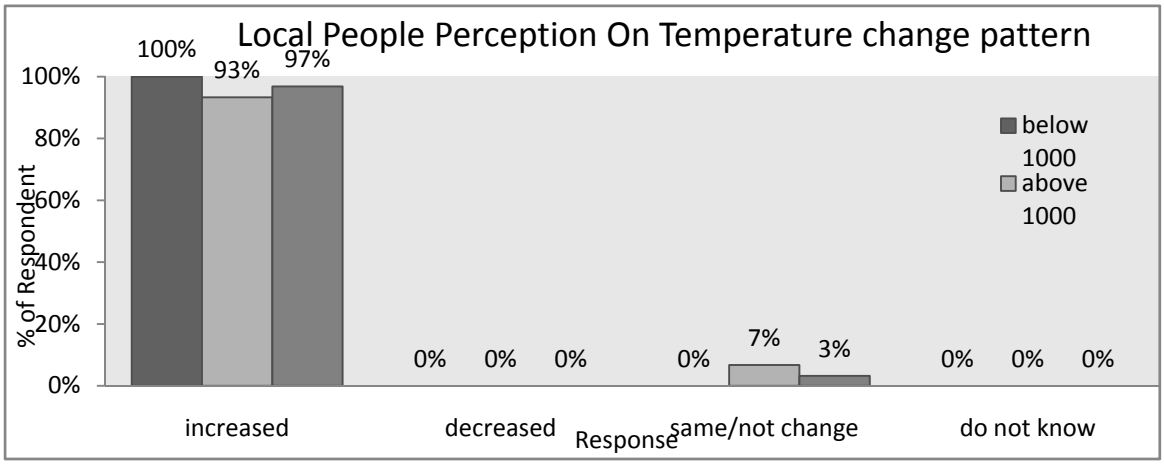


Figure 26: People's perception on temperature change.

Almost all the local residents, especially elder people think that temperature is increasing in recent decades. All respondent living in the zone below 1000 m felt that temperature has been increased while 97% respondent of above 1000 m accept the same but 3% said it has not changed (Figure 24). When respondents were asked about the change pattern of the precipitation in their region, 73% of upper zone and 55% of lower zone residents said that it is in decreasing trend these days. Those respondents who are directly related with agricultural practice have noticed rainfall change pattern more in depth and said it is decreasing (Figure 25). More than 75% of the respondent felt that snowfall in the upper part of the watershed is decreasing while few respondents said it's also increasing (Figure 26). This type of perception may be due to their short and long term experience in the snowfall pattern because there is very rare snowfall event in their area and they have to see it in upper belt.

Case Study -1

Devendra Kumar Jha, 45, Siraha - a subtropical climate born person is serving in Khudi as high school science teacher from last 25 years. As science teacher he is very concern about climate change and disasters issues. He had seen surrounding mountains covered with snow for more than 3 months. But now it's different the snow fall only in the peaks and remains only for few weeks. He in his initial days felt very difficult to cope with cold climate of the area. But case is different now, days are hotter. He said in the past winters were very cold but now it's not so.

He feels the changes as

- Summer days are more hotter than previous years,
- Winter are less cold and frosty
- Rainfall is unusual and less in winter with shifted time.

He thinks these changes impacts as

- Increase mosquitoes which is carrier of different diseases
- Crop cultivation timing has been changed and it gives less production hampering local farmers
- Rate of heavy rainfall is increasing and flood in Khudi is more frequent and increased too.

He gives some solutions as

- Climate change is not in our control- best solution is to cope with it.
- We can increase plantation,
- Use mitigation techniques to minimize flood and landslides impacts

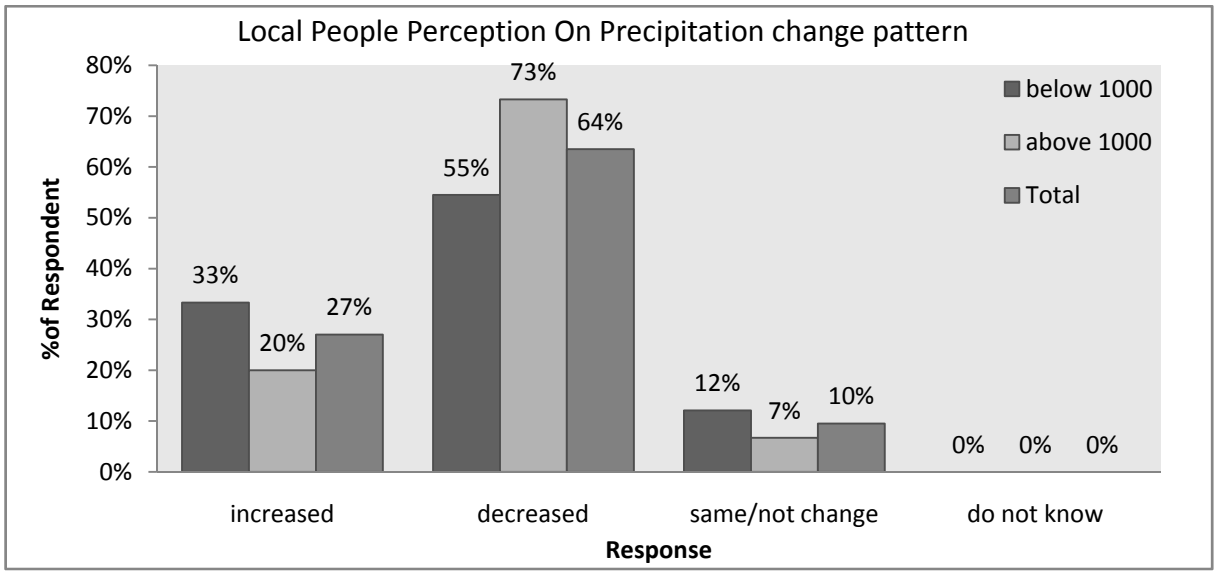


Figure 27: People's perception on Precipitation change pattern.

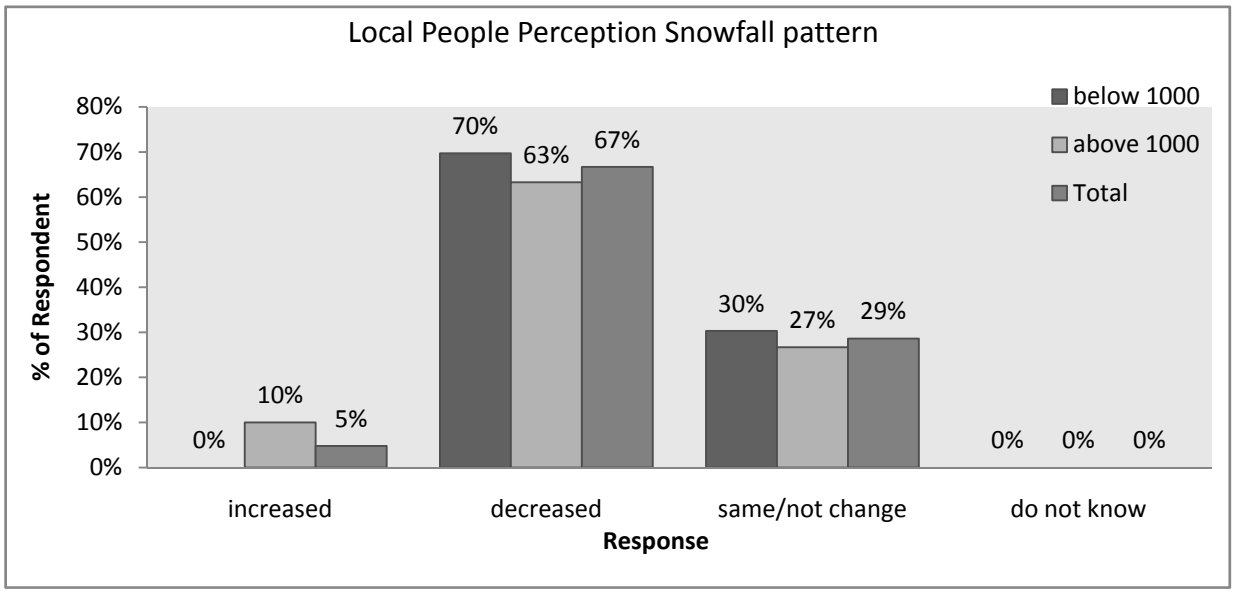


Figure 28: People's perception on snowfall pattern.

Similarly the number of respondents who felt increased number of cloudy days is 21% while that of decrease is 16% and not changed is 64%. In case of frost raining pattern, 48% of the total respondent felt the change, above 47% of the respondent in upper zone said that they felt decreased frost raining days while only 18% in lower zone felt same (Figure 27).

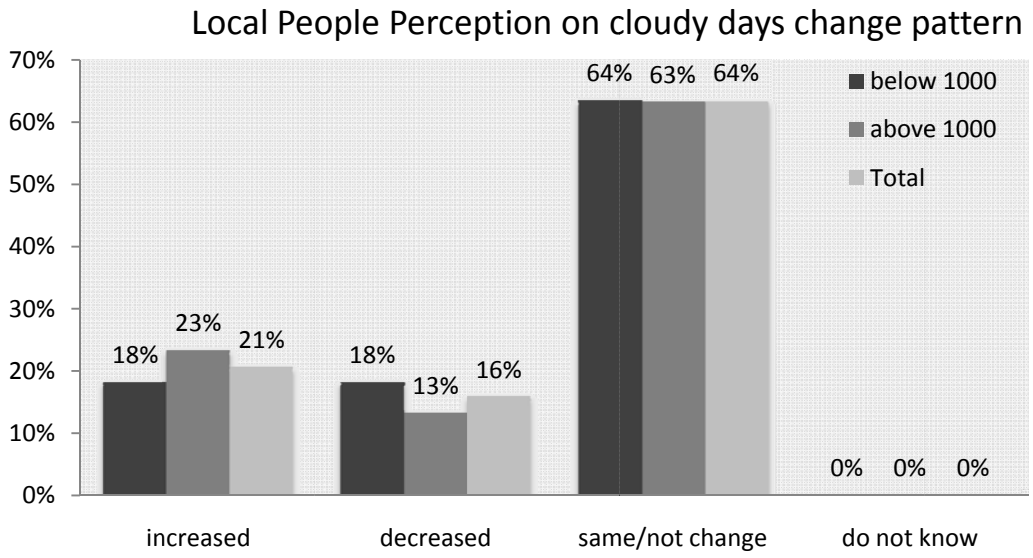


Figure 29: People's perception on Cloudy days.

Because frost raining days are more common in upper belt, the perception supports the change in upper belt climatic variables (Figure 30).

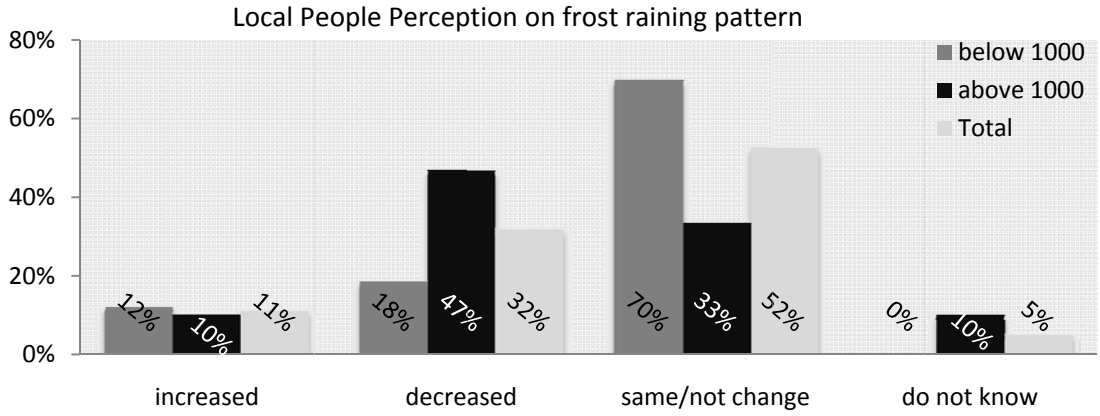


Figure 30: People's perception on Frost raining pattern.

When people were asked about their experience on hailstorm and lighting pattern, about 52% respondent said they do not have experience of any change in the hailstorm while more than 70% said frequency of occurrence of lightening is increasing (Figure 29). Although it can't be concluded that climate change is inducing more lightening, it's increasing in the area, causing huge loss of life and properties each year. Change in hailstorm pattern indicates changing climatic trend.

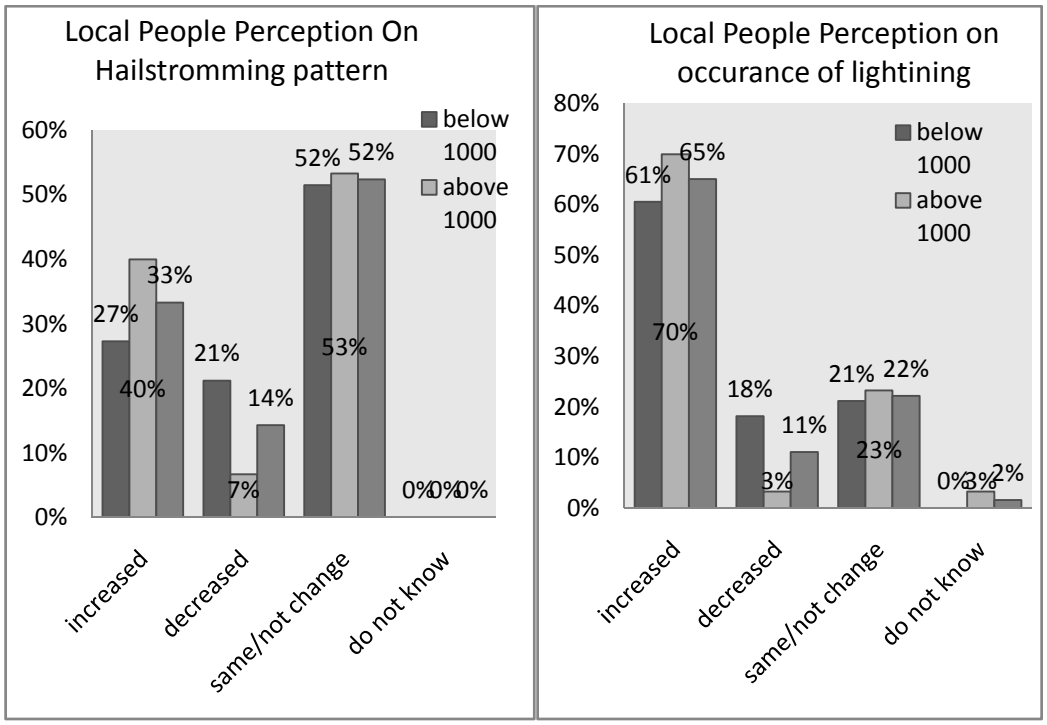


Figure 31: People's perception on Hailstorm pattern and frequency of occurrence of lighting.

2. Perception on changing climatic season

a) Summer and winter day's temperature change

58% of the respondent in upper zone felt winter are less cold and frosty while 33% in lower zone felt the same (Figure 30). 93% of total respondents felt that the days are becoming hotter supporting their perception on increasing temperature in the area in recent decade. Similarly 53% of upper zone respondent felt less cold winter days and 73% felt extreme hot summer days in the region. In case of lower zone, 94% respondent felt extreme hot summer days but only 21% said they have felt less cold winter days. These figures show the significant differences in experiencing the changing climate. According to the elder people, especially from FGD, winters are less chilly, winter rainfall has been decreasing and summer days are hotter in recent decades.

These figures also indicate significant change in the local climatic conditions particularly with respect to temperature, precipitation and experiences in summer and winter day's temperature. The local people say that the region is not only getting warmer but also

affecting their livelihood. The Khudi watershed, lying in the hilly region has temperate climate, altitude varying from 850 m at Khudibazar to above 2000 m in Ghanpokhara.

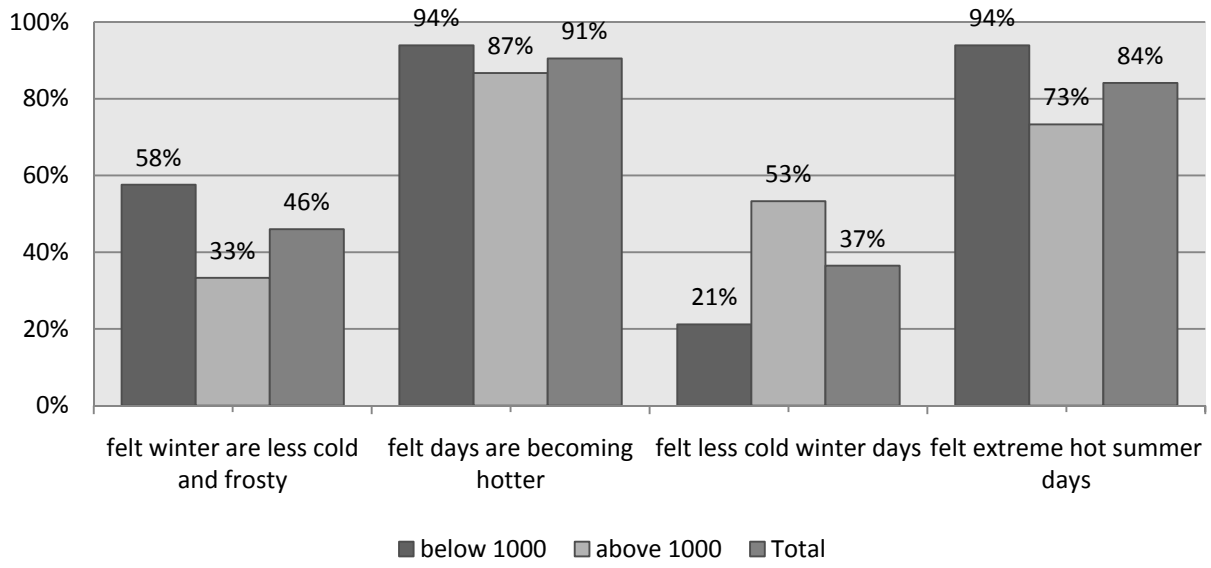


Figure 32: Experience in changing days in both strata.

b) Temperature seasonal change

On average 60% of the respondent felt the increase in winter temperature. Upper belt respondents have perception of no increase in temperature. Only 10% of populations have no perception of any change in temperature (Figure 31). Allmost all repondents said that summer temperature is in increasing trend in recent years. These perception strongly support that local community is vulnerable to spreading of vector agents and diseases both to human and crops, the area is being more drier each year, with decrease in water level and may cause effect on crop production too.

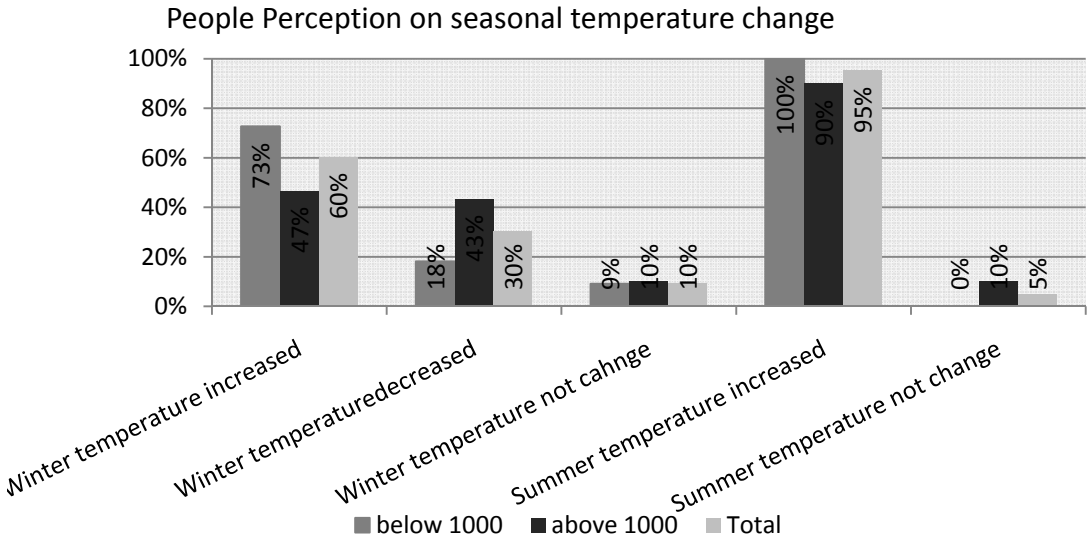


Figure 33: People Perception on climatic variables I.

c) Rainfall pattern change

Almost all the respondent perceived the unusual rainfall pattern in the area which is in increasing trend these years. 97% of the lower zone respondent experienced that rainfall pattern has been changed and increased uncertainty of rainfall which has direct impact on the rain fed agriculture practice in the area. On average 1.67 *ropani* of rain fed *khet* per household depends on rain water and unusual rainfall is affecting these households. Similarly crop yields of *Bari* are also affected by this unusual rainfall phenomenon. 83% of respondent said frequency of heavy rainfall has also been increased (Figure 32) but about 10% said it has not change. Increase in heavy rainfall in short time enhances flash flood in the area. Overall rainfall is lowering, 52% respondent said the lowering of rainfall is occurring while 24% believe it has not changed. The low rainfall in the area decreases water level in the river and can make the area drier. It has direct consequence on agricultural production. Most respondent (86%) felt that the winter rainfall has been decreased, it's being sporadic. Few decades ago, there used to occur heavy rainfall in winter but in these years it's highly sporadic and sometimes even a single mm of rainfall in winter is not observed.

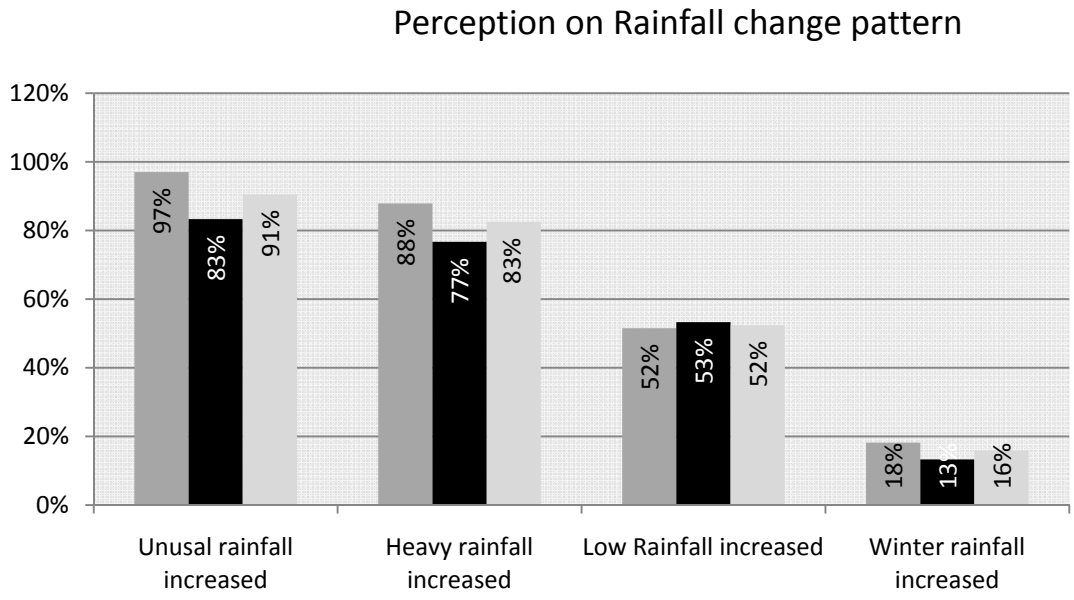


Figure 34: People's perception on climatic variables II.

d) Monsoon change pattern

Monsoon rainfall duration has been changed. About 97% response that starting time of monsoon has been delayed. The delay in starting of monsoon with heavy but low rainfall has effects in every sector, especially agriculture (Figure 33).

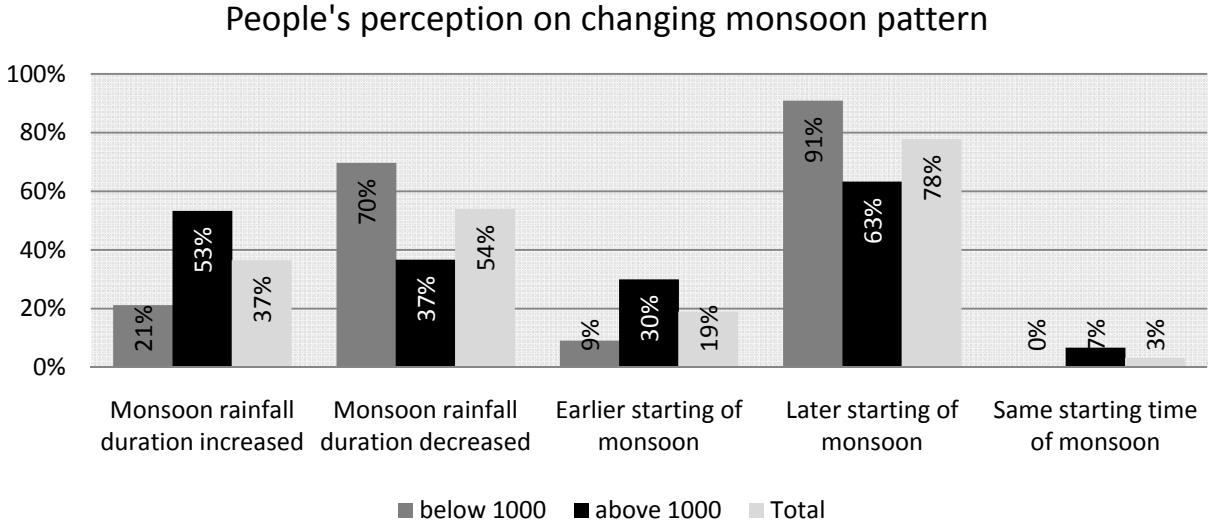


Figure 35: People's perception on climatic variable III.

3. Climatic risk in the area/Disasters

a) Disasters rank and cause

From field observation, KII and FGD survey along with household survey, the climate related vulnerable risk area includes the flood, landslides, water scarcity in dry season, and loss in agricultural production. The local people think that one of the most prevalent problems in their community is natural disaster specially flooding, erosion and landslides in upper belt.

Picture 2: Inundated farmland due to flooding at Khudi River.

The lower belt people gives flood as first ranked disaster (82%) and remaining respondent consider landslides and other disasters as first rank disaster for them. But in case of upper belt respondent rank landslide (62%) followed by lighting and flooding (22%) as first ranked disaster affecting their life. According to them, in recent year, drought and lighting is also increasing and inviting consequences related to it. Some elder people said that not only the frequency of occurrence of disasters increase but also the losses they cause are significantly increasing in recent decades. Figure 34 shows people's perception on causes of occurrence of the disasters in the area.

About 46% people thinks that these disasters occur due to unusual weather related events like heavy rainfall. Similarly about 40% think that the occurrence of the disasters is due to the deforestation although very less deforestation has been observed during field visit. ACAP is doing a lot to conserve forest of the area, and about 11% considered that

disaster occur due to other reasons such as development activities like construction of roads, households etc.

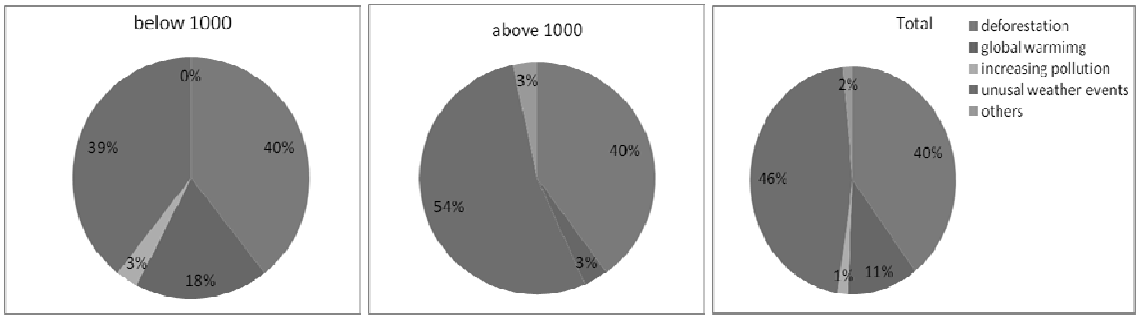


Figure 36: Perception on causes of Occurrence of the Disasters.

46% respondent said that unusual heavy rainfall is causing the disasters implying that the frequency of disasters, especially flood, is increasing as the large number of respondent feels the increasing unusual heavy rainfall events in recent decades.

b) People's perception on disaster events

About 51% of the respondents said that the trend of natural disasters has been increasing in recent years while 25% felt the decreasing trend and remaining 24% thought that either it's not changing or they do not know about it. Almost all the residents (94%) have experienced the increased frequency in heavy flood coming in recent years. The upper belt residents said that landslides events are also increasing in spite of their effort to control landslides through afforestation. The reason may be haphazard construction of rural roads and deforestation.

Soil erosion rate is also increasing. 68% of the total respondents felt that its increasing. Increase soil erosion may be due to unusual heavy rainfall, haphazard road constructions. From the disastrous perspectives occurrence of lighting frequency has also been increased in recent years. 73% of total respondent felt it. Similarly in upper eco-zone 37% of the respondent has felt the increased hailstorm frequency in recent years. But frequency of occurrence of household firing has decreased (97% lower belt and 77% upper belt). It may be due to the constructions of the new houses with concrete and

corrugated roofs. The local residents said that due to the increased prolonged dry season, the chances of forest firing have also increased.

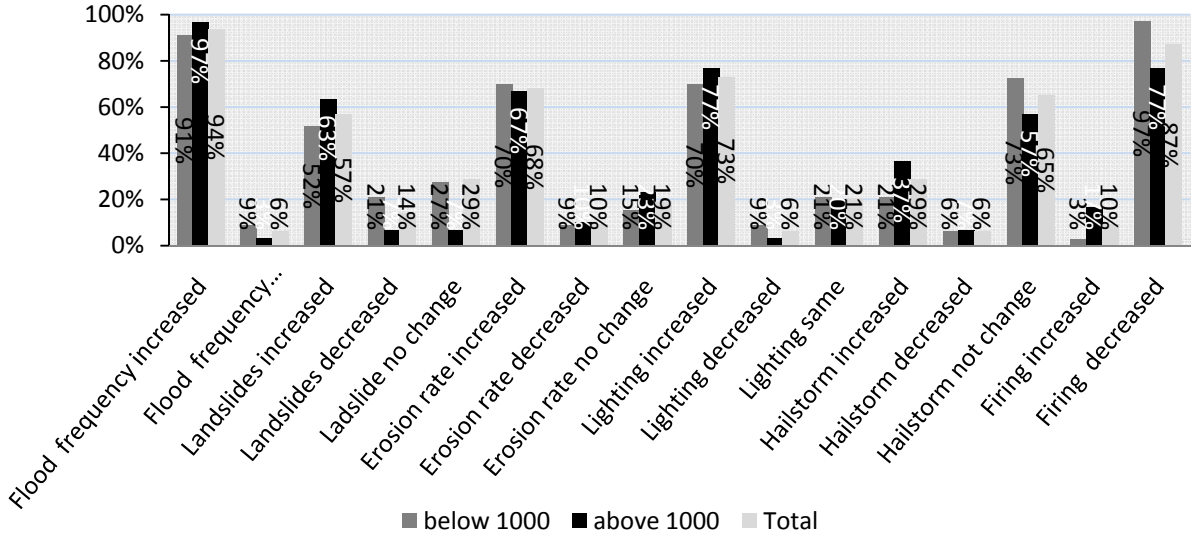


Figure 37: People perception on changing disasters event.

The losses from different disasters in the area are not so pronounced although there are some losses as in table 6.

Table 4: Loss from different disasters in the area in past 10 years.

Disasters	People killed	Livestock killed	Land lost *(ropani)*	Crop lost in *muri*	Properties loss(amount)
Flood	0	0	13	69	685000
Landslide	0	0	20	52	550000
Lightning	0	3	0	0	35000
Drought	0	0	0	0	0
Fire	0	0	0	0	0
Storm	0	0	0	0	0

c) People's perception on different disasters impacts

About 77% of the respondents felt that flood disaster has impacts on land and crops and 60% said it also affect the water resources because it can sweep away the water sources and also contaminate the water supply. Locals also felt that landslide has also great impacts on crops and household. Although most of the respondent do not feel any risk from flood to household they feel high risk of landslide, and 40% said landslide have impacts on water resources too. 60% respondent said the drought has impacts on arable

land, crops and water resource. The soil erosion also has impacts on arable land and by consequence on agricultural yield. The respondent said that increasing heavy rainfall frequency has increased the soil erosion indirectly affecting agriculture yield. Figure 36 shows the percentage of respondent observing different sectoral impacts of disasters.

Flood and landslide has great impacts on land and crop, making the agrarian community more vulnerable because it directly affects the crop yield. Similarly frequently occurring drought also affect on crop yield and water resources. Frequent and prolonged dry period makes area drier. Prolonged dry period affects on biodiversity as it increases the chances of forest fire too.

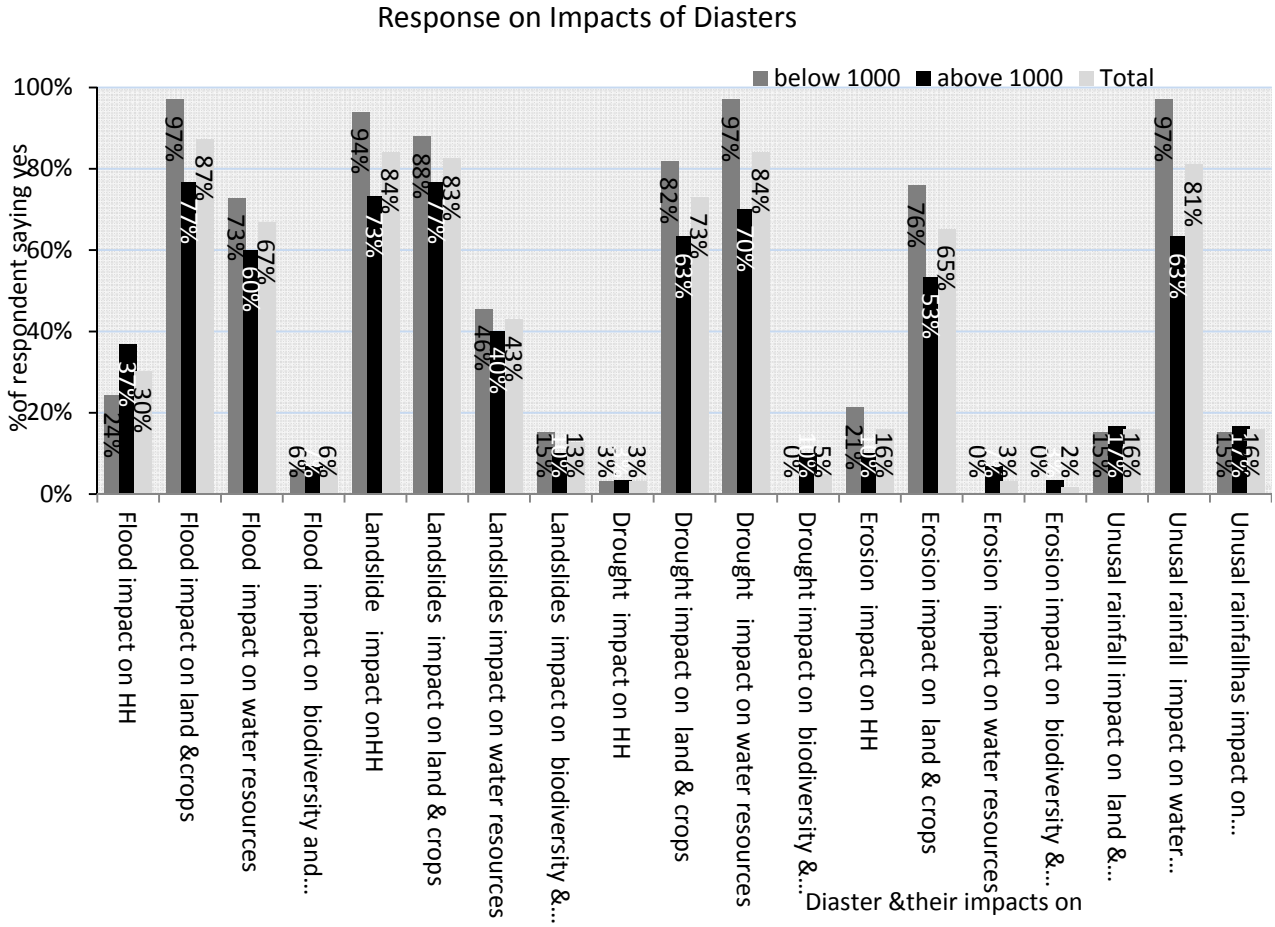


Figure 38: % of respondent saying yes to different impacts of the disasters.

d) Adaptive measures in the study area

Adaptive measures to cope with extreme disasters have not been adopted. 99% respondents said "no" when asked about their practice of adaptive techniques. There are not any adaptive techniques such as early warning system, knowledge transfer through interactions and trainings, institutions and community forums etc to work for disaster prevention. In the study area, other than political organization only *Ama Samuha* (Mother's Groups) are working as community forum whose scope is very limited to social and agricultural work. Therefore there are not any institutions to cope with changing climate and induced risks.

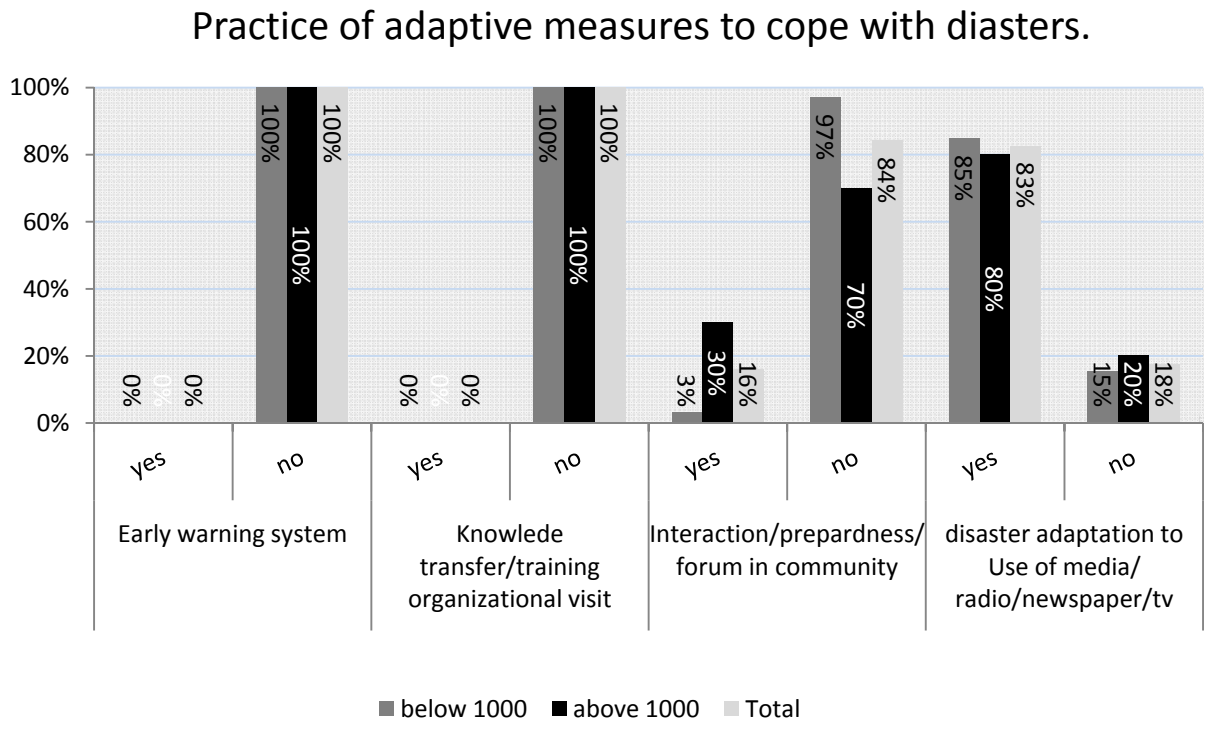


Figure 39: Adaptive measures to cope with disasters.

4. Agricultural impacts and adaptation

The study area is mostly agricultural land with almost all household directly or indirectly involved in the agricultural practices. Climatic factors like temperature and precipitation has direct impact on the agricultural production. Climate change, especially changes in

rainfall pattern, temperature, humidity and frequency of occurrence of prolonged drought has direct impacts on agricultural yield.

These changes have great effects on incidence of pest and insects, disease and microorganisms. These also impacts on starting time of the cropping and phenology of crops, generally, result is reduced yield.

Similarly heavy rainfall and increased soil erosion reduces soil nutrient content and soil fertility.

Most of the people in the study area said that productivity is decreasing in these days. About 83% of the above belt residents said paddy, the major crop in the area, production is in decreasing trend(3 *muri* per *ropani* to 2/2.5 *muri* per *ropani*) in spite of increase input of fertilizers and other care, and thinks it's because of unusual rainfall. Similarly those who practice other crops like maize, potato, millets also experienced the decreasing trend of the production in latest years (Figure 32). It was asked whether they have practiced adaptive measures to minimize the impact of climate change in agriculture, and very few of them have practiced it.

Case Study -2

Daya Sagar Ghimire, 54, diploma in Amini with two sons and a daughter is veteran resident of the Khudi watershed.

Picture 3: Ghimre giving information to researcher about his lost land.

He has observed different climatic changes in the area with time. With about 50 *ropani* of agricultural land both irrigated and rain feed, he is producing paddy, maize, potato and in some amount other commercial vegetables. From his experience and observation he says "Do not talk about the past years. These were the golden years for us- the farmer. Now time has changed, there is no sufficient rainfall in time. I think and feel that monsoon is changing its time and if it continues, we will have to leave this place or die due to starvation because production is decreasing day by day ". He gives the example of his own- he left 1.5 *ropani* of land without paddy cultivation because there is no sufficient rainfall in *Asar* when it is suitable for cropping and delay cropping do not give profitable production.

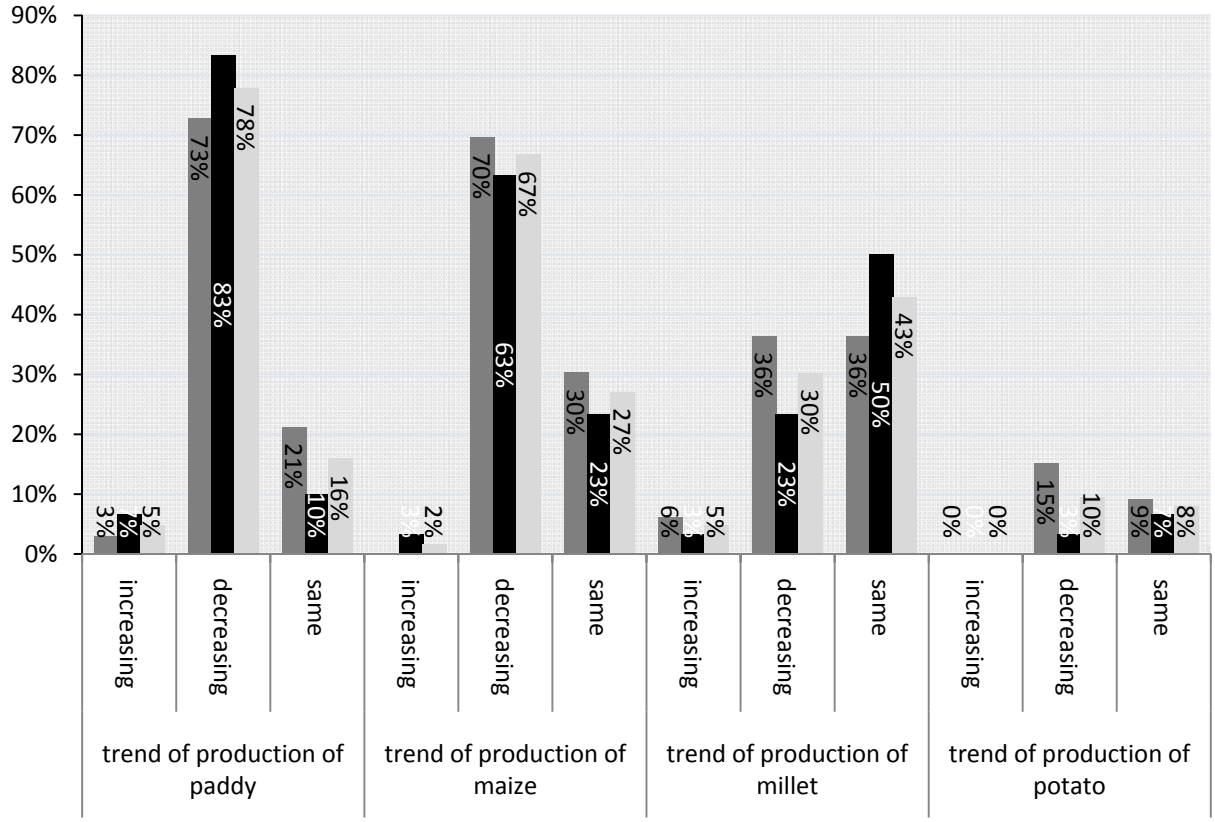


Figure 40: Production trend of the major crops.

The only adaptive strategy to reducing impacts of crop yield and hence risks posed to food security is to crop new varieties, search for new water sources or to shift occupation. Very few people (10%) knowing or unknowingly are adapting some adaptive measures such as use of new crop varieties, rotational irrigation etc. No canal water system has been developed and used for irrigation; development of such system will reduce the effect caused by low and unusual rainfall.

Although loss of productivity is already in progress, this issue is being addressed institutionally, neither from government nor from CBOs and NGOs. Shifting from agricultural occupation and easy availability of imported food are helping to reduce climate induced crop yield loss risk.

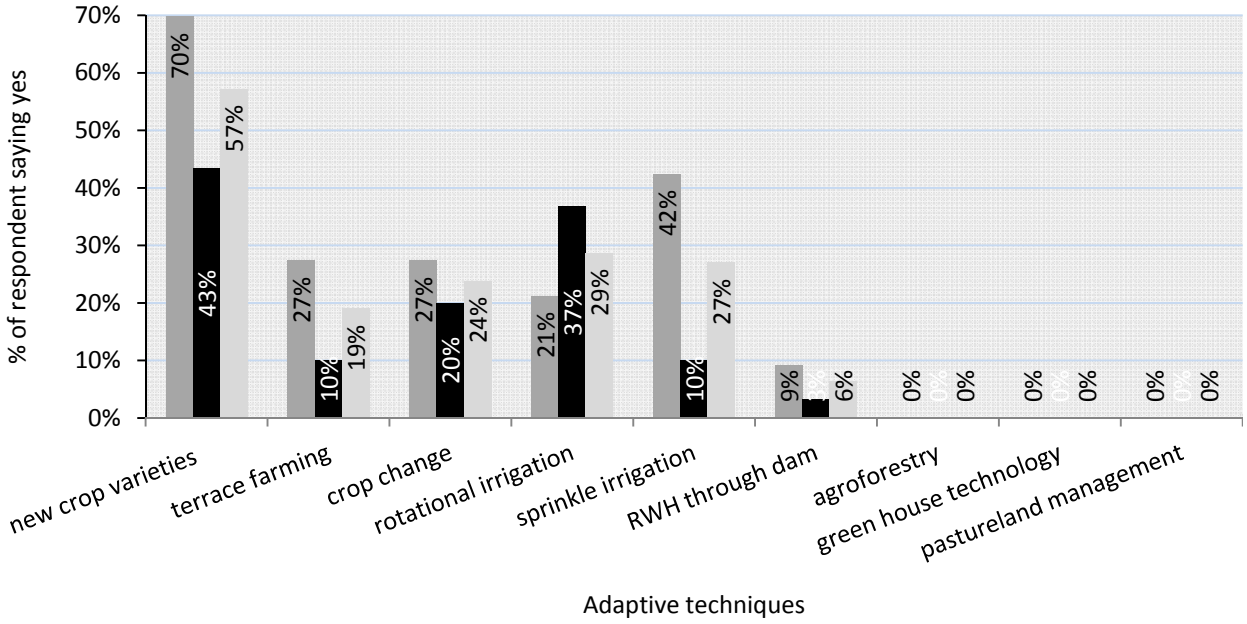


Figure 41: Respondent % saying 'yes' to the adaptive measures adapted to agriculture.

5. Water resources

It is obvious that impacts of climatic change in water cycle are direct. Long dry season, abnormal rainfall and less rainfall will affect the water recharge towers as well as affect the water sources like well springs, river and rivulet. They start to dry up. Heavy rainfall in short time duration will cause flash flood, landslides and debris flow and erosion. About 58% of upper belt respondent said that they are under high risk of flash flood during heavy rainfall, especially in monsoon. Because water is the basic need for livelihood, the respondents have great concern upon it. Although most of the respondent said that they have now new tap water distribution and they do not care about other local sources, they also said local water sources are being depleted in recent years.

100% respondents have tap water distribution for drinking purpose from 6 central collection chambers within study area, where water is collected from nearby brook. Though they have sufficient water these days, in case of drought and emergency period they have to depend upon local sources. But the elder people said that the local water sources like well and spring are now no more in existence. These were perennial in past years but now they had become seasonal, may be due to carelessness and deforestation near these sources, or may be due to climate change which enhanced prolonged drought and less rainfall in recent decades. Similarly in lower belt, as all respondent said, main source of water for irrigation is Khudi and Marsyangdi river water that is sufficient in monsoon season but not in summer. The case of upper belt is different. 78% respondents said they use the local water sources for irrigation of their rainwater fed *Khet,* remaining depends upon the local canal from nearby rivulet.

Case Study -3

Loss of a local well *Timure Kuwa,*

According to Chitra Bd Bhandari, 69, ex- ward representative and farmer describes how they lost a local water source near to their home Called *timure kuwa.*

Picture 4: Local giving information about lost Timurekuwa to researcher.

it was supplying water for 24 households from the time he knew for round the year. But now condition is different. This *kuwa* goes dry for about 4 months (*Falgun,Chaitra, Baisakh, and Jetha*) and no more supply of water. This water was used for not only drinking but also to some extent local irrigation. But these days there is no water. Although there is no water problem due to community water supply, if some disturbances occurred in that water sources, there will be *HAHAKAR*(extreme scarcity), because there is no more *Timure Kuwa* to give water. He thinks there are two reasons behind the loss of this *kuwa* first people ignore it due to community tap and carelessness lead towards the drying and next, there are such unusual climatic variations/changes that the water cycle must be changed drying their *timure kuwa* for about 3 months per year .

Almost all respondent agree that decrease in the water quantity and availability is increasing. The common consensus among the villagers is that water scarcity is going up day by day making it one of the major environmental challenges of climate change in water resource in the study area.

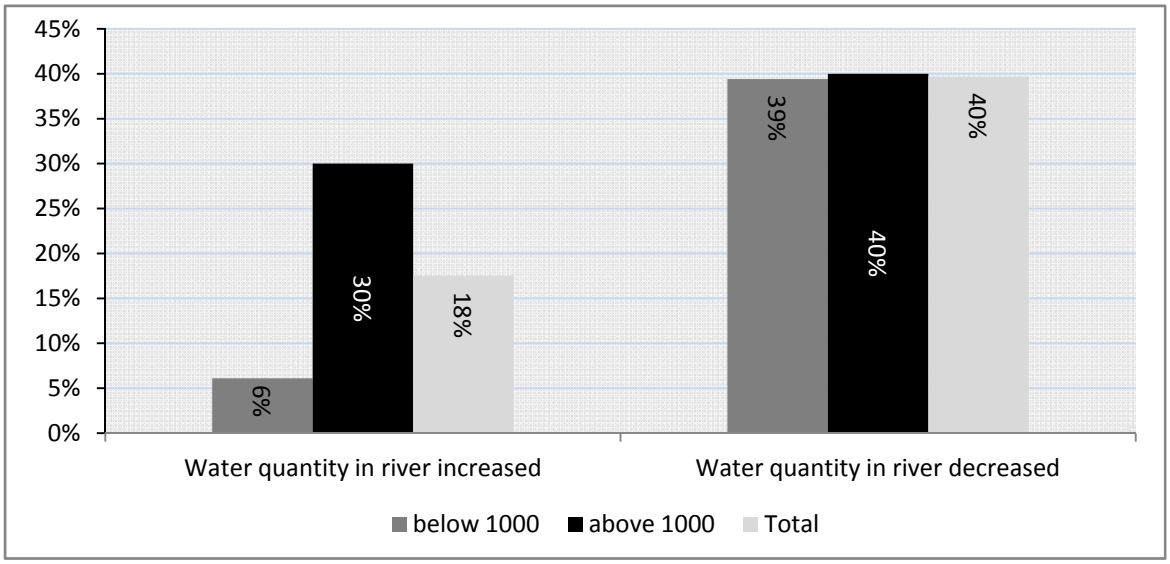


Figure 42: People perception on the change in the water quantity in the river.

From Figure 40, 40% respondent agrees that water level in river is decreasing while only 18% said it is increasing, remaining has no idea about the water level fluctuation in the river. More than 60% respondent said that flood, landslides and drought have direct impact on water resources. There was not any institutional practice to conserve and manage the water resource in the area. Any particular adaptation measures have not been obeyed by the villagers to cope with water scarcity.

Almost all HHs have shifted from traditional water sources to well managed piped water system (93% of total respondents). Similarly above 60% of response was yes to wise use of water in the time of scarcity.

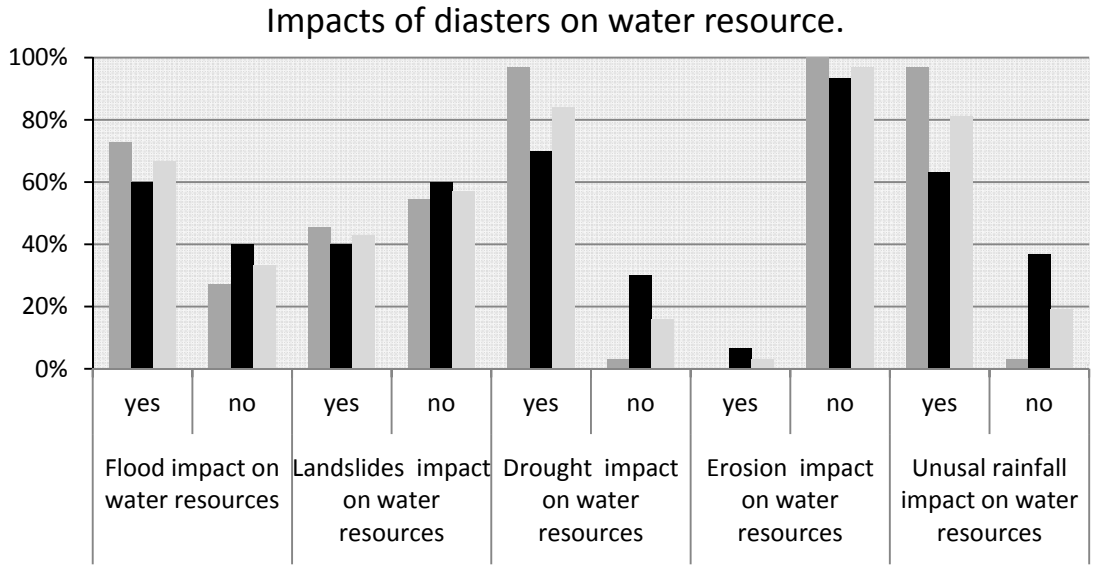


Figure 43: People perception on impacts of different disasters on water resources.

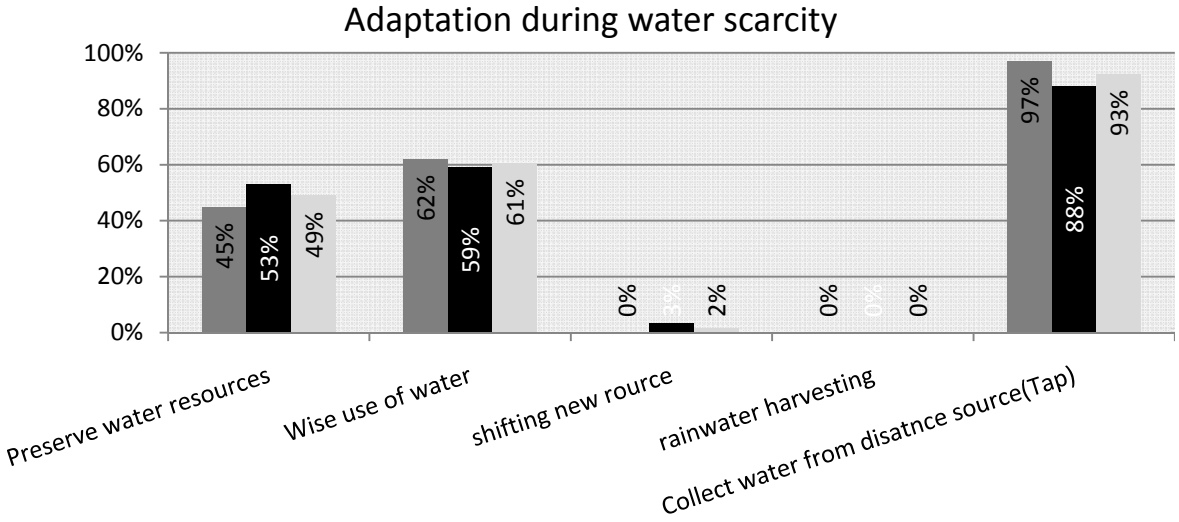


Figure 44: Adaptation to water scarcity.

About 50% respondent agree with preserving water sources to cope with its scarcity but remaining 40% think they will never face the problem of water scarcity as they have large forest nearby and water coming from the brook near to forest will never go dry (Figure 42).

6. Drought

The elder people of the study area shared their experience in frequency of occurrence of drought in their area. They claim that days are becoming more dry and hotter along with increased frequency of occurrence of prolonged drought.

About 97% respondents said that drought does not do any impact on household but the same population said it has great impacts on arable land & crops. Similarly all most all agree that prolonged drought will have impacts on water resource, biodiversity and forest resources. On average 84% respondent think that there will be impact of drought on water resources.

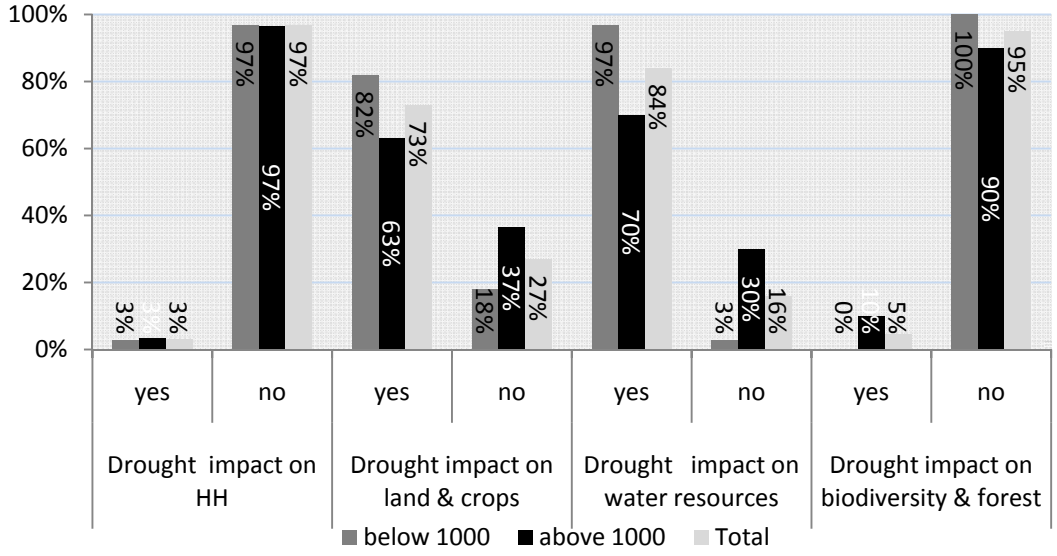


Figure 45: Impacts of drought in different sector.

Not particular adaptive techniques have been adopted to cope with these impacts of drought; more than 90% have not adopted any particular adaptive measure.

Table 5: % of respondents adopting techniques to combat drought effects.

Adaptive techniques	Percent of respondents adopting these techniques(Yes)
Do nothing	96%
Rotational irrigation	45%
Other (specific)	10%
Planting crops that need less water	2%
Water preservation activities	1%
Changing cropping pattern	0%
Rainwater harvesting	0%
Storage of water	0%

7. Soil erosion

Soil erosion is another problem local people are facing these days. The unusual heavy rainfall brings flash flood and heavy erosion of fertile soil in the steep villages. More than 70% respondents (94% in upper belt and 61% in lower belt) think that landslides and debris flow are the key driving force to the loss of fertile soil in their area. Construction of rural road is also enhancing erosion in the area. 90% of total respondents think that continuous loss of such erosion in the area will lead to decreased productivity and turn their fertile land into a sterile one in long term. 65% respondent said that soil erosion has impacts on fertile land and crops.

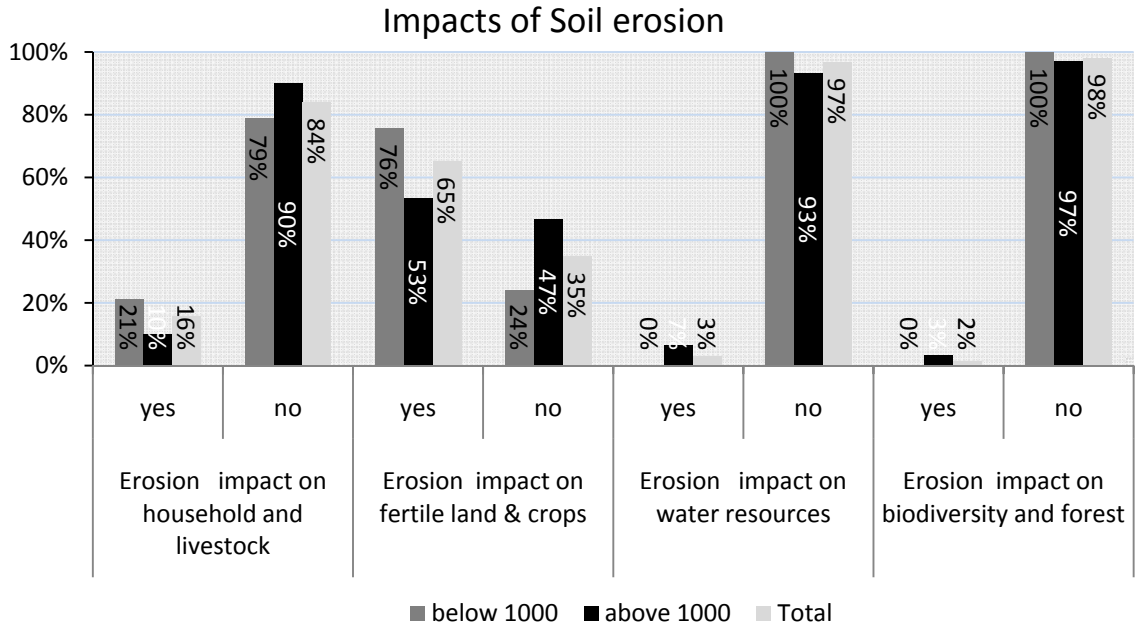


Figure 46: Impact of Soil erosion on different sectors.

They said it's urgent to minimize the impacts of soil erosion. Plantation and construction of infrastructure such as gabion walls etc may control the erosion but they have not practiced this. They seek the initiation for this from third party such as government or ACAP, a leading conservation program working there; or someone else.

E. Adaptive Measures and Future Exposure

1. Factors for adaptive measures

From above data analysis and field inspection it can be said that the watershed is highly vulnerable to climatic related disasters risk. Preceding data analysis has tried to summarize the risk, impacts and adaptive measures. From the analysis of the climatological data it's clear that the temperature, precipitation and other climatic variables changes in recent decades are alarming. 93% of elder respondents have felt these changes through their experiences.

As the effect of such climatic variables, agricultural production is decreasing from 5 to 10% annually with some fluctuation *(Household Survey 2008),* area is being drier, water resources are at high risk, extreme weather events are highly increased and frequency of occurrence of disasters such as flood, debris flow, lighting etc has been increased. These changes are jeopardizing the socio-economic condition within the watershed. The major threats from such change to the community are reduction in agricultural production and hence increased susceptibility of food scarcity, lack of income and hence shifting to new income sources, migration etc which have direct impacts on their livelihood such as food consumption, education, daily and seasonal working routine.

Case Study -4

Prem Pd Pokhrel, 50 has experienced completely new climatic pattern as compared to his youth days. He said that days are hotter, there is less and unusual rainfall ad his rice production has been decreased from 8 *muri to* 6 *muri* in his two *ropani* land within this *decade*. New palnt species are abundant and they are affecting crop yield,new palnt deseases has been observed.

Picture 5: Local showing the new species of plant starts to grow in the area.

There is irrigation but not sufficient amount of the water. in those previous year there was sufficient water but these days it's not. In past year, there was rainfall in month of *Asar* and good to crop paddy, but now time has been changed. Rainfall occurs either in *Jestha* or *Srawan* disturbing *ropai* schedule and reduction in the production. Cloud burst are common which enhances the soil erosion. Due to heavy rainfall less infiltration of the water making water dry and reducing total production.

It is beyond community capacity to control the adverse impacts of climate related impacts and disasters. At community level, to minimize these effects only what can be done is to minimize the adverse impacts which are either occurring or obvious to occur in coming days. The strong effective and sustainable strategy and policy are to be formed and its implementation is essential to mitigate these impacts.

Some of the current governing factors to adaptive capacity in the local area include

- **Communities Forum and social Networking**

Different institutions, which are also considered as major stakeholders are working in Khudi watershed. *Ama Samuha* (Mother's group) are working as the form of social networking in each village. Their working area is focused on social work and rituals of the community and agricultural. Their promotion and update is essential to overcome worse impacts in coming days. Most of the residents also agree with this but they are seeking others technical and financial support to do this. Youth Clubs and other social organization building and working will be very useful to reduce risk. Such community forum will also help poor locals in the area who are directly and more prone to be affected by disasters.

- **Governmental organizations**

It is governments' responsibility to provide basic civil services and relief to the community during the time of disasters. The district level organizations whose office lies about 10 km from the study sites are working for disaster mitigation. But their scope is limited to government policy. CDO's office disaster mitigation and rescue unit, directly under the Ministry of Home Affairs has major responsibility during the time of disasters. Agriculture Office, Irrigation Office, Local Development Office, Forest Office are the government bodies to work for climate change impacts mitigation. But they are doing nothing in this aspect.

- **Non-governmental organizations**

In the country like Nepal where large numbers of national and International non-governmental organizations are working in different capacity to work for different issues of people, their role is vital for the awareness and mitigation technology utilization. It's time for such organization to work to cope with disasters and climate change induced risk. NTNC is one of the national level conservation organizations which has been conserving the watershed as a part of its ACAP project, has did nothing in the sector of climate change risk reduction. Now it's time for such organization to work here. Khudi Hydropower Company is there. These organizations can provide maximum relief and support. They also can provide technical assistance to local community to cope with risk.

- **Indigenous Knowledge technology and practices for Early warning system**

The early warning system to forecast weather events can reduce loss of human life and properties to some extent. In Khudi watershed, still there exists traditional *Katuwallli Partha* (Calling villagers by a person under the order of village head). It can be one of the good ways of early warning system in local area. But it should be systematized, modernized and updated. Community based preparedness and adaptation strategies work better for the reduction of climatic risk. Here in Khudiwatershed, there no availability of any weather forecasting system. Only about 10% people hear through media about the weather and most of the rural people do not know what's happening. General practice is that most family remains alert during long heavy rainfall, strong lighting etc but there is no any particular early warning system. The mega loss of life and properties by KhudiKhola flood in monsoon of 2007 is best example of lack of early warning system. A lot of property and human life could have been saved if they were timely informed and warned.

- **Technology**

Wise use of technology and techniques are best factors that mitigates the worse impacts of climate change induced risk not only of disasters but also of agricultural production, water scarcity, drought and erosion. Most of the villagers are unknown about cost effective and simple techniques and technologies such as rainwater harvesting, sprinkle irrigation etc. Availability of technical assistance such as heavy equipments will help to reduce flooding and debris flow through land reclamation.

As temperature increase the chances of increasing pest is also increasing. Proper pest control technology will minimize its worse impacts.

- **Infrastructures**

The facility of physical infrastructures is also one of the best adaptive measures to cope with impacts of climate change. Although lower part of the watershed is somehow facilitated with certain infrastructures such as gravel road, school building and irrigation canal, health post and financial institutions, the upper belt lack all of these. Constructions of bridges in river and road facilities to travel and work during the time of heavy rainfall. Similarly the river canals, especially from Perennial River like Marsangdi and Khudi will help to irrigate the land during dry period. As agriculture is the main occupation which

have to face climatic change risk, the construction of agricultural related infrastructure is vital. Construction of running water collection dam, water reservoirs etc will also help to cope during the time of water scarcity.

- **Knowledge, Awareness and communication**

Knowledge, knowledge sharing and communication are very important to minimize the impacts. In Khudi, very few people are well educated and know the context but most of the rural people have very little knowledge of what's happening and why it is happening. From survey it was found that no one has even participated in any training or knowledge sharing program about climate change, disaster etc. It's important to aware the people through local level workshops and idea sharing programs about climate change, its impacts and ways of mitigation.

- **Diversification of Livelihood (Remittance and Migration)**

Almost all population depends upon agriculture for their income source. Very few have excess agricultural production to sell them in the market. In recent year's remittance, business and tourism has replaced the earning source from agriculture. Families with diversified income source have recovered substantially compared to those who have only one source of income.

Similarly loan given to rural people will help to uplift their economic status which will minimize the worse impacts of disasters and other climatic risk.

Micro insurance is one of the good systems to resilience the loss due to disasters. Micro-insurance policy has not been adopted and this practice of micro insurance will reduce the risk. There is *Mutthi Dan* system, an indigenous practice of traditional insurance scheme. It can be developed as micro-insurance scheme.

Migration is one of the best strategies for local community people to cope with disasters. Those who can afford to buy new house in safe place will migrate to minimize the risk. In the study area this practice was not observed. The victims are poor. Remittance is another best solution to minimize worse impacts.

2. Future Exposure

Most of the climate modeling and study report predicts that attribute of climate particularly change in rainfall pattern, increased temperature, and extreme climatic events, weather related disasters are going to be problematic in global, regional, national and local level. Climate science literature provides an indication of future trend and changes in the climate conditions and events with some level of uncertainty. Different models adopted to predict future projections estimates that average annual temperature of Nepal will rise in the range of 2 to 4^{o}C when CO_2 level is doubled (MoEST, 2008). Magnitude of temperature rise is greater in western part, in the periphery of Khudi watershed. Similarly GFD3 model project general increase in precipitation for whole Nepal with gradient from south west to north east in magnitude of 150 to 1050 mm when CO_2 level is doubled (MoEST, 2008). Such fluctuation in precipitation and temperature will impact more to local communities. From data analysis of the Khudi watershed, it is clear that in coming days the community has to face more challenges due to the impacts of climate related disasters. The fragile mountain area of Nepal is more prone to erosions, landslides and flashflood. Small changes in regular weather pattern may bring great impacts on these fragile eco-zones. Hence in coming days community will be more vulnerable to climate related disasters and climate change impacts. When respondents were asked about the chances of increased impacts of climate change on them almost all agreed that they may have to face the worse impacts especially on agriculture, increased frequency of flooding and water scarcity. Their perception on future exposure is as in Figure 45.

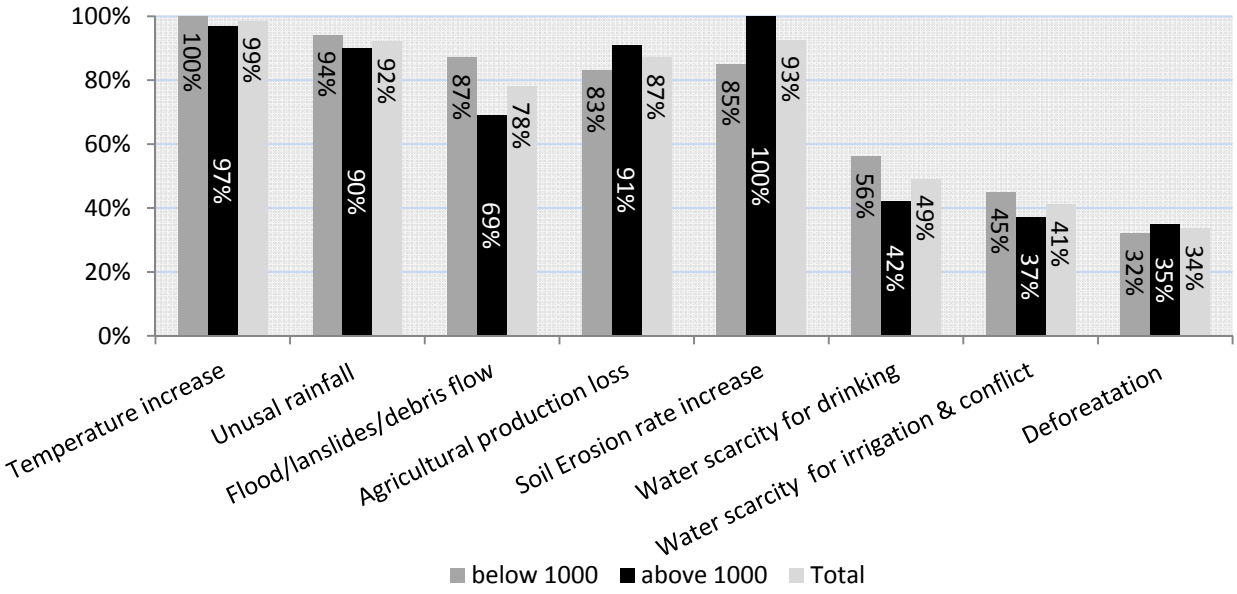


Figure 47: % of respondents saying 'yes' future climatic risks.

99% respondents, based on their experience and observation said that temperature will increase more in coming days. 92% respondents are sure that in future day's trend of unusual rainfall will increase and 87% respondent said the agricultural yield will decrease more in coming days. Similarly 93% think that soil erosion rate increases with increasing heavy rainfall while 78% agree that in coming days the flood and other disasters occurrence frequency and quantity will increase. About 50% of the respondents think that in coming days there will be scarcity and conflict due to water within different villages of the community. They think that in future days there will not be deforestation. Only about 30 % agree the fact of deforestation and remaining say that due to ACAP and awareness among people, they will conserve the forest.

As said earlier there are problematic issues not only in Khudi but whole Nepal, due to climate change and risk. Strong adaptive policy and its implementation through people participation are basic needs to minimize the impacts of climate change in the area.

CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

The Khudi watershed lies in the central western hilly region of Nepal in Lamjung district with altitude from 823 m to above 3000m. The agrarian watershed with seven hundred households was dominated by Bahun/Chettri (51%), Gurung (21%) and several others (28%). Other then agriculture, the main sources of income includes pension and remittance, tourism and related business. The area is also characterized by low human development indicators like education, health, infra structures and economy in upper belt while medium human development indicators in the lower belt around the Khudibazar. The HDI of Lamjung district is 0.429, ranking 14th (Thapa, 2008) out of 75 district of Nepal.

The Meteorological station of DHM operating since 1975 in the Khudibazar has generated data of climatic variables. The data analysis indicated some visible changes in the climatic variables in recent years. Temperature and precipitation data analysis between 1987 to 2006 and 1975 to 2006 respectively showed some changes. Average temperature was increasing. Annual mean maximum temperature trend was increasing at 0.81^{0}C/decade, and annual mean minimum temperature trend was increasing at 0.26^{0}C/decade. Seasonal temperature data also showed increasing trend, winter seasons temperature trend is very high (1.17^{0}C/decade maximum temperature and 0.76^{0}C/decade minimum temperature). Average Precipitation trend of two driest months, November and December, is decreasing by 0.583 mm/yr and 0.10 mm/yr while that of wettest month, July showed the increasing trend of 1.91 mm/yr.

The people's perception the area indicates that 100% respondent of the lower belt has experienced that the temperature is increasing in recent years while upper belt 93% response same. Similarly about 70% respondent said that the rainfall pattern has been changed; almost 91% respondents have experienced the unusual rainfall pattern while

83% felt that in these days rainfall is heavy. 75% of the respondents said that winter rainfall has been decreased while above 50% agree that total rainfall is lowering. These changes in the rainfall pattern is very significant for the community people because the community is directly dependent upon the rain fed agricultural practices and any changes in rainfall will hamper the production. The changes in the rainfall pattern is of more concern among the people of the area and people are worrying about what to do next if such unusual behavior of rainfall continues and hence their farming schedule has been lingered.

The study area is vulnerable to natural disasters specially flooding in Khudiriver during monsoon when large amount of precipitation occur and upper belt is at high risk of both landslides as well as rivulet's flash flooding. People near to Khudi River are experiencing increased frequency of river flooding nearby. About 82% of the respondent in lower belt rank first to flood disaster while 62% of the respondent of upper belt consider landslides as their first rank disaster, lighting and flooding specially from nearby brook is their second ranked problem related to disasters. In recent years drought and lighting is also causing them trouble. 46% respondent thinks disasters occur due to unusual weather related events like heavy rainfall, 40% think that the occurrence of the disasters is due to the deforestation and 11% considered due to other reasons such as development activities like construction of roads. About 50% of the respondents said that frequency of occurrence of the disasters is increasing in recent years in which 94% of respondents have experienced the increased frequency in heavy flood. Soil erosion rate is also increasing. 68% of the total respondent felt that it's increasing. Most of the respondents agree that lighting and hailstorm occurrence frequency is increased in recent years. The loss due to disasters in past 15 years is not so pronounced. Each year certain amount of the crops has been swept away by the river flood and sometimes heavy flood is causing large loss of life and property, specially land and crops.

About 78% of the respondents said that their agricultural production is decreasing in spite of their increased care, cropping of new variety of crops and use of fertilizers. Most of the respondents claim that unusual and uncertain climatic events are causing negative impacts in the field of agriculture. The agricultural yield is decreasing due to long dry

periods(as winter rainfall become sporadic in recent years), extreme weather events, excessive soil erosion and less input of human labor as most of the working man power are leaving the village in search of new jobs and opportunities outside.

Local adaptive capacity is very poor. There is no availability of precautionary institutions to cope with risks. Knowingly or unknowingly insignificant coping strategies are being adapted within the community and neither particular coping strategy has been neither formed nor likely to be formed in coming years, so the community is at high level of vulnerabilities without well institutionalized coping mechanism. Very less educated people used to live within the community and they do not have resources and knowledge how to minimize the worse impacts of climate change induced disasters. The Khudi watershed communities' level of vulnerability is sure to be high in coming years. About 97% respondent said that the temperature will rise more in coming years while about same fraction of respondent said the chances of extreme rainfall pattern will increase and the agricultural production will decrease. They are worrying about their future. Although some local NGOs are doing awareness on solid waste management, children and human right issues, on one is working in the field of reducing climate change impacts in the area, lots have to be done in coming years so that the exposure to the disasters will be less. Factors that enhance the adaptive capacity includes common social forum, awareness and communication, training and advocacy, institutions and infra-structures, wealth and economic growth through income generating activities, modernization and practice of indigenous knowledge.

Sufficient database and detail study is still lacking in study area. Proper predictions of impacts and policy formulation to cope with such impacts require elaborate local to regional level research in this field, only then the community will strengthen giving sustainable living continuity of the area.

Looking at the picture of future climate both from previous data analysis and people's perceptions of the study area, in spite of development efforts and socio-economic trends, Khudi watershed vulnerability to climatic induced disasters will be similar to what exists today. Climate change is likely to enhance the severity of disasters, mainly flooding and

unusual rainfall having impacts on agriculture in coming future. A shorter, intense monsoonal rainfall in rainy season will result increased flood. Less or no rainfall in winter or other season is causing drying of the area.

B. Recommendations

In order to reduce the climatic change impacts on community following recommendations are made.

These recommendations will be helpful to the climate change impacts adaptation and mitigation not only within the research area but also other parts of the country of similar nature; it would be useful for disasters managements and planning to minimize the extent of impacts of loss of life, property and community vulnerability in the region. It is better to invest for prevention and mitigation rather than investing after the disaster have occurred. The following are the recommendations.

Local community need to be aware of climate change induced impacts. Different hazards zone can be mapped, safety measure can be taken to minimize the impacts of hazards in the area. This delineation of the impacts and risk posed by climate change and weather extremes must be backed by awareness building among the community.

Preparedness and early warning system should be built up in the community. The loss of life and properties can be minimized by installing appropriate warning systems. Proper maintenance of the warning system is a necessity otherwise it may not function when needed.

Improving climate information applications through work with the meteorological office, agricultural office, water resource managers, and other users would be quite useful for enhancing flood and related disasters preparedness.

Efforts to preserve indigenous methods of forecasting could also prove useful, although these have not been well-documented. The *Kattuwali partha* is one that can be modernized and practiced. *Mutthi dan* is a traditional practice of mutual cooperation

during disaster; it can be developed as the background for micro-insurance within the community.

In the country like Nepal where most people are innocent rural villager, communities forum are very important. Social networking between local stakeholders to policy making and implementing institutions brings strong dynamic force to cope with changing scenario. Neighborhoods and relatives are the group who directly help during the time of disasters, scarcity and needs. Strong community forum formed by the local people is one of the best assets to cope with these worse impacts.

The integrated working mechanism between different stakeholders/institutions is essential. The government officers who are working in Lamjung district even do not know the climate change issues (Personal communication, 2008) therefore it's hard to expect anything from them in this sector. Government has to formulate new policy and should implement coping strategy in the local area where communities are vulnerable to climatic risk.

Both autonomous and planned adaptation practice should be started in practice. Awareness among the local people for the autonomous adaptation practice and proper policy and plan formation and implementation is required for planned adaptation programs. Farming adaptation is one of the important coping strategies to reduce the impacts. Discussions with the communities of both above and below belt show the importance of agricultural extension services and use and implementations of the adaptive techniques in agriculture. Agricultural impacts are making the community more vulnerable. It is recommended that the people in the community should be provided with irrigation facility not depending only on the traditional practices of irrigation from the nearby river but also can be done with the water collection dams and reservoir or rain water harvesting practices. For this government's irrigation department along with local NGOs and CBOs can do more. Also new varieties of food cropping may be beneficial.

Conservation of the forest and biodiversity is very important. Conservation of these resources also saves water sources. Local water sources should be conserved so that during dry period also they can provide water.

Community should have to change livelihood practices in order to reduce the risk of impacts of disasters induced from climate change in coming days. Less dependence on natural resources would be helpful to reduce vulnerability due to disasters and climate change, however, its possibility is very less because the Khudi watershed community still depends upon an agrarian economy and is sure to depend on same for coming many years. Different income generating activities could be introduced. Income generation through different indigenous to modern economic activities and flow of money through local level co-operatives within the community is very beneficial not only to reduce the risk but also to enhance the economic status of the local people. Further research, assessments and local people training may be more fruitful. It is recommended that new projects should be launched in the area to train local about the climate change induced vulnerability and coping mechanisms.

Thus it is recommended to practice or perform the following activities in order to minimize the risk of climate change impacts in local area. They includes research and awareness, afforestation, water resources preservation, weather and climate information distribution, alternative livelihoods through new and income generation economic activities, proper policy and legislation and its implementation, land use and land use mapping , infrastructure and institutions and disaster preparedness at community level.

REFERENCE

ADB/ ICIMOD. (2006). *Environmental Assessment of Nepal:Emerging Issues and Challenges.* Kathmandu,Nepal: Asian Development Bank, ICIMOD.

ADB/WB. (2002). *Proverty and Climate Change:Reducing the Vulnerability of Poor through Adaptation.* Kathmandu, Nepal.: Asian Development Bank/World Bank.

Adger, W. N. (2000). Social and Ecological Resilience: Are They Related ? *Progress in Human Geography , 24* (3), 347-364.

Agrawal, A. (1999). *Green politics: Global Environmental Negotiations* (Vol. 1). New Delhi, India.: Center for Science and Environment.

Agrawal, S., Raksakulthai, V., Aalst, M. v., Larsen, P., Smith, J., & Reynolds, J. (2003). *Development and Climate Change in Nepal: Focus on Water Resources and Hydropower.* Paris, Cedex 16, France: Organisation for Economic Co-operation and Development.

American Geological Union. (2003). AGU Position Statement on Human Impacts on Climate. *EOS, Transactions American Geophysical Union , 84* (51).

Baidhya, S. K. (2008). Cliamte Change Senario in Putalibazar Municipality, Syangja.

Benisten, M. (1994). *Mountain Environments in Changing Climates.* London New York: Routledge.

Benson, C., & Twigg, J. (2004). *Measuring Mitigation Methodologies for Assessing Naturehazard Risks and the Net Benefits of Mitigation - A Scoping Study.* New york: Provention Consortium, Cambridge Unversity Press.

Bhushal, R. P., Rokka, M., & Bajracharya, S. (2009). *Carbon Stock Estimation of Shivapuri National Park.* Kathmandu.: WWF Nepal.

Blaikie et al, P. (1994). *At Risk.* London: Routledge.

Bolin, C. (2007). What Makes a Disaster even more Disastrous: Is Disaster Reduction Possible ? *Agriculture and Rural Development , 14 N2007*, 36-37.

Burton, I., Kates, R. W., & White, G. F. (1985). *The Environemnt as Hazard.*

Carter, T., Parry, M., Harasawa, H., & Nishioka, S. (1994). *IPCC Technical Guidelines for Assessing Climate Change Impacts and Adaptations with a Summary for Policy Makers and a Technical Summary.* Department of Geography, University College London, UK and the Centre for Global environmental Research, National Institute for Environmental Studies, Japan.

CBS. (2006). *District Profile of Lamjung District.* Statistical Section Office Gorkha,Central Bureau of Statistics, National Planning Commision Secretariat, Government of Nepal.

CBS. (2001). *Nepal Census Report 2001.* Kathmandu: Central Bureau of Statistics,National Planning Commission, Government of Nepal.

CBS. (2005). *Statistical Year Book of Nepal.* Kathmandu,Nepal: Central Bureau of Statistics, National Planning Commission, Government of Nepal.

Chalise, S. (1994). Mountain Environment and Climate Change in the Hindu-Kush Himalays. (M. Benisten, Ed.) *Mountain Environment in Changing Climates* .

Chalise, S. R., & Khanal, N. (2001). Rainfall and Related Natural Disasters in Nepal. (S. R. Lin Tianchi, Ed.) *Landslide Hazard Mitigation in the Hindu-Kush Himalayas* , 63-70.

Chalise, S., & Khanal, N. (2002). Recent Extreme Weather Events in Nepal Himalayas. (H. P. A Snorasson, Ed.) *Publication 271*, 141-146.

Chaudhary, R. P. (1998). *Biodiversity in Nepal.* S Devi, Saranpur India.

Chhetri, M., & Bhattarai, D. (2001). *Mitigation and Management of Floods in Nepal.* Kathmandu, Nepal.: Ministry of Home Affairs, HMG/Nepal.

Dhital, M., Khanal, N., & Thapa, T. (1993). *The Role of Extreme Weather Events, Mass MOvements and Land-use Changes in increasing Natural Hazards.* Kathmandu: ICIMOD.

Dixit, A. (2003). Floods and Vulnerability: Need to Rethink Flood Management. In *Adaptation to Climate Change:causes impacts and responses.* Kathmandu: German Technical Zatrum.

Dow, K., & Downing, T. E. (2006). *The Atlas of Cliamte Change: Mapping the world's greatest challange.* London, UK: Earth Scan.

Encyclopedia of Nations. (2007, August 23). *Encyclopedia of the Nations: Asia and the Pacific.* Retrieved August 23, 2008, from Nepal: http://www.nationsencyclopedia.com/economies/Asia-and-the-Pacific/Nepal.html

Garg, Shukla, & Kapshe. (2007). From ClimateChange Impacts to Adaptation: A Development Perspective for India. *Natural Resources Forum , 31*, 132–141.

Grabherr, G., Gottfried, M., & Pauli, H. (1994). Climate Effects on Mountain Plants. *Nature* , 369-448.

Gurung, H. (2004). *Landscape Change in the Nepal's Hills: Evidence from Lamjung.* Kathmandu,Nepal: ICIMOD.

HMG/MoFSC. (2002). *Nepal Biodiversity Strategy.* Kathmandu: Ministry of Forestry and Soil Conservation, HMG/Nepal.

HMGN/MoFSC. (2002). *NEPAL BIODIVERSITY STRATEGY.* Kathmandu, Nepal: Ministry of Forests and Soil Conservation, HMG, Nepal.

Howard, J. (2004). *General Climatology* (4th ed.). New Delhi: Prentice-Hall of India.

ICIMOD. (2002). *Community Risk and Vulnerability Assessment(Internal Report).* Kathmandu: Participatory Disaster Managemnt Program(Nep99/014) and ICIMOD Nepal.

IFRC. (2001). Disaster Data: Key Trends and Statistics. *International Federation of Red Cross and Red Crescent Sociesties* .

IFRC. (2005). *World Disasters Report.* International Federation of Red Cross and Red Crescent Societies.

International Landslide Centre. (2008). *Department of Geography.* Retrieved August 23, 2008, from Department of Geography, University of Durham: http://www.dur.ac.uk/geography/research/researchprojects/?mode=project&id=71

IPCC. (2001). *Climate Change 2001: Scientific Basis. A Contribution of Working Groups to the TAR of IPCC[Watson, R.Tand core writing teams (eds)].* New York, NY,USA: Cambridge University Press.

IPCC. (2007). Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. (O. C. M.L. Parry, Ed.) 617-652.

IPCC. (2007). *Climate Change 2007: Synthesis Report.* Intergovernmental Panel for Cliamte Change.

IPCC. (2006). *Climate Change Synthesis Report.* Cambridge University Press.

IPCC. (2007). *Intergovernmental Panel on Climate Change Fourth Assessment Report Climate Change 2007: Synthesis Report Summary for Policymakers.* Intergovernmental Panel on cliamte Change.

Ives, J. D. (1986). *Glacial Lake Outbrust Floods and Risk Engineering in the Himalaya(Occasional Paper no 5).* Kathmandu: ICIMOD.

Jager, J., & Ferguston, H. L. (1991). Climate Change Science: Impacts and Policy. *Proceedigs of the 2nd world climate conference.* NewYork Sydney Melborne: Cambridge University Press.

Karki, M. B. (2007). Nepal's Experience in Climate Change Issues. *14th Asia Pacific Seminar on Climate Change.* Sydney, Australia: 14th Asia Pacific Seminar on Climate Change.

Kates, R. W. (2000). Cautionary Tales: Adaptation and the Global Poor. *Climatic Change , 45* (1), 5-17.

Kelly, P., & Adger, W. N. (2001). Theory and Practice in Assessing Vulnerability to Climate Change. *Climate Change , 47* (4), 325-352.

Khanal, N. R. (1999). *Assessment of Natural Hazards in Nepal.* Kritipur, Kathmandu: Research Division, Tribhuvan University.

Khanal, N. R. (2005). Water Induced Disasters: Case Studies from the Nepal Himalayas. (A. Hermann, Ed.) pp. 179-188.

Library of Congress. (2008, September). *Federal Research Division, Library of Congress.* Retrieved September 9, 2008, from A Country Study: Nepal: http://memory.loc.gov/frd/cs/nptoc.html

Liu, X., & Chen, B. (2000). Climatic Warming in the Tibetan Plateau During Recent Decades. *International Journal of Climatology* , 1729-1742.

Meehl, G. A., Washington, W. M., Collins, W. D., Arblaster, J. M., Hu, A., Buja, L. E., et al. (2005). How Much More Global Warming and Sea Level Rise ? *Science , 307* (5716), 1769 - 1772.

Messerschmidt, D. (1976). Ecological Changes and Adaptaion Among the Gurungs of Nepal Himalaya. *Human Ecology , 4* (2), 167-185.

Miller, G. T. (2002). *Living in Environment:Principles connections and solutions.* USA: Wadsworth/Thomson.

MoEST. (2008, August 12). *Ministry of Environment,Science and Technology*. Retrieved August 12, 2008, from http://www.moest.gov.np/

Mool, P. K., Bajracharya, S., & Joshi, S. P. (2001). *Inventory of Glaciers,Glacial Lakes and Glacial Lake Outbrust Floods: Monitoring and Early Warning System in the Hindu Kush-Himalayan Region.* Kathmandu: ICIMOD.

Mool, P., Bajracharya, S. R., & Joshi, S. (2001). *Inventory of Glaciers and Glacial Lakes and Glacial Lake Outbrust Flood Monitoring and Early Warning Systemms in the Hindu-Kush Himalayan Region-Nepal.* Kathmandu,Nepal: ICIMOD.

MoPE. (2000). *State of Environment of Nepal.* Kathmandu: Ministry of Population and Environemnt, HMG/Nepal.

Muhammed, A. (2003). *Climate Change and Water Resources in South Asia.* Islamabad: Asians Agro Dev International.

Oven, K. D., Petley, N., Rigg, J., Dunn, C., & Rosser, N. (2008). *Landscape, Livelihoods and Risk: A Study of Community Vulnerability to Landslide Events in Central Nepal.* Department of Geography, University of Durham.

Regmi, B. R., Pandit, A., Pradhan, B., & Kovats, S. (2008). *Climate change and health Country Report- Nepal.* Pokhara,Nepal.: Local Initiatives for Biodiversity, Research and Development (LI-BIRD).

Reilly, J. (2001). *Agriculture: The potential Consequence of Climate Variability and Change for the United States.* NewYork, NY: US National Assessment of the Potential Consequences of Climate Variability and Change, US Global reseach Program,Cambridge University Press.

Shrestha, A. B., & Wake, C. (2000). Precipitation fluctuations in the Himalaya and its vicinity: An analysis based on temperature records from Nepal.

Shrestha, A., Wake, C., Mayewski, P., & Dibb, J. (1999). Maximum Temperature Trends in the Himalaya and its Vicinity: An Analysis Based on Temperature Records from Nepal for the Period 1971 – 94. *Journal of Climate , 12* (9), 2775-2786.

Smit, B., & Wandela, J. (2006). Adaptation, Adaptive Capacity and Vulnerability. *Global Environmental Change , 16* (3), 282-292.

Stockingtaking Report. (2008). *Stockingtaking Report on Cliamte Change.* The National Capacity Needs Self Assessment Project Ministry of Environment, Science and Technology, Government of Nepal and United Nations Development Program.

Sutherland, S. N. (2004). Vulnerability to Cliamte Change and Adaptive Capacity in the Samoa: The Case of Saoluafata Village. *Master Thesis* . The faculty of Graduate Studies, University of Guelph.

Thapa, S. (2008, August). *The Human Development Index: A Portrait of the 75 Districts in Nepal.* Retrieved August 14, 2008, from www.unescap.org/esid/psis/population/.../V10N2A1.html

Tianchi, L., & Behrens, J. (2002). *An Overview of Poverty, Vulnerability and Disaster Management in Nepal.* Kathmandu: ICIMOD.

Tunner II, B. L. (2003). Science and Technology for Sustainable Development Special Feature: A framework for vulnerability analysis in sustainability science. *Proceedings of the national Academy of Sciences of the United States of America(PNAS) , 100*, 8059-8061.

UNFCCC. (2006). *Climate Change:Impacts, Vulnerabilities and Adaptation in Developing Countries.* United Nations Framework Convention on Climate Change.

UNFCCC. (2002). *Report of the Conference of the parties on its seventh session held at Marrakesh from 29 Octuber to 10 November 2001.* United Nations Framework Convention on Climate Change .

UNFCCC. (2007). *UNFCCC int*. Retrieved September 13, 2007, from United Nations Framework Convention on Climate Change: http://unfccc.int

UNFCCC. (2001). *United Nations Framework Convention on Cliamte Change.* Retrieved Sptember 13, 2008, from http://unfccc.int/resource/docs/cop7/13a02.pdf

UNFCCC. (1992). United Nations Framework on Convention on Climate Change. United Nations.

UNISDR. (2005, October 12). *International Strategy for Disaster Reduction*. Retrieved September 21, 2008, from http://www.unisdr.org/eng/public_aware/world_camp/2005/2005-iddr.htm

Uprety, B. N. (1999). An overview of the Stratigraphy and Tectonics of the Nepal Himalaya. *Journal of Asian Earth Sciences , 17* (5-6), 577-606.

Weiss, N., & Hassett, M. (1982). *Introductory Statistics.* Addison- Wesley Publishing Company,Inc.

WMO. (2004). *Weather, Climate and Water in the Information Age.* World Meteorological Organization.

WWF. (2007, Sptember). *WWF Conservation News*. Retrieved Sptember 12, 2007, from www.panda.org: http://www.panda.org/wwf_news/

Xiaodong, C., & Baode, L. (2000). Climatic Warming in the Tibetan Plateau during recent decades. *International Journal of Climatology , 20*, 1729-1742.

Y2Y. (2007, Sptember). *Yellowstone to Yukon Conservation Initiatives*. Retrieved Sptember 10, 2007, from www.y2y.net: http://www.y2y.net/

ANNEXES

Annex I: Questionnaire For Household Survey.

Household Survey on Community Vulnerabilities & Coping Mechanisms@ Khudi.

HH No.;…….. VDC Name:…….

Interviewer:…….. Date: ……

I. General Information:

a. नाम :

b. जातियता: c. लिङ्ग: पुरुष ☐ महिला ☐

d. गाऊँ।टोल :..... e. वार्ड नम्वर :.....

f. शैक्षिक योग्यता :.....

II. Family Poster:

S no	नाम (optional)	सम्मन्ध *	लिङ्ग	उमेर	वैवाहिकता	शिक्षा	पेशा	कैफियत
01								
02								
03								
04								
05								
06								
07								
08								
09								
10								

**Relation to respondent (एउटै चुलो प्रयोग),*

Husband/wife	1
Son	2
Daughter	3
Daughter in law	4
Grandson/daughter	5
Others in family	6

Marital status

Married	1
Unmarried	2
Widow	3
Widower	4

Education Level

Illiterate	0
Literate	1
Up to SLC	2
IA/+2	3
BA & above	4

III. Socio-economic (Land, Livestock & Income):

1. के तपाईको आफ्नै जग्गाजमिन छ ?

1. छ ☐ 2. छैन ☐

1.1 यदि छैन भने, तपाई कसरी जग्गाजमिन बिहिन हुनु भयो

……

1.2 यदि छ भने, तपाईको जग्गाजमिनको बारेमा निम्न जानकारि दिनु हुन्छ ?

जग्गाको किसिम		आफ्नो आफैले कमाएको	अर्काको आफूले कमाएको	अर्कालाई कमाउन दिइएको	एक रोपनि जग्गाको मूल्य(रुपयाँमा)
खेत	पूर्ण सिंचित्				
	आकासे पानिमा सिंचित्				
बारी					
खुल्लाजमिन।खोरिया					
वन जंगल					

2. गत बर्ष तपाईले कति अन्नबालि उत्पादन गर्नु भयो ? के तेस्लाई बेच्नुपानि भयो ?

बालिको किसिम	बालिलगाएको जमिनको क्षेत्रफल(रोपनिमा)	उत्पादन (मुरिमा)	बेचेको भए, बिक्रि गरेको मूल्य	किनेको भए, किनेको मूल्य	उत्पादन को क्रम (ब/घ/उ)*
धान					
मकै					
कोदो					
गहुँ					
जौ					
आलु					
फापर					
तोरि					
भट्मास					
अन्य					

3. अन्नबालि उत्पादनमा किन त्यसरी घट्बड भएको होला ?

……

4. बिगत १०-२० बर्षमा बालिनालिमा आएको परिवर्तन बारे बताईदिनु हुन्छ कि ?

बालि /परिवर्तन	धान		मकै		गहुँ		कोदो		अन्य	
	पहिले	अहिले	पहिले	अहिले	पाहिले	अहिले	पहिले	अहिले	पहिले	अहिले
क्षेत्रफल (रोपनिमा)										
जात(नाम)										
मल प्रयोग										
बिऊबिजन प्रयोग										
प्रविधिको प्रयोग										
सिंचाई(क्षेत्रफल)										
अन्य										

5. तपाँईको परिवारको बार्षिक आम्दानि विवरण बारे जानकारि दिनु हुनछ कि ?

आम्दानिको स्रोत		बार्षिक आम्दानि (12 * per month Rs)
कृर्षी	अन्नपात	
	वस्तुभाउ	
यहिठाउँको जागिर		
नेपालमा जागिर		
नेपालबाहिरको जागिर(काम)		
व्यपार/पर्यटन		
अन्य		

6. के बिगत १०-२० बर्षमा आम्दानिका स्रोतहरु बद्लीएका छन् ?

1. छन ☐ 2. छैनन् ☐

यदि छन् भने कसरी बद्लिएका छन् ?

.....

7. तपाँईको घरको बार्षिक खर्च विवरण दिनुहुन्छ कि ?

खर्च		खर्चित् रकम (रुपैँयामा)
कृर्षि	ज्यालादारि	
	प्रविधि	
स्वास्थ्य		
शिक्षा		
व्यपार		
अन्य		

IV. Climate Change:

Changes(परिवर्तन)

9. के तपाँईले बिगत ३०-४० बर्षमा तलका मध्य कुनै परिवर्तन महशुस गर्नु भएको छ ? (कृपया √)

	छ	छैन	ऊस्तै छ	थाहा छैन	येदि छ भने		
					बड्दो	घड्दो	अन्य
तापक्रम घटबड्							
बर्षा							
हुरिबतास							
हिउँपर्ने तरिका							
चट्याङ							
बादललाग्ने दिनहरु							
सिमसिमे पानिपर्ने							
अन्य							

10. के तपाँईले तलका कुराहरु महसुस गर्नु भएको छ ?(√)

1. धेरै ताता गर्मिका दिनहरु(Extreme hot summer days)
2. अत्यन्त चिसो जाडो मौसम (Extreme cold winter)
3. जाडोमा कम चिसो र शित पर्ने क्रम (Winter are less cold and frosty)
4. दिनहरु अझ बढि ताता हुँदैछन् (Days are becoming hotter)
5. अन्य (Specify)……..

11. यस्तापरिवर्तन, प्राकृतिक प्रकोपहरुले सामाजिक चालचलनमा के कस्ता असरहरु पारेका छन् जस्तो लाग्छ?

- ……..
- …….

12. Impacts and mitigation (असर र समाधानका उपायहरु)

Impacts due to change on (पारिवर्तनले गरेका असरहरु)	**Impacts**(असर हरु)	**Mitigation/adaptation/technology adapted** (समाधानका उपाय,प्रविधि आदि)	**Remarks** (कैफियत्)
Land use			
Agriculture(कृषिमा)			
Forest(वनजंगलमा)			
Snow cover area(हिउँपर्ने क्षेत्रमा)			
Waste land(त्यसै छाडिएको जमिनमा)			
Pasture land(चरन क्षेत्रमा)			
Biodiversity(जैविक विविधता)			
Forest(वन)			
NTFP(काठबाहेकका वन पैदावार)			
Agriculture(कृषि)			
Animal(जनावर)			
Birds(चराहरु)			
Fish(माछा)			
Crops			
Crop productivity(उत्पादकत्व)			
Crop quality(गुणस्तर)			
Crop species(बालिको किसिम)			
Crop calendar(Phenology) (बालि रोप्ने र पाक्ने अवधि)			
Water resources			
Water availability (पानिको प्रयापता)			
water quality(पानिको गुणस्तर)			
Natural disasters			
Flood(बाडी)			
Landslides(पहिरो)			
Drought(खडेरी)			
Others(अन्य)			
Pest/Diseases and Health(किटानु,स्वास्थ्य र रोग)			
Tourism(पर्यटन)			

12. ति असरहरुलाई कम गर्न तपाँई ले केहि तरिकाहरु अप्नाउनु भएको छ ? जस्तोकि,

Impacts on	Adaptation/Technology	√
Agriculture (कृषिमा)	नयाँ जातको बालि लगाउने	
	Adoption to agroforesty/Horticulture/crop rotation	
	बालि परिवर्तन	
	थोपा सिंचाई (Drip irrigation)	
	आलोपालो पानि लगाउने (Rotational irrigation)	
	पाइपबाट पानि छरेर गर्ने सिंचाई(Sprinkle Irrigation)	
	हरित् गृह प्रिविधि (Green house technology)	
	चरन व्यवस्थापन (Pasture management)	
	गरा बनाउने (Terracing)	
Water resources (जल स्रोतमा)	बर्षातको पानि संकलन गर्ने(Rainwater harvesting)	
	भेलबाडिको पानि संकलन(water harvesting through dam)	
	नयाँ स्रोतको प्रयोग (shifting to new source)	
Disasters(flood/landslides/ drought etc) (प्रकोप)	पूर्वजानकारी दिने पद्दति (Early warning system)	
	तालिम, भ्रमण र ज्ञान (Knowledge transfer/training organizational visit)	
	सामुदायिक छलफल र पूर्वतयारि (Interaction/preparedness forum in community)	
	संचार (रेडियो, टिभि, पत्रपत्रिका)(Use of media(radio/newspaper/TV etc)	

V. **Disasters(प्रकोप):**

14. यो समुदायमा बढि असर गर्ने प्रकोपहरु के के हुन् ? (Rank)

1. पहिरो (Landslide) ☐
2. बाडि (Flood) ☐
3. खडेरि (Drought) ☐
4. चट्याङ्ग (Lighting) ☐
5. भू-क्षय (Erosion) ☐
6. हुरिबतास (Hail/wind storms) ☐
7. अन्य (Others)…… ☐ ……

15. यो क्षेत्रमा जाने बाडिपहिरोको कारण तपाँईलाई के हो जस्तो लाग्छ ?

1. वन फडानि २. विश्वव्यापि तापक्रम वृद्धी 3. बड्दो प्रदुषण

4. अस्वभाविक मौसमि परिघटनाहरु 5. अन्य……

16. पछिल्ला बर्षहरुमा तपाईले तलका कुराहरुमा कस्तो परिवर्तन अनुभव गर्नुभएको छ?

परिवर्तित् विषयहरु(√)	बडेको	घटेको	उस्तै	थाहा छैन	कैफियत
बाडिको मात्रा (Flood)					
पहिरोको मात्रा(Landslide)					
भू-क्षयको दर (Rate of soil erosion)					
चट्याङ्गको क्रम(Lighting)					
हूरि बतास (Hail/Wind storms)					
अगलागि (Firing)					
जाडोको तापमान(Winter temp)					
गर्मिको तापमान(Summer temp)					
मुसलधारे पानि (Heavy rainfall)					
कम पानि (Low rainfall)					
जाडोमा पर्ने पानि (Winter rain)					
बर्षामा पानि पर्ने अवधी(Duration)					
कम पानि पर्ने क्रम(low rain)					
बेमौसमि बर्षात (Unusual rain)					
बर्षात शुरुहुने समय (monsoon)					
खोलामा पानिको तह					

17. बिगत १० बर्षमा प्रकोपले तपाँईको परिवारमा पुर्याएको क्षतिको विवरण दिनु हुन्छ कि ?

प्रकोपहरु	बर्षहरु	क्षति						
		जन्(व्यक्ति) (संख्या)	वस्तुभाठ		खेतियोग्यजमिनकोक्षति		बालिनालिको क्षति	
			संख्या	रुपैंया	रोपनि	रुपैंया	मुरि	रुपैंया
बाडि								
पहिरो								
खडेरी								
हुरि								
चट्याङग्								
हिमपात								

18. तलका कुराहरुले तपाँई र तपाँईको समुदायमा पारेका नकारात्मक असरहरु के के हुन् ? (Please quantify)

	घरगोठको क्षति (संख्यामा)	खेतियोग्य जमिन, उत्पादन (रोपनि, मुरि)	पानिको स्रोत	वन एंवम् जैविक विविधता	अन्य
बाडि					
पहिरो					
खडेरि					
भू-क्षय					
बेमौसमि बर्षात्					
अन्य					

19. यस क्षेत्रबाट कुनै प्रकोपले मान्छेको बसाँई सराई गराएको छ ? यदि छ भने

1. बाडीले 2. पहिरोले 3. भू-क्षयले 4. अन्य .....

20. विपद।प्रकोप आईपरेको समयमा तपाँईलाई क-कस्ले सहयोग गरे (√)

1. छिमेकिले 2. सरकारले

3. स्थानिय संघसस्था र रेड क्रस 4. ऋण। विदेशी पैसा ५. अन्य.....

VI. <u>Awareness/knowledge/institution/Needs for capacity development.</u>

20. के तपाँई जलवायू परिवर्तन र प्रकोप न्यूनिकरणका लागि तपाईहरुले अप्नाउनु भएका र यस समुदायमा भएका तरिका बारे जानकारि दिनु हुन्छ ? जस्तोकि (√)

1. पूर्वसूचनादिने पद्दति(Early Warning System) 2. मुठ्ठिदान। बिमा (Insurance)

3. कटुवाल 4. पूर्वतयारि एवं तालिम ५. अन्य.....……

21. तपाँईको विचारमा,जलवायू परिवर्तनले निम्त्याउने जेखिम कम गर्न के-के आवश्यक पर्ला, कस्ले र कसरि गर्ने ?

आवश्यक्ता	बारेमा(Description)	कसरी कार्यन्यन गर्ने	कस्ले कार्यन्यन गार्ने
संघसस्थाहरु			
जनचेतना			
प्रविधि र स्रोत			
पूर्वसूचनादिने पद्दति			
खाद्य सुरक्षा			
उद्दार र राहत			
सुरक्षित् स्थान			
बिमा			
अन्य			

22. तपाँई कुनै संघसस्था सँग आबद्द हुनुहुन्छ?

1. छ ☐ 2. छैन ☐

यदि छ भने,

संघसस्था	पद	उद्देश्य

VII. <u>Interviewer's comment</u>

……
……
……

 **The End** 

Annex II: Checklist for Focal Group Discussion.

Focal Group Discussion on Community Vulnerabilities & Coping Mechanisms@ Khudi.

(Base line survey in different ecological zones)

Village Name:…….

Location (GPS Points): Lat:…… Lon:…….. Elevation:…….

Moderators: Aseem, Raju, Yubraj Date: ……

Checklist.

Climate Change (temperature):

I. Trend

13. Have this community experienced any changes in temperature in last 30 years?

    What type of change in Temperature?

14. How temperature is changing? (promote by following points)

(Extreme hot summer days, Extreme cold winter, winter are less cold and frosty, Days are becoming hotter, other)

II. Impact/ Adaptation/mitigation

Then what you think are the impacts

(In agriculture, diseases spreading, water resources,…..)

15. What, you think, are the consequences of warmer days and seasons?

16. Then to escape from such changes, what your community use to do?

Climate Change (Rainfall/snowfall):

17. Have you experienced any changes in rainfall/snowfall within last 30 years?

If yes then,

What type of change?

1. Rainfall/Snowfall increasing
2. Rainfall/Snowfall is decreasing
3. I don't know

18. Do you have any experiences on followings?
    1. Unusual rainfall
    2. Increasing cloud burst (heavy rainfall at once)
    3. Longer rainy season

4. Shorter rainfall
5. Delayed monsoon starting
6. Longer drought
7. Decreased winter rainfall
8. Increased winter snowfall
9. Increased in hailstorm/windstorm

Impacts:

19. What, you think, are the consequences of changed rainfall pattern in agriculture?

    (In Agriculture yield increased/decreased)

20. What are the consequences of changed rainfall pattern in Water Resources? (Water availability increased/ decreased, Flood frequency increased/decreased etc)

21. What are you doing to cope with these changes in rainfall?

    (Delay cropping, new variety of plantation etc…)

Climate Change (Others):

22. Have you noticed any changes in wind pattern in this region?

23. Is there any long drought in this area in past years, how long was it , what are the impacts and how you mitigate?

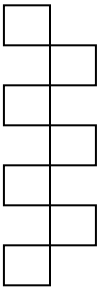
24. What about lighting occurring frequency in these days?

25. What are the impacts of these changes and how you are mitigating them?

Disasters:

26. What are the most significant disaster in this community, you think?(Rank)

1 Landslide
2 Floods
3 Droughts
4 Lighting
5 Erosion
6 Hail/wind storms
7 Others.....



27. What, you think, are the causes of landslide/ flood in the region?

(Deforestation, Global change, increased pollution, abnormal weather events (abnormal rainfall, increased temperature etc)

28. Does this community feel any changes on the following in these years?

29. What are the losses you have due to disaster (flood, landslide, lighting, drought, hailstorm etc.. within last 10 years ?

Disaster(√)	Increased	Decreased	Not changed	Do not know	Remarks
Flood					
Landslide					
Drought					
Lighting					
Hail/Wind storms					
Firing					
Winter temperature					
Summer temperature					
Heavy rainfall					
Low rainfall					
Winter rainfall					
Duration of rainfall in monsoon					
Trend of cloud burst					
Trend of unusual rainfall					
Starting time of rainfall					
Amount of water level in river					

30. Which disasters have caused migration of people from the village (If any) ?
31. What helped to recover you from disaster?
    1. Support from neighbors
    2. Support from government organization
    3. Support from local NGOs and Red Cross
    4. Loan/ Remittance
    5. Migration

Annex III: Data of Temperature as recorded in DHM's Khudi Station.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature Maximum												
1987	20.2	22.4	24.5	28.8	30.1	30.3	28.5	29.1	29	26.4	24.4	21.1
1988	20	22.2	24.9	30.2	30.4	30.2	29.2	29.3	29.3	28.2	25.2	20.5
1989	17.6	20.3	25.2	31	31.2	29.9	28.4	29.6	29.2	27.9	24	20.8
1990	21.8	20.6	24	29.1	30.3	31.9	30.7	31	30.1	27.2	25.7	21.2
1991	18.9	23	26.8	29.9	31	30.6	30.9	30.4	31	28.8	24.3	19.8
1992	18.2	22.3	27.5	32.2	30.2	31.9	30.2	30.2	30.1	27.2	24.5	20.1
1993	19	23.6	25.3	30	30.3	32.1	31.7	30.2	29.8	28.9	25.2	23
1994	21.7	21.8	26.7	30.6	32.8	32.2	32.6	32.3	30.6	29.3	27.2	22.1
1995	20	22	27.1	31.9	33.2	31.4	31.4	31.8	31.2	29.8	26.5	21.9
1996	19.9	22.4	27.9	31.7	33.2	31.1	31.1	31.6	31.5	28.1	26.5	22.8
1997	20.2	21.2	27.1	27.7	31.5	31.5	31.1	30.7	29.5	26.3	24.4	19.2
1998	19.6	23.1	24.8	29.8	31.4	31.9	30	29.5	30.6	28.8	25.4	
1999					31	32.1	30.7	30.4	30.5	28.7	25.2	22.1
2000	20.3	21	26.3	30.7	31	30.7	30.5	29.7	29.1	28.5	25.2	21.3
2001	20	23.3	27.8	30.8	29.4	31.1	30.7	30.9	29.2	28.3	26.6	20.5
2002	21.1	23.7	27.8	29.1	30.4	31.3	29.5	30.7	29.5	27.1	25.6	22.4
2003	22.6	22.4	25.1	30.3	30.2	29.6	29.5	29.8	28.9	28.3	24.3	20.8
2004	19.2	22.7	28.2	28.1	29.6	29.6	29.2	30.2	28.6	27	24.2	21.3
2005	19.7	22.3	26.7	30.5	29.8	31.2	29.9	29.8	29.9	26.9	23.6	21.4
2006	22	24.9	27	29.6	30.2	30	31.2	30.4	30.3	28.7	25.7	21.9
Temperature Minimum												
1987		12.6	13.6	16.5	18.7	21.8	21.7	21.5	20.9	15.9	12.2	9.2
1988	8.8	11.1	13.6	17.8	19	21.1	22.2	21.8	20.9	16.1	11.5	10.4
1989	8	8.8	13.4	17.7	19.7	21.1	21.6	21.3	20.8		9.4	6.9

1990	8.8	9.6	11	15.3	18.1	21.2	21.1	22.3				7.2
1991	6.5	9.8	14.5	17.2	19.3	21.1	22.1	21.7	20.6	16.2	10.9	8
1992	7.7	11.1	13.5	17.7	17.4	21.3	21.2	21.5	19.9	16	10.8	6.8
1993						20.6	21.8	21.5	19.8	16.1	12.1	8.8
1994	7.1	7.8	13.6	15.8	19.1	21.2	21.8	21.7	20.5	14.6	10.1	7.1
1995	5.9	8.2	11.8	16.3	20.6	21.8	21.5					
1996		8.5	13.5	16.2	18.3	20.2	21.6	21.1	19.6	15.4	11.7	8.2
1997	6.4	8	11.6	13.7	16.8	19.2	21.1	21	19.5	13	10.5	7.3
1998	6.3	8.7	11.3	15.4	19	21.3	22	21.7	21	18.1	12.6	8.2
1999	6.9	10.7	13.4	17.7	19.1	21.3	22	22.5	20.6	16.7	11.9	NA
2000	7.5	7.6	11.4	17.3	21.5	20.6	21.6	21.1	19.6	15.9	12.4	8.2
2001	7.8	8.8	12.8	16.2	18.7	21.7	22	22.2	20.7	17.3	14	8.4
2002	7.3	10.9	14.7	17.1	19.6	21.2	21.6					
2003						21.7	21.8	22.2	20.7	16	12.3	8.4
2004	7.2	9.6	15.8	16.5	19	20.3	21.4	21.6	20.3	15.3	10.7	8.5
2005	7.5	9.8			18	20.9	21.9	21.9	20.7	16.2	11	7.6
2006	7.1	13	13.3	16.2	19.5	20.8	22.4	21.6	20.7	16.6	12.4	10

Annex IV: Data of Precipitation as recorded in DHM's Khudi Station.

Rainfall (mm) for KHUDI BAZAR												
Latitude(deg/min): 2817												
Longitude(deg/min): 8422												
Elevation(m): 0823												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1975		54.9	25.4	140.4	235.4	676.8	923	554.8	620.4	154.2	0	4.4
1976		37.7	1.2	99.8	227.2	740.2	807.8	715.8	426.2	33.8	0	0
1977		7.8	21	169.1	193.2	334.8	938.6	976.1	491.6	105	85	39
1978		38.8	128.6	58.7	114.8	568.6	699.2	715.7	416.3	48.3	8.8	21
1979		61.6	37.5	107	154.8	464.1	1017.1	845.1	312.9	285.1	14.8	40.3
1980		46.4	156	82	76.5	361.7	954	717.4	641.1	12.4	0	0
1981		20.4	67.9	44.5	224.5	236.1	684.2	533	354.9	1.9	26.3	0
1982		59.1	166.2	129.1	120.5	423.3	633.9	842.4	436.5	47.1	34.4	3.2
1983		89.7	53	38.8	205.6	318.7	780	796.1	573	257.5	0	36.2
1984	12	4	47.6	95.5	465.4	737.6	1056.8	871.5	414.1	31	0	0.5
1985	19.5	75	106.1	157.3	485.2	307.4	1067	904.9	563.7	292.2	90	61.1
1986	0	27.9	86.7	142.3	121.8	641.6	860.4	595.7	949.8	69	54.3	43
1987	10.3	18.8	146	214.4	125	500.6	1064.4	933.5	355.4	116.2	2	32.2
1988	0	37.8	67.4	40.2	99.1	591.2	1038.6	1157.4	380	15.3	2.4	93.6
1989	100.6	63.5	30.2	38.4	373	700.3	602.2	869.2	497.5	15.4	37.5	18.1
1990	0	66.5	133.2	191.9	245.2	758.5	689.7	744	575.3	71.4	0	4.6
1991	34.7	46	95.4	86.8	216.6	538.3	642.7	1033.5	473	38.6	7	44.4
1992	25.4	38.8	15.2	8.5	113.6	206.7	646.5	849.5	557.1	170.2	12.2	23.7

1993		20.4	84.4	136.6	242.2	498.7	644.8	1079.8	425.2	96	0	0
1994	23.5	51.1	88.1	85.9	145.2	657.4	711.6	898.3	482.7	34.4	13.5	2
1995	32.6	83.2	89.5	50.1	434.5	464.3	995.2	735.4	409.7	88.2	97.2	6
1996	50	204.1	142.9	25.1	111.6	873.6	1075.9	1298.3	561.3	93.1	0	0
1997	42.7	39.3	0	151.8	130.5	488.5	827.4	824.2	437.6	97.5	26	189.9
1998	0	25.4	192.3	79.2	254.2	653.9	819.9	1095	344	70.5	15	0
1999	18	0	0	60	440.5	556	880.1	749.6	631.2	100.6	0	0
2000	22	24.4	83.5	65.5	288.7	616.5	874	884	684	2	0	0
2001	11.5	63	15.5	88.5	246.7	620.3	599	737.5	565.5	184	6.5	1.8
2002	105.3	33.2	42.8	39.8	330.3	784.2	993.3	645.6	257	52.8	20.1	0
2003	0	70.5	79.8	75.8	129.2	533.8	1427.5	785.4	673.5	36	1.5	36.2
2004	26.1	6.7	48.6	395	500.2	685.4	1109.2	681	465.2	222.5	1	0
2005	72.5	41.3	86	154	152	298	888	638.2	358.4	149.5	0	0
2006	0	5.7	54.1	171	280.7	472.2	630.8	840.5	307.5	54.6	4.5	30.1

Annex V: Snaps of Field Research.

Picture 6: Researcher conducting FGD with stakeholders.

Picture 7: Khudi Bazar is Vulnerable from the flood of Khudi River. An evacuated house due to flooding in the Khudi River.

Picture 8: Researcher conducting Household survey.

Picture 9: Making Final presentation of the research work.