Chapter - 1
INTRODUCTION

1.1Background

Climate is commonly defined as the weather averaged over a long period of time (AMS 2009). The standard averaging period is 30 years (BMO 2009). Climate change is defined 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" (UNFCCC 1997). Climate change refers to the variation in the Earth's global climate or in regional climates over time. It describes changes in the variability or average state of the atmosphere over time scales ranging from decades to millions of years. These changes can be caused by processes internal to the Earth, external forces that are variations in sunlight intensity or, more recently, human activities (IPCC 2001). It is one of the most serious challenges of this century. It is affecting people, animals, plants and natural environments–from the deepest ocean to the highest mountain. These climate change effects are due to an increase in greenhouse gases (GHGs) in the atmosphere. The main gases are carbon dioxide, methane, nitrous oxide and fluorocarbons, principally from the burning of fossil fuels, forest destruction, industrializations and agriculture (rice field cultivation and the keeping of livestock). Water vapor in the atmosphere also plays a role that resulted in global warming. With the increasing emission of GHG into the atmosphere, further climate change is forecasted (NBCCAB 2004). The Warming trend that has been observed in Nepal is higher than the global average. The rates of increasing temperature differ from place to place but in general, larger in higher altitude compared to low land. The ongoing records of national temperatures since 1962 and recent analyses of these records show high inter-annual variability, and that maximum temperatures in Nepal are progressively increasing in line with global and regional records (NCSAP 2008 cited in ADB 2009). Since 1977 and 1994, the mean annual temperature is estimated to have

increased by 0.06°C, and is projected to increase by another 1.2°C by 2030, 1.7°C by 2050, and 3.0°C by 2100 (ADB 2009). Another report of the government of Nepal, based on an analysis of the temperature recorded between 1981 and 1998, shows an increase of 0.41º Celsius per decade (HMGN 2004). According to the records of the Department of Hydrology and Meteorology, the average temperature of Nepal was increased by 1.8^0C per `annum during the period of 1975 to 2006. Now, average temperature rise is estimated at 0.5^0C per decade, which is very high compared to several other developing countries. Precipitation is also becoming unpredictable and more erratic than ever, with more droughts and shorter periods of heavy rainfall (Shrestha *et al.* 2000). Days and nights are becoming warmer and cooler days and nights are becoming less frequent. Precipitation extremes show an increasing trend in intense precipitation events at most recording stations. The assessment indicates that more weather-related disasters such as floods and landslides can be expected in future (ADB 2009). To understand climate variation and change, it is essential to assess the climate's sensitivity to a variety of factors, both the human and natural.

Nepal, located in geologically young and unstable rugged terrain in the Himalayas, has natural environment with diverse and vulnerable ecosystems. These ecosystems are increasingly threatened by a rapidly growing population by putting pressure on its fragile natural resource base including land water and forest resources (ADB 2009). Although Nepal has a negligible share in global emissions of greenhouse gases, it is particularly vulnerable to climate change due to its fragile mountain ecosystem. Various studies have shown that the impacts of climate change are evident on forests, biodiversity, water resources, agriculture and other sectors in Nepal. Therefore, different types of impact of climate change have been noticed on water resources, forests, biodiversity, environment, health and livelihoods. However, climate change creates opportunities and risks for human development. In order to address the possible impacts of climate change adaptation practices should lay emphasis on sustainable development. Adaptation can be defined as: "adjustment in ecological, social or economic systems in response to actual or expected climatic stimuli and their effects or impacts" (Smith *et al.* 1999). It is manly about warning people about certain events in advance and preparing them to deal with vulnerability and uncertainty (Chaudhary and Aryal 2009). Adaptation

to climate change has received increased attention in the scientific and policy debate, and is seen as complementary to mitigation (UNFCCC 1997; McCarthy *et al.* 2001). Adaptation assessments are developed and impacts of climate change on livelihood and its adaptation practices, this study was carried out in Fulkharka VDC of Dhading district.

1.2 Statement of the Problem

Climate Change is an emerging problem of global scale having deep impacts at local scale. Effects of global warming encompass all the vital systems supporting world populations ,namely ,water resources ,human health, agriculture, forests and biodiversity .Scientists have suggested that future climate change will significantly affect the distribution , condition, species composition and productivity of ecosystem. Already in Nepal some of the greatest increases in temperature and rainfall have been recorded but the over impacts is very uncertain due to lack of expertise ,studies and publications on country specific issues of climate change issues in Nepal ,an exact evaluations could not be done on areas of impacts ,effected geographic regions and type and level of impacts .While awareness and capacity are the basic barriers, lack of research and credible evidence on the impacts of climate change is the next major challenge.

Although several agencies are concern for climate change .they mainly focus on high altitude and the glacial retreat .So it is important that local conditions and there adaptations pattern be studied .There is limited understanding on the issues of climate change on livelihood .There is a clear need to educate .But before that it is important to know how people on the ground are dealing with the changes that they are facing .Local communities can play a vital role in determining adaptation practices based on local information and knowledge.

1.3 Rationale of the Study

Climate Change is one of the most emerging problems in the global scale having deep impacts at local scale. It is due to the effects of global warming which encompass all the vital systems supporting world populations, namely, water resources, human health, agriculture, forests and biodiversity. Scientists have suggested that future climate

change will significantly affect the distribution, condition, species composition, and productivity of ecosystem. Some of the greatest increases in temperature and rainfall have already been recorded in Nepal but the overall impact is very uncertain due to the lack of strong evidences gathered through researches. Scarcity of information and lack of resources, studies and publications on country specific issues of climate change is evident; this study tries to resolve the above mentioned problems to some extent.

Although several agencies are concerned for climate change, they mainly focus on high altitude and the glacial retreat. So it is important that local conditions and their adaptation pattern be studied. There is limited understanding on the issues of climate change on livelihoods. Therefore, it is necessary to alert the farmers on the possible effects of climate change and appropriate strategies to cope with these effects. But before that, it is important to know how people on the ground are dealing with the changes they are facing. Local communities can play a vital role in determining adaptation practices based on local information and knowledge.

Therefore this study leads towards the understanding and knowledge of people on the issue of climate change, the impacts they are going through and also the adaptation options that can emerged from within them.

1.4 Objectives of the Study

General Objective:

To assess the impacts of climate change on rural livelihoods and its adaptation practice in Dhading district.

Specific Objectives:

- To determine the local understanding on climate change.
- To identify the impact of climate change in rural livelihoods.
- To document the current adaptation measures practiced.

1.5 limitation of the Study

- There was lack of baseline information on the physical as well as socioeconomic data of concern; it was collected on the basis of memory of the people.
- This is a case study from a VDC, a small unit, which may have limitations in generalizing the findings for elsewhere.

1.6 Structure of the Thesis

The report is structured as follows:

Chapter 1 Deals with general study context, statement of the problem, rational of the study, objective and limitation of the study.

Chapter 2 Gives with the literatures related to the study starting from the overview of climate change, its impact on livelihood and adaptation and mitigation practices..

Chapter 3 Describes the overview on the methods and approach used during the study.

Chapter 4 Provides the short overview of the study area.

Chapter 5 Presents results and discussions including socio-economic condition of the respondents, rural understanding on climate change, impact of climate change, and its adaptation practice.

Chapter 6 draws conclusion and recommendations drawn from the study.

Chapter 2
REVIEW OF THE CURRENT KNOWLEDGE CLIMATE CHANGE

2.1 Definitions of the Concepts

Adaptation

Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

Biodiversity

Biodiversity is the numbers and relative abundances of different genes (genetic diversity), species, and ecosystems (communities) in a particular area. In this study biodiversity denotes only species and ecosystem diversity.

Climate

Climate is defined as the "average weather" or more rigorously as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These relevant quantities are most often surface variables such as temperature, precipitation, and wind. More than 20-25 years of average weather is known climate in this research.

Climate change

Climate change refers to "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. 20-25 years of average weather change is known climate change in this research

Climate impact assessment

Climate Impact assessment is the practice of identifying and evaluating the detrimental and beneficial consequences of climate change on natural and human systems.

Greenhouse gases

Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorbs and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere, and clouds. This property causes the greenhouse effect. Water vapor (H2O), carbon dioxide (CO2), nitrous oxide (N2O), methane (CH4), and ozone (O3) are the primary greenhouse gases in the Earth's atmosphere.

Impacts of climate

Climate Impacts is the Consequences of climate change on natural and human systems.

Local peoples

Local peoples are the individuals living within the same political boundary of the study sites.

Livelihood (s):

Livelihood is a combination of the resources used and the activities undertaken in order to live. According to Ellis (2000) "A livelihood comprises the assets and the access to these (mediated by institutions, social relations and organizations) that together determine the living gained by the individuals or households." Agriculture, water resources, biodiversity, and health are the indicator of livelihood, in this study.

Vulnerability

Vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Vector-borne diseases

Vector-borne disease is that type of disease which is transmitted between hosts by a vector organism such as a mosquito or tick (e.g., malaria, dengue fever etc.).

2.2 Climate change

Climate change is a reality now and will continue for decades and potentially centuries to come. It is clear that burning of fossil fuels and deforestation are responsible for emission of GHG that ultimately change the climate (Smith 2006). Direct observation of climate change is seen as increase in global average air, ocean temperature, widespread of snow and ice, unpredictable rainfall pattern and rising average sea level.

For the global average temperature, warming in the last century has occurred in two phases, from the 1910s to 1940s (0.35°C) and more strongly from 1970s to present (0.55°C). An increasing rate of warming has taken place over the last 25 years, and Eleven of the last twelve years (1995-2006) rank among the twelve warmest years in the instrumental record of global surface temperature (since 1850) (IPCC 2007). IPCC has also reported that the overall observed surface air temperature in Asia has increases by approximately 1-3°C over the last century from 1906 to 2005. Similarly, the mean annual temperature of Nepal is estimated to have increased by 0.06°C from 1977 and 1994; and is projected to increase by another 1.2°C by 2030, 1.7°C by 2050, and 3.0°C by 2100 (ADB 2009).

Amount, intensity, and frequency of precipitation are changed recent years. Pronounced long term trends from 1900 to 2005 have been observed in precipitation amount in many large regions. Over this period, precipitation increased significantly in eastern parts of North and South America, northern Europe and northern and central Asia

whereas precipitation declined in the Sahel, the Mediterranean, southern Africa and parts of southern Asia. (IPCC 2007). However there is not any significant change in annual as well as monsoon precipitation in Nepal (Baidya *et al.*2007, Shrestha *et al.*2000). Though no definite trends could be found in the annual precipitation records, clearly decreasing trends was seen in the annual number of rainy days during the last four decades (Baidya *et al.* 2007).

2.3 Impact of Climate Change on Natural and Human System

It is clear that climate change will, in many parts of the world, adversely affect socio-economic sectors, including water resources, agriculture, forestry, fisheries and human settlements, ecological systems and human health and the developing countries being the most vulnerable (IPCC 2001). It is widely accepted that poor, natural-resource dependent communities in the developing world are especially vulnerable to climate change, especially those living in high-risk areas such as small islands or low lying coastal areas (IPCC 2007). Similarly, the current climatic changes are likely to have impacts on different sectors of Nepal. The several sections that provide accounts of observed impacts and impacts that are likely to occur in the future in different sectors may be, Water Resources, Agriculture, Flora and Fauna, Health and Livelihood sectors.

Water Resources

Nepal has more than 6,000 rivers, which provide a dense network of rivers with steep topographic conditions. All the river systems drain from North to South towards the Ganges. River basins in Nepal are spread over a diverse and extreme geographical and climatic condition that the potential benefits of water are accompanied by risks. Rising temperatures have caused glaciers to melt and retreat faster. Receding glaciers mean an increased risk of the sudden flooding following glacial lake outbursts. Glaciers are excellent indicators of climate change and global warming (Ageta and Kadota 1992, Oerlemans 1994). Warming led glacier retreat in the Nepalese Himalayas is widespread and alarming. According to a study carried out by the International Commission for Snow and Ice, snow in the Himalayas will disappear by 2035 if no proper initiative is taken to

reduce warming. Due to snow and glacial melting, several glacial lakes are under tremendous risk of flooding in Nepal (Oerlemans 1994). Lakes either overflow or seep and dams are sometimes broken, sweeping lands, forests and houses, and damaging valuable property downstream. Moreover, there are still at least 20 glaciers in Nepal that are likely to outburst in next 5-10 years (UNEP 2002).

Agriculture

Agriculture is the mainstay of the economy, providing a livelihood for over 80% of the population and about 80% of the total population depends on the forests for daily fuel wood supply. Poor, marginalized and disadvantaged people in rural areas of Nepal, whose livelihoods primarily depend on natural resources and climate sensitive sectors such as agriculture, forestry and fisheries are vulnerable to climate change.(Raut 2006, Dahal 2006, Regmi and adhikari 2007). Majority of farmers depend on monsoon rain for crop cultivation. Changes in rainfall pattern can be devastating for their crops; extreme rainfall can also cause injuries and loss of life. (Regmi and Adhikari 2007).

Studies have been carried out on the impacts of climate change study on some of the cereal crops of Nepal. Vulnerability assessment of rice yield showed that a 4°C rise in temperature and 20% increase in precipitation could result in marginal increase yield from 0.09 to 7.5 %. Beyond that, the yield would continue to decline. In the case of wheat, the actual yield showed increased output in the western region of Nepal with the rise in temperature, but a decline in other regions. Similarly, temperature rise showed a decrease in maize yield with increase in temperature. Though temperature rise had more negative effects on maize yield, the trend was almost similar to wheat. However, rice, wheat, and maize responded positively under double CO_2. Wheat potential went as high as 60%, rice yield 21% and maize yield 12% under double CO_2 condition (ADB 2009).

Biodiversity

Biodiversity is the part of climate system. Both the storage of carbon and nitrogen compounds in vegetation, plankton biomass, soils, and river sediments and their release

through respiration and decomposition are influenced by the composition of plant, animal, and microorganism communities. Nepal supports a disproportionately high number of globally important wild animal and plant species and contributes to majority of people's livelihood. Climate is one of the main factors that influence the distribution and population density of species of flora and fauna on Earth. Many observations suggest that recent climate change has already influenced animal and plant populations in a number of ways. The influence can be seen in the timing of seasonal events (e.g. flowering, migration), in rates of growth and reproduction, and in the distribution of species. Because species react differently to climate change, climate change is also influencing species interactions (e.g. predation, parasitism, competition, symbiosis). Lengthening of the growing season in colder region and shortening of the same in warmer part of the earth are some examples. This has resulted in the expansion and reduction of species habitat (ADB 2009).

Rising temperatures, glacial retreat and changes in water availability will also lead to changes in natural biodiversity. Global warming may cause forest damage through migration of forests towards the polar region, change in their composition, and extinction of species. Tropical wet forest and warm temperate rain forest would disappear, and cool temperate vegetation would turn to warm temperate vegetation (ADB 2009). Climate change will not simply lead to a shifting of animal and plant communities as we know them today. Rather, new types of communities will develop. Species most likely to be at risk will be the species with low dispersal capacity (e.g. soil fauna, non-flying insects, and tree species with heavy fruits). Vegetation patterns would be different under the incremental scenario (at 20°C rise of temperature and 20% rise of rainfall) than the existing types.

Climate change will also have a direct impact on wildlife. Furthermore, shift of vegetation and decline in biodiversity will have further adverse impact on wildlife.

Human health

The impacts of rise in temperature on human health have not been well studied yet in Nepal. Diarrhea, dysentery malaria, Ka-lazar, and Japanese encephalitis are the top

five diseases in the country. Climate change may upset the achievement of last decade in bringing down the burden of diseases.(WHO 2008). Subtropical and warm temperate regions of Nepal, in particular, would be more vulnerable to malaria and Ka-laazar. Increase in temperature would make the subtropical region of Nepal more vulnerable to Japanese encephalitis as well. Adaptation options in this sector could be considered and drawn out from historical perspective and experiences. Chemical control of the potential outbreak of disease may not be appropriate because of the growing chemical-resistant mosquitoes and associated ecological effects. More research and development of alternative approaches are required to control possible disease outbreak (INC, 2004).

Weather related disasters

Weather refers to the specific condition of the atmosphere at a particular place and time. It is measured in terms of states of temperature, wind, atmospheric pressure, cloudiness, humidity and precipitation. Weather can vary from hour-to-hour, day-to-day, and season-to-season. The occurrence of sub-normal weather conditions is known as weather extremes. Intensive precipitation, prolonged drought, hailstorms and windstorms are the main weather extremes that frequently result into disasters. A disaster refers to the phenomenon that causes severe damage to the livelihood of the significant number of vulnerable people (Blaikie et al. 1994). Due to weak adaptive capacity, which mainly depends on economic condition, public awareness/attitude and institutional arrangements (Shrestha 2005), poor countries incur most losses caused by natural disasters (UNESCO 2003). Thirteen times more people die from natural disasters in the least developed countries (LDCs) than in the developed countries (Shrestha 2005). Weather related disasters associated with excessive rainfalls are the major natural disasters in Nepal. The average area-weighted annual precipitation for Nepal is about 1630 mm, with half of the country lying within a 1500-2000 mm precipitation zone. There is noticeable temporal and spatial variation in precipitation within a total area of 147181 km2 of the country. Close to 80 percent of the total precipitation occurs during the monsoon season (June-September), followed by 8 percent during post-monsoon (October-January), and 12 percent during the pre-monsoon season (Chalise *et al.* 1996). Spatially, the recorded

average annual precipitation ranges from 163 to 5244 mm (Chalise *et al.* 1996 cited Goutam 2008).

During 1983-2005, Nepal witnessed an annual loss of 942 lives due to disasters, 36 percent of which were directly associated with weather related disasters, and 60 percent by death due to fire and epidemics indirectly related. Weather related disasters have not only caused loss of lives but also jeopardized people's livelihoods. Table 1 presents the annual loss by flood, landslides and avalanches, the major weather related disasters in Nepal, between 1983 and 2005.

Table 1: Annual loss of lives by disasters in Nepal (1983-2009)

Types of disaster	Number of people killed
Flood and landslide	96
Windstorm, hailstorm and thunderbolts	18
Avalanches	5
Fire	52
Epidemics	520
Others	35
Total	726

Source: DWIDP (2009)

Livelihood:

The livelihoods of most poor people, especially in rural areas, depend on natural resources and climate sensitive sectors such as agriculture, forestry and fisheries. They have few options for diversifying livelihoods away from these sensitive sectors and reducing vulnerability. Poor people often do not have enough assets to sustain or rebuild livelihoods after the impact of hazards, because of low financial resources, poor health, lack of clean water and sanitation, weak physical infrastructure and remoteness from government services. Lack of access and ability to use technology reduces their speed of recovery and options for livelihood strategies.

Data on impacts of climate change on livelihood in Nepal is limited as there are no analytical means to assess such impacts. It is indeed a challenging task to ascertain the

impacts of climate change on livelihoods given the diverse topography and different habitats with varied climates even within a small distance. Nepal is basically an agricultural country. About 80% of the people are dependent on agriculture for their income and employment. Agriculture and livestock farming is the most common livelihood for the majority of people living in rural areas. Their livelihood may well be threatened due to impacts of climate change on crops production and livestock-raising. Indeed, climate change will weaken the livelihoods of poor people by eroding their livelihood assets. Poor people are vulnerable to loss of physical capital (because of damage to shelter and infrastructure), human capital (because of malnutrition and diseases), social capital (because of displacement of communities), natural capital (because of loss of productivity in agriculture and fisheries) and financial capital (because of more disasters and lower income). Degradation of livelihoods by climate change will thus leave poor people with less of the assets they need to withstand shocks and stresses (ADB 2009).

Every year, diseases and natural calamities caused by such changes claim the lives of several people, the majority being poor women and children who lack the capacity to adapt to change. For instance, Diarrhea kills 28,000 people annually in Nepal and most of the affected are children below age 5 (Eriksson 2006). It is likely that when the weather gets warmer, microorganisms become more active and act more quickly on the foods we eat. Since people in developing countries often have poor sanitation and lack refrigeration, and thus have no choice but to eat leftover foods, they are likely to be affected by such pathogens very easily. Floods following ice melting and lake outburst or river overflow also kill several people by adversely affecting water quality from debris carried along with the flood. Between 2000 and 2005, more than 1300 people, mostly poor, were killed by floods and landslide related disasters (CBS 2006).

Impact of Climate change take place in different assets of livelihood therefore different adaptation option should be taken for strengthening livelihood assets to build resilience to climate change and support poverty reduction.

2.4 Adaptation and Mitigation Measure to Climate Change Impact

In many countries around the world the impacts of climate change are assessed and adaptation options identified. Adaptation to climate change has received increased attention in the scientific and policy debate, and is seen as complementary to mitigation (UNFCCC 1997; McCarthy et al. 2001). Adaptation aims to reduce the vulnerability and improve the adaptive capacity, or resilience, of people who rely on climate-dependent resources for their livelihoods (FAO 2009). The adverse impacts of climate change and cost of adaptation have become a substantial challenge to developing countries, since these countries have inadequate resources and capacity, inefficient institution and a weak knowledge base. Against this backdrop, there is now an urgent need to identify financial ways and means for adaptation financing, both at national and international levels. It is particularly important to implement anticipatory adaptation actions effectively and in time, otherwise the cost of reactive adaptation will be much higher.

Nepal signed the UNFCCC on June 12 1992, as steps towards controlling greenhouse gas emissions or mitigating the impacts of climate change. Since then, Nepal has been regularly participating in Conference of Parties (COPs) and other side events organized by Subsidiary Body for Scientific and Technological Advice (SBSTA). Nepal also became party member of Kyoto Protocol by submitting its instrument of accession on September 16, 2005. To take advantage of the Clean Development Mechanism (CDM) as a source of new investment and technology, Nepal is trying to develop various CDM projects which promote clean energy and sustainable development in the country. Nepal has recently set up the National Designated Authority under the Ministry of Environment, Science and Technology (MoESC) to approve CDM projects. National Climate Change policy and National Adaptation Program of Action (NAPA) are being formulated. The purpose of the NAPA Project is to develop a strategic framework of action on climate change that identifies immediate priorities for climate resilient low carbon development behind which the government, the civil societies and the donors can align their actions in a more synergistic manner. Furthermore, the project will deliver a NAPA document that outlines Nepal's immediate and urgent priorities in climate change adaptation and will guide the provision of follow-up funding, including financing from the Least Developed

Country Fund (LDCF) to implement climate change adaptation and climate risk management activities in Nepal.

Recently, however some research works are being done on the impacts of climate change and some NGOs are involved in raising awareness on this issue (CEN 2009). In the adaptation process, both coping and adaptation strategies constitute short term activities, as well as long term activities. As the first step, communities try to modify their existing practices to better respond to the impact of climate change. At the second step, they seek alternative livelihoods. In order to address the community needs for adaptation, program and activities also need to be designed accordingly. The following is a list of major activities for both coping and adaptation program: a) agriculture and livestock development; b) water resources management; c) forest, land and soil conservation; d) income and livelihood diversification; e) local infrastructure reconstruction; f) awareness and education; and g) institutional development. (Gurung and Bhandari 2009).

There are many reports and case studies focusing on the various aspect of climate change in Nepal. These studies mostly focused in high altitude and glacier retreat. Impact of climate change and its adaption measure applied by the locals are rare in the context of mid hill. Available literature has been reviewed before carrying the study

Chapter 3

METHODOLOGY

3.1 Stakeholder Consultation and Finalize the Study Area

This study was carried out in middle mountain Dhading district. The district was purposively selected for study. Prior to the field study individual consultation were carried out with development organization of the district. Consultation was organized to inform various organizations about the study and their experience on climate change scenario in the area. They were consulted to understand their current and future intervention for climate change adaptation. The study area was finalized upon consultation with personnel of DDC/VDC and other key persons. The predominant bases of study area were as follows:

- Vulnerable from different climate and weather related disaster.
- Frequency of climate and weather related disaster since last 30 year
- Altitudinal and aspect variation
- Ethnic diversity.
- Livelihood based on agriculture.
- Easily accessible.

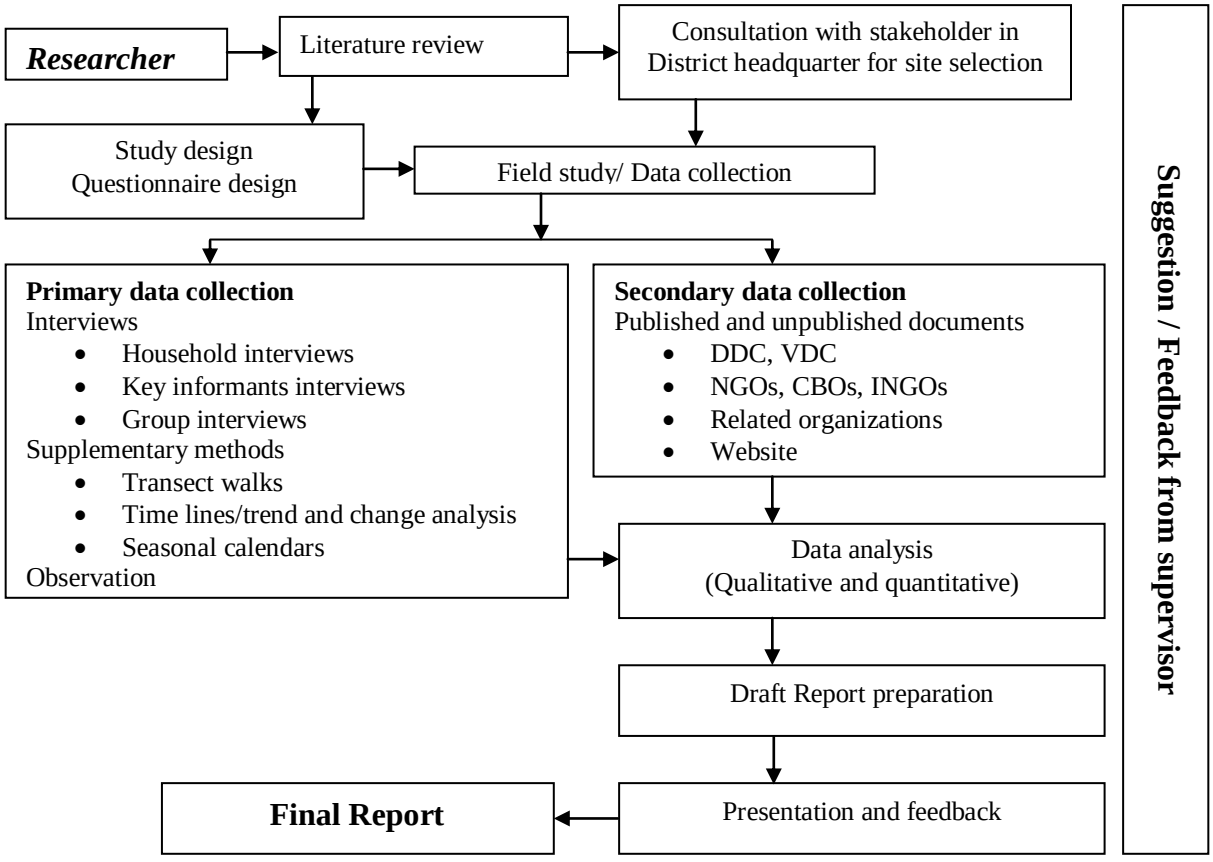
Variation of vulnerability and hazard by location, the place based approach for vulnerability assessments is more relevant than studying larger area (Turner *et.al* 2003 cited in PA 2008). Magnitude of climate change impact is increased from Terai, Mountain, Himalayas where Fulkharka represents the mountain physiographic zone of Nepal. That is why the VDC was selected for the study area.

3.2 Sample and Sampling Design

Stratified random sampling is often used when the population characteristics are heterogeneous. This sample technique gives a better cross-section of population so as to

gain a higher degree of precision. Selected VDC was stratified based on altitudinal variation, considering that altitudinal variation creates heterogeneity in the livelihoods of local people, especially on the factor related to the climatic variation (Weiss and Hassett 1982 cited Sharma 2009). Therefore entire VDC was taken for homogeneity and better representation of respondents. The total numbers and list of the households was taken from the VDC records. Out of total seven hundred households fifty-one household were selected randomly for interview with the consultation of CFUG member, local resource persons and VDC personnel. Remaining 19 persons were included through group discussion (13) and key informant interview (6) to make 10% sampling intensity.

3.3 Research Design



3.4 Nature and Source of Data

Both primary and secondary data were collected from the study area. The source of primary data were household questionnaire, key informant interviews, group discussion, official discussion, field observation and secondary data were collected from the record of CFUGs, VDC, DDC and other organization's reports, published and unpublished booklets and research, relative journals on different aspect of the study, obtain from different source and offices.

A. Primary Data Collection:

Primary data was collected through various methods including household interviews / questionnaire, direct observation and a range of participatory rural appraisal (PRA) techniques. Checklists/interview guides and questionnaire were prepared for collection of primary data.

Interviews/Discussion

Household interviews

Household interviews are the most crucial component of the data collection process in this research, and that was conducted in all the sampled households using a pretest structured or semi structure questionnaire. Information was collected on climatic phenomena, its impacts in farming practices, forest condition and socioeconomic condition of the community. Fifty one interviews were conducted with the household head, who is generally the oldest and the most experienced person in the household affairs.

Key informant interviews

Time series data regarding the climate variability, climate change impacts and the adaptation techniques are particularly important for this research. The elderly individuals, who have lived in that area throughout their lives, were key informants for this type of information. Six elders as key informants were identified consulting with village leaders, local resource person and interviewed using a checklist.

Group discussions

Group interviews were conducted to supplement and triangulate information gathered from the household interviews and other sources. Due to interaction among participants, group interviews will have inherent quality control in them (Robson 2002). Three groups from each of the mixed, women, ethnic and socially disadvantage group was interviewed separately. It was expected to provide information on differential perceptions across social groupings. Separate checklists were prepared to guide interviews in different groups.

Supplementary methods

Transect walks

Transect walk refers to "walking with or by local people through an area, observing, asking, listening, discussing, … identifying local and introduced technologies etc. seeking problems, solutions and opportunities…" (Mascarenhas 1990, cited in Chambers 1994). Direct observation and simultaneous discussion about physical phenomena (such as landslides and floods) during the transect walk helped people to recall and explore more information regarding climate change impacts and adaptations.

Time lines and trend and change analysis

Participatory timelines and trend and change analysis was exploring the chronologies of events in the community over time. For this research, this analysis was useful to obtain information on the approximate changes in climate and land use pattern, degree and magnitude of climate change impacts, the evolution of local adaptation technologies and trend of migration over time.

Seasonal calendars and daily time use analysis

For this research, preparing seasonal calendars was particularly important to look into approximate distribution of rains throughout the year, frequency and magnitude of

rains and their impacts to people's sustenance. Similarly, daily time use analysis gives information regarding how people relocate their time for different activities. Comparative analysis of seasonal calendars and daily time use for same time intervals in the past gave a picture of climate variability over time and the local efforts to cope with it.

Field Observation:

A Field observation was carried out to cross check the information gathered during group discussion, interview and questionnaire survey.

B. Secondary Data Collection:

Secondary data necessary to fulfill the objectives of the study was collected from Meteorological stations, various stakeholders of Dhading district relating to climate change issue, concerned literature, libraries etc. Furthermore essential information was collected from related websites and journals.

C. Data Analysis:

Data were analyzed both qualitatively and quantitatively. The data were categorized and variables were formulated. The data were logically interpreted along with simple tables, charts, and graphs. Mainly Statistical Package for Social Science (SPSS) and Microsoft Excel work sheets were used to analyze the information.

Chapter 4
INTRODUCTION OF STUDY AREA

4.1 The Study Area

Dhading district lies in the Central development region of Nepal. The geographical position of the district is between latitude 28°20′ N to 28°47′N and longitude 83° 8′E to 83° 53′ E. The district is characterized by the fragile mountain topography ranging altitude from 792 m to 8167 m above mean sea level. It covers 2297.07 Sq. Km area that comprised of 8 percent of Lowerbesi, 56 percent of High Hill and 36 percent of High Himalayas, bordering with Gorkha, Nuwakot, and Rasuwa districts in the east; Nuwakot in the west; Gorkha in the south china and in Rasuwa north. The main types of climate in the district are humid warm temperate and humid cool temperate with the range of mean annual temperature varies from 38° to 3° C respectively. The district receives mean annual rainfall of 407 mm to 2960 mm.

Dhading district occupied by 8.48 percent of cultivated land, 36.76 percent of forestland, 1.85 percent of shrub land 21.27 percent of pasture land, 0.06 percent of land slide area, 11.68 percent of snow covered area, 9.03 percent of settlement area, and 2.61 percent of hard rocky land. 1.47 percent of land covered by rural trail/road and 6.56 percent of drainage system. The total population is 1, 14,447 in which the female being 61,269 (56 percent) and male 53,178 (46 percent) consisting of major ethnic groups as

Chhetri 45.31 percent, *Kami* 12.09 percent, *Bharmin* 25 percent, *Damai* 5.21 percent, *Sarki* 2.88 percent, *gurung* 4 percent, , *Newar* 3percent, and other 0.97 percent. About 92.04 percent of the populations are engaged in agriculture and land holdings are of less than 0.5 hectares per family (DDC, 2007). The district was ranked on 34th place according to poverty and deprivation index developed by district development profile of Nepal (DDPN, 2004).

The overall literacy rate was 55.74 percent and drinking water coverage 37.19 percent. The average family size was of 4.68 HH and livestock per farm household was 3.78 no per HHs. The percentage of irrigated area was 6.01.

4.2 Core Study Area

Fulkharka VDC

Fulkharka VDC lies in the northern part of district head quarter (Dhading beshi). Altitude of this VDC ranges from 1200 m to 3100 m. above the mean sea level. Total household of this VDC was 700 and the population was 3332 including 1802 female and 1530 male. The average population size per household was five; and main ethnic groups/castes were *Brahmin, Chhetri, Newar, Magar* (upper castes) and *Kami, Damai, Sarki* (*dalits*, so-called untouchable castes) which includes 57.8 percent *Chhetri*, 17.4 percent *Brahmin* and 24.8 percent *Dalit* and other castes. Education status of Fulkharka VDC is grouped into three categories which are illiterate, literate/under SLC and above SLC which are illiterate 26.1 percent, 63.4 percent literate and under SLC and 10.5 percent more than SLC. Main occupation is agriculture and followed by government/other service, foreign job and business. People of the study area grow rice as a main crop which constitute 44.8 percent, and is followed by Wheat 21.1 percent, Maize 21.2 percent, 13 percent millet production (DDC 2000). Most of the forest areas (88.03 percent) of Fulkharka are handed over to the community for the protection, management and utilization. Total 11 community forest user group (CFUG) were formed to manage 448.98 ha forest area. (Baral 2005).

Chapter 5
RESULT AND DISCUSSIONS

5.1 Socio-economic Characteristics of the Respondents

Socio-economic features such as sex, occupation, age structure, family size; land holding, food sufficiency, cropping pattern and livestock management system etc. of the respondent's give quick understanding of the scenario of socio-economic condition of the users in the study area. Thus, different socio-economic aspects are presented and analyzed under this heading in a graphical form.

5.1.1 Social Characteristics of Respondents

Males constitute 82 percent of the total respondents. Although the survey was targeted to the household heads, who were supposed to be adults and elderly, the youths (Below 35 years) share 17 percent of the respondents, with 68 and 15 percent by adults (35-55 years) and elder (>55years) respectively. Twenty two percent of the respondents were dalits (So-called lower untouchable castes), representing an estimated 24 percent of the total households in the studied communities. In terms of occupation, 69 percent of the respondents were farmers, the rest being teachers, small business holders and wage laborers. Seventeen percent of the respondents were illiterate, 53 percent were literate and only 30 percent of them had completed secondary or higher level. General characteristics of the respondents are given in Table 2.

Table 2: General characteristics of the respondents

Characteristics	Percentage of respondents
Gender	
Male	82
Female	18
Caste	
Non-dalit	78

Dalit	22
Age group	
Youths (<35 years)	2
Adult (35-55 Years)	54
Elderly (> 55)	44
Education	
Illiterate	17
Literate/primary level	53
Under SLC	18
Above SLC	12
Family size	
Less (up to 5 members)	35
Medium(5-10 members)	47
High (more than 10 members	18
Primary Livelihood option	
Agriculture	69
Job/Service	19
Foreign job	4
Trade/Business	4
Labour	4

Source: Field Survey 2011

5.1.2 Duration of Residence and Migration

Almost two-thirds (65 %) of the respondents had been living permanently in the study area and remaining 35% migrated from different areas for several reasons. Detail is given in Fig 1 and table 2. Except for two respondents, who came from another district; all the other respondents migrated from high altitude area of Fulkharka VDC to lower altitude area of same VDC. Out of migrated respondents 61% migrated for employment opportunities available in the lower weather related hazards like landslides and droughts.

Table 3: Respondents living in Study area

S.N.	Status	Percentage
1.	Permanent residence	65
2.	Migrated from another district	4
3.	Migrated from high altitude of same VDC	17

4.	Migrated from lower part of same VDC	14

Source: Field Survey 2011

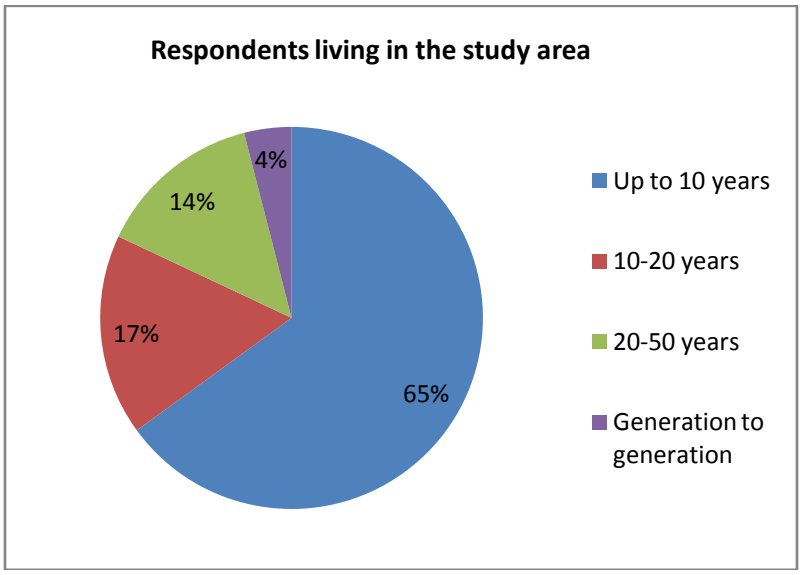


Figure 1: Respondents living in study area

5.1.3 Irrigation Practice in the Study Area

Irrigation is not available in all the agriculture land in the study area. Thirty three percent of the respondents completely depend on rain for their agricultural production. Remaining respondents have facility of irrigation in some way or the other. Respondents with rain-fed agricultural land cultivate only two crops (Millet/Wheat and Maize) a year. In semi-irrigated and irrigated land respondents cultivate three crops like rice, wheat and maize along with vegetables. Irrigated and semi-irrigated lands lie in lower altitude whereas rain-fed land lies in higher altitude. For detail see Figure 2 and table 4.

Table 4: Irrigation practices of Respondents

1.	Dependent on rainfall	33%
2.	Partially irrigated	57%
3.	Irrigated	10%

Source: Field Survey 2011

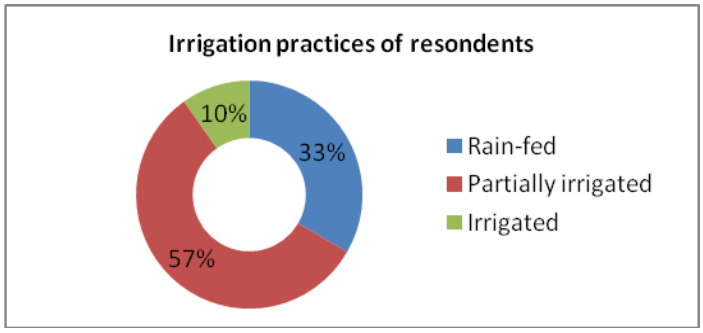


Figure 2: Irrigation practices of respondents

5.1.4 Livestock Management

The most common animals reared in the study area include buffalo, ox and goat. Around 94% of the respondents rear buffalo, 61% cow/ox and 39% goat/sheep. These animals were grazed in three ways viz. stall feeding, open grazing and seasonal grazing (for detail see Figure 3 and table 4). Stall feeding is the most common practice because of presence of eleven community forest in the study area.

Table 5: Respondents on livestock management

S.N.	Livestock Mgmt.	Percentage
1.	Stall feeding	78
2.	Open grazing	20
3.	Seasonal grazing	2

Source: Field Survey 2011

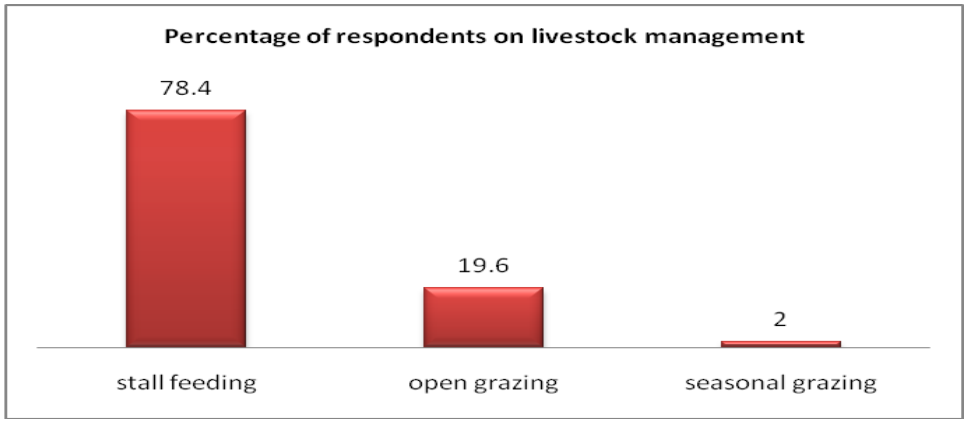


Figure 3: Responses on livestock management

5.2 Climatic Data Analysis

Climatic data of the Dhading beshi, nearby to the study area was collected from the department of hydrology and meteorology, Kathmandu. Available data was analyzed thoroughly in subsequent paragraphs.

5.2.1 Temperature

Data was only available for the eighteen years. Temperature analysis showed that temperature of the area is in increasing trend in maximum mean annual temperature, minimum mean temperature and overall mean. Fig 5 shows the yearly mean temperature of Dhading beshi temperature of the study area is increased in 0.062°C. Minimum mean temperature is increased alarmingly comparison with maximum mean temperature.

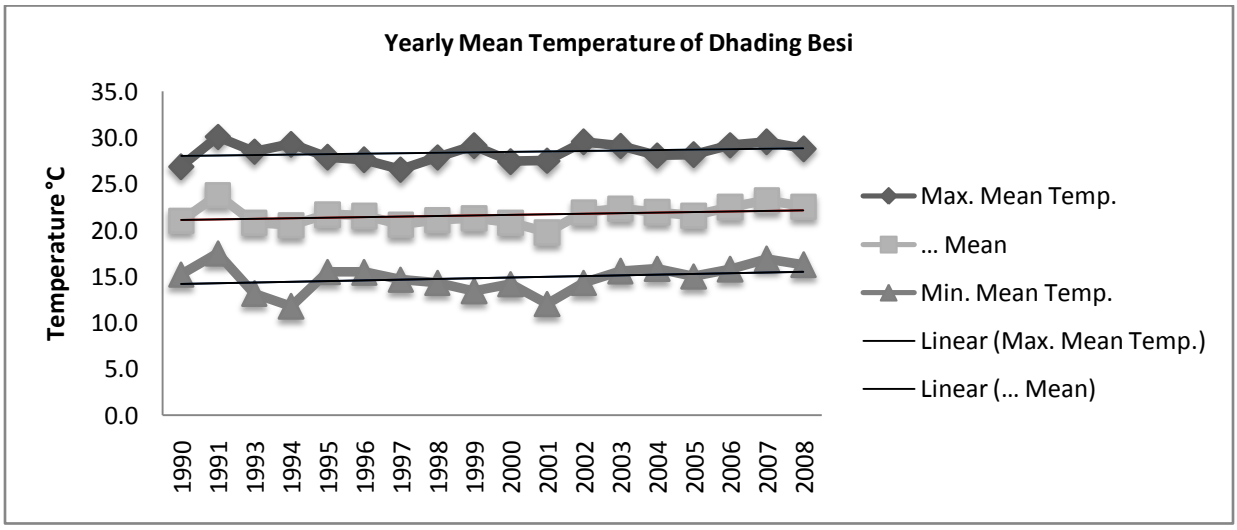


Figure 4: Yearly temperature of nearby station of study area

Monthly Mean temperature analysis showed that maximum mean temperature reaches its peak value in May and dipped in December. Whereas minimum mean temperature rose up to July and lower to the January (Fig 6).

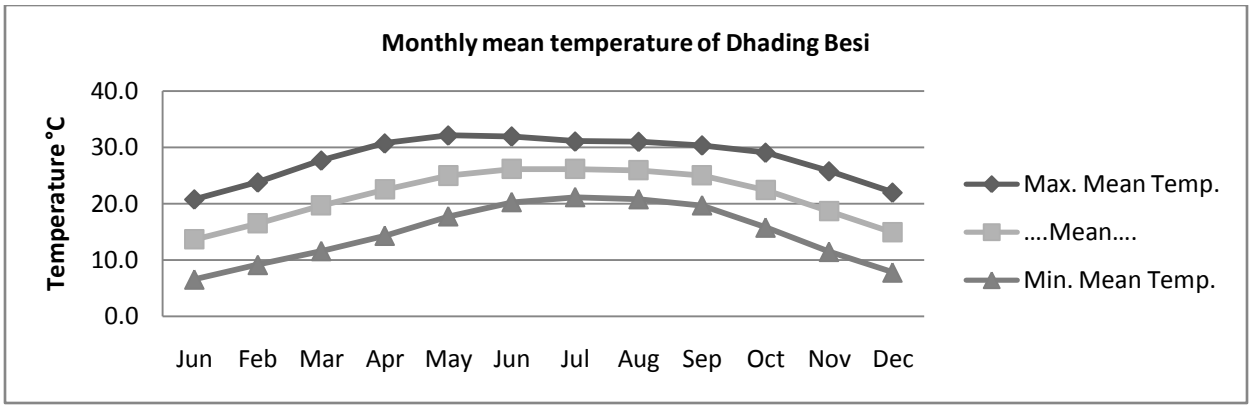


Figure 5: Monthly mean temperature of Dhading beshi

5.2.2 Precipitation

The 30 years average monthly rainfall showed that mean annual rainfall of Dhading |beshi station is 1605 mm. November is the dry month with only 11mm of average annual rainfall whereas July is the wettest month with 415 mm of average rainfall (Fig 6) and table 6

Table 6: Monthly rainfall pattern at Dhading beshi

S.N	Months	Millimeter(m)
1.	Jan	22
2.	Feb	29
3.	Mar	38
4.	Apr	55
5.	May	124
6.	June	294
7.	July	415
8.	Aug	384
9.	Sep	220
10.	Oct	45
11.	Nov	11
12.	Dec	13

Source: Hydrological and Metrological Station Kathmandu-2009

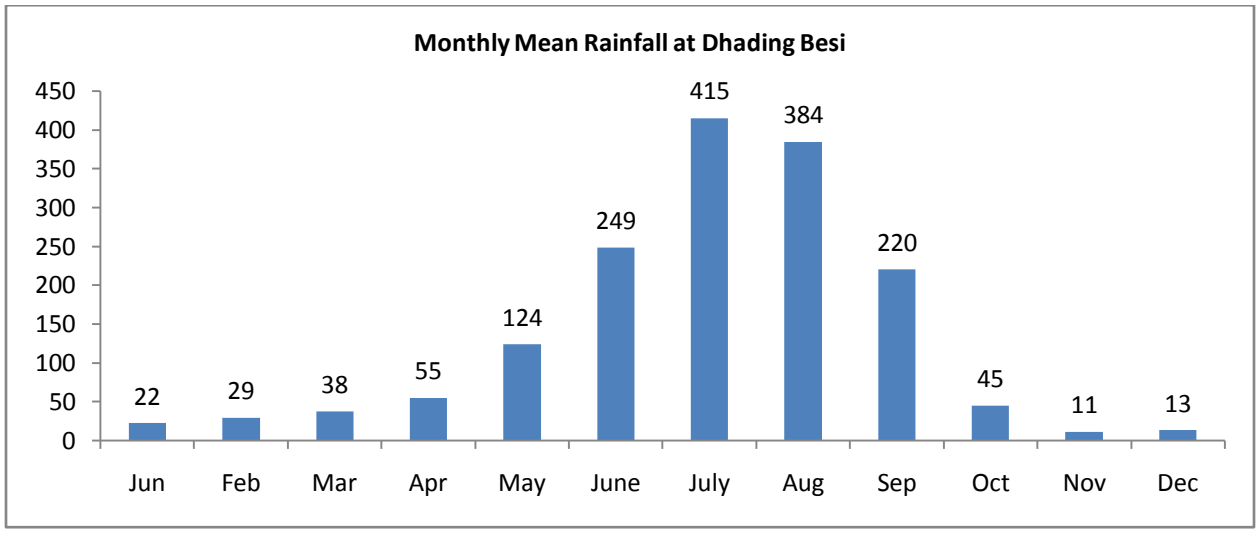


Figure 6: Monthly mean rainfall at Dhading beshi

Four month of monsoon season from June to September contribute about 79% of the total annual rainfall. This four month is highly sensitive to weather related disasters. Pre monsoon (March to May) account for 13% of annual total rainfall. Winter (December to February is the driest season fallowed by post monsoon (October to November) season both contributing about 4% of total rainfall (Fig 7 and table 7).

Table 7: Seasonal rainfall Pattern

S.N.	Seasons	Percentage
1.	Pre monsoon	13%
2.	Monsoon	79%
3.	Post Monsoon	4%
4.	Winter	4%

Source: Hydrological and Metrological Station Kathmandu, 2009

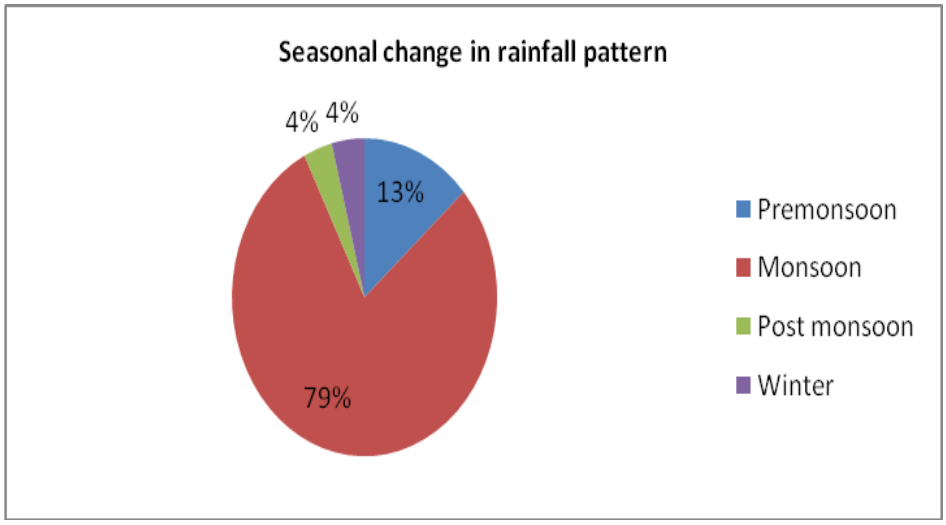


Figure 7: Seasonal change in rainfall pattern

5.3 Understanding of People on Climate Change

This section tries to analyze what people have understood or perceived about the ongoing climate change in the surrounding area. In this heading, understanding of people regarding change in climatic factors, water resource, and biodiversity is tried to analyze.

5.3.1 Understanding of Change in Climatic Factors

The climate of the area has changed and it has been perceived by locals too. Most of the respondents have felt difference in precipitation pattern, occurrence of drought, temperature, and fog and dew formation. While discussion on the precipitation pattern, respondents revealed that the time of rain, amount of rain, and intensity of rain has changed then before. Other details are discussed in the subsequent paragraphs.

5.3.1.1 Precipitation pattern

Change in time of rain

The result of the questionnaire survey shows that time of rainfall has changed. All the respondents unanimously opined that time of rainy season has altered. In general, the

rainy season started from first week of June. But in recent years the rain occurred mostly from the first week July. However, responses regarding the year of changing rainfall time is different. Most of the respondents (41%) said that time of rainfall has changed since five years. Similarly, 25% respondents thought that rainfall time has change since last six years. Other responses include 4 years (16%), 8 years (12%) and 10 years (6%) (For detail see Figure 8 and table no 8.). On an average, the rainfall time has changed since last 5.75 years as per the questionnaire

Table no.8: Response upon rainfall time

S.N	Responses upon years	No of Respondents
1.	Five years	41
2.	Six years	25
3.	Four years	16
4.	Eight years	12
5.	Ten years	6

Source: Field Survey 2011

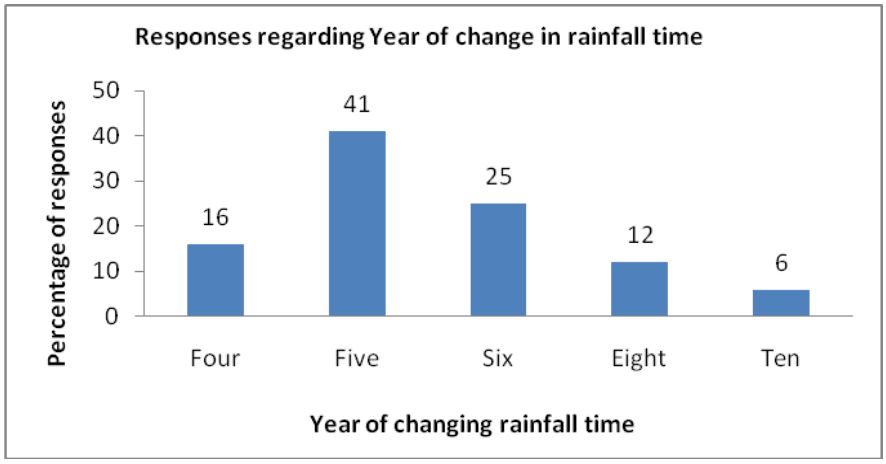


Figure 8: Year of changing rainfall

Change in amount of rain

Cent percent respondents have perceived that intensity and amount of rainfall has changed. According to respondents recent rainfall occurs with high intensity for the short duration. When asked about the numbers of years that they learnt about change in amount and intensity of rain 43% respondents conceded that it has changed since last five years. Similarly, 27% said that amount and intensity of rain has changed since last six years. Other responses are less than four years (16%) and more than six years (13%). For detail responses see Figure 9 and table 9. As per the responses the rainfall intensity and amount has changed since 5.5 years at average.

Table 9: Responses upon change on rainfall intensity

S.N	Years	Respondents
1.	Five years	43
2.	Six	27
3.	Four	16
4.	More than six	13

Source: Field Survey 2011

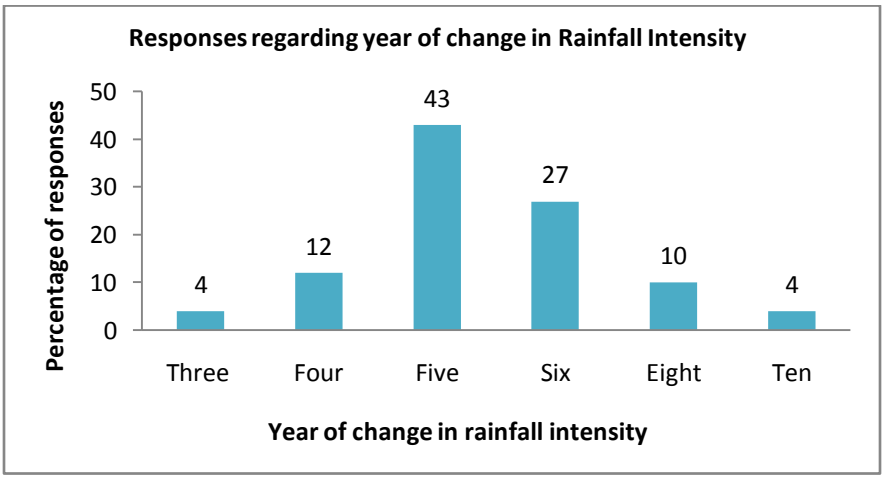


Figure 9: Year of change in rainfall intensity

Change in rainfall pattern in winter

Regarding the responses on change in rainfall pattern in winter, all the respondents agreed that it has also changed. As said by respondents, in past winter rainfall used to occur in the month of January and December. However, in recent years they have not seen any such rain during the month of January and December. But, the responses regarding the number of years of change in rainfall pattern in winter differs. At an average, the rainfall pattern in winter has changed since last five years. 43% respondents said that rainfall pattern in winter has varied since last five years. Similarly, 14% responded that rainfall pattern changed in last three years, 16% four years, 22% six years, 5% said more than six years. For detail see Figure 10 and table 10.

Table 10: Responses regarding rainfall pattern in winter

S.N	Years	Respondents (%)
1	Five years	43
2	Three years	14
3	Four years	16
4	Six years	22
5	More than six years	5

Source: Field Survey 2011

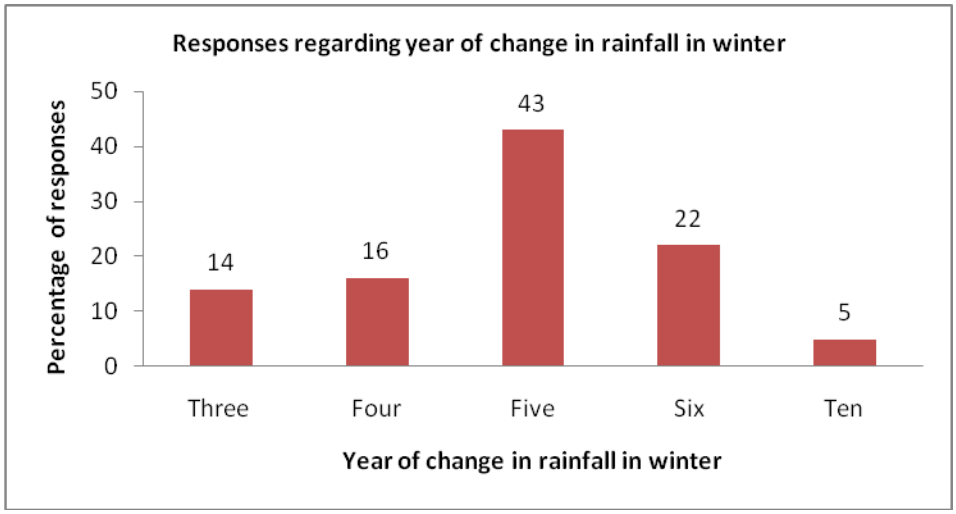


Figure 10: Year of change in rainfall in winter

5.3.1.2 Drought

Almost all the respondents acceded that there has been change in drought pattern in recent years. Locals said that they have been facing long drought periods since last some years. In past drought used to be at most two months long after which they used to get rain. But last year rain didn't occur from October 2008 to April 2009. At an average the drought pattern has changed since last 4.9 years. Figure 12 clearly shows that 43% respondents claimed that drought pattern changed since last five years, 34% said it changed in this three or four years and 24% said that it has changed more than five years ago. This is illustrated on figure 11 and table 11.

Table no 11: Responses upon the changing pattern of drought

S. N.	Years	Respondents(%)
1	Five years	43
2	Three/four years	34
3	More than five years	23

Source: Field Survey 2011

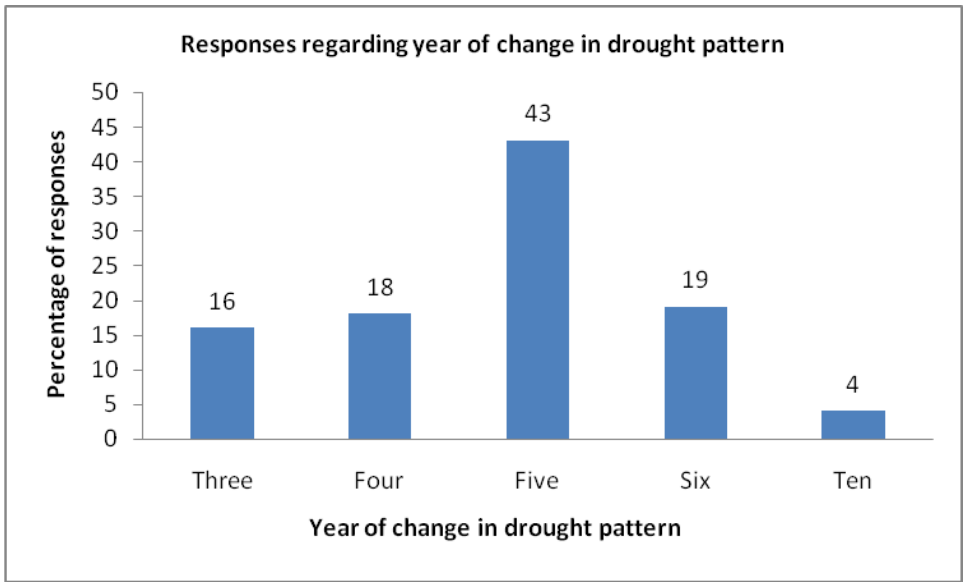


Figure 11: Year of change in drought pattern

5.3.1.3 Temperature

All the respondents in single voice said that temperature has changed. The temperature in the summer season has gone up and winter has become less cold. This shows that temperature has increased in recent years. According to respondents, since last 4.4 years the temperature has increased. 37% respondents claimed that summer hotness has increased and winter coldness has decreased since last three years. 21% people said that temperature increased since last four years. 19% perceived that temperature has risen since last five years. Remaining 23% assumed that temperature increment started more than five years ago. Detail information is given in Figure 12 and table 12

Table 12: Responses upon changing temperature

S.N	Years on changing summer hotness and winter coldness	Respondents (%)
1.	Three years	37
2.	Four years	21
3.	Five years	19
4.	More than five years	23

Source: Field Survey 2011

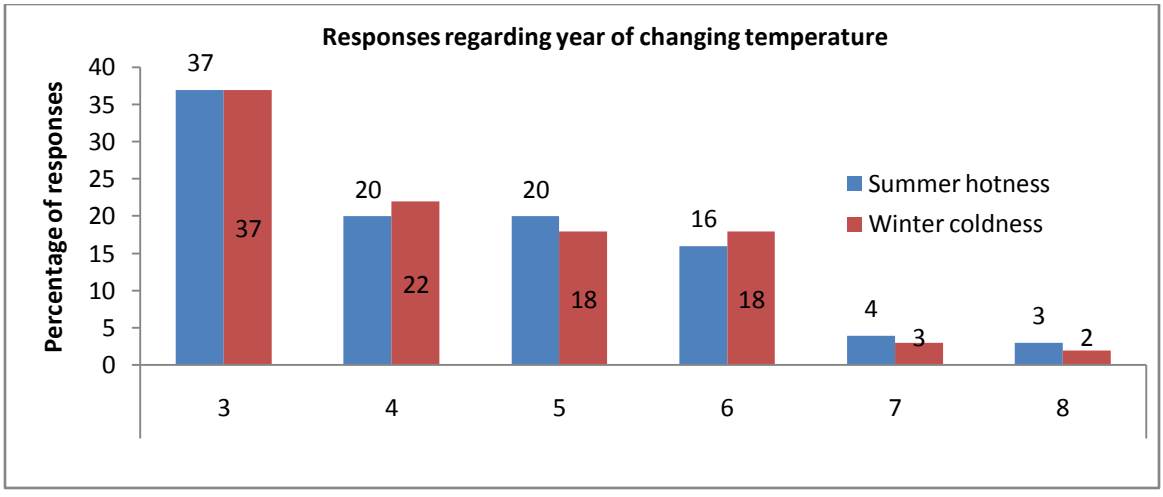


Figure 12: Year of change in temperature

5.3.1.4 Other climatic factors

When asked for alteration in other climatic variation most of people conceded that fog density, dew formation and storm intensity has changed (see Figure 14). All the respondents have observed change in fog density in recent years. According to them, fog didn't occur in past time but they have been observing fog since last some years. 59% respondents have noticed the formation of dense fog since last six years, 37% since last five years and 4% said it is forming since last three years. Hence, we can infer that fog formation has started in the area just recently (six years) which was not common in the area in past. However, only 26% respondents mentioned about decrease in dew formation and 37% mentioned about the increase storm frequency. Out of respondents who mentioned about decreased dew formation, 77% agreed that decrement has occurred since last three years. In case of increased storm frequency, 58% said increment occurred since last three years and 32% felt it since last six years.

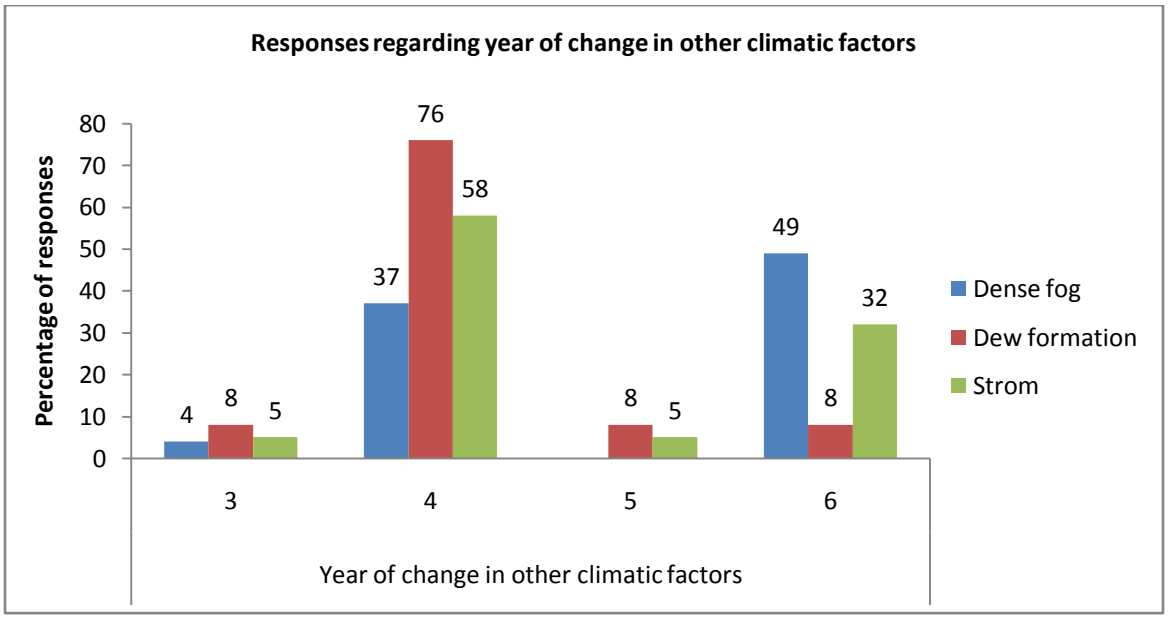


Figure 13: Year of change in other climatic factors

5.3.2 Understanding of Change in Water Resources

The result of the questionnaire shows that all the respondents have noticed decrease in water resource in recent years. According to respondents, water springs have

dried up in recent years and they have to go further away to get drinking water. They have felt decreased water level in nearby rivers and ponds. Most of the respondents (97%) agreed that water resource has decreased in these six years. Detail information is given in Figure 14 and table 13.

Table13: Responses upon decreasing water resources

S. N.	Years on decreasing water resources	Respondents
1	Two years	4
2	Three years	18
3	Four years	22
4	Five years	31
5	Six years	20
6	Eight years	3
7	Ten years	2

Source: Field Survey 2011

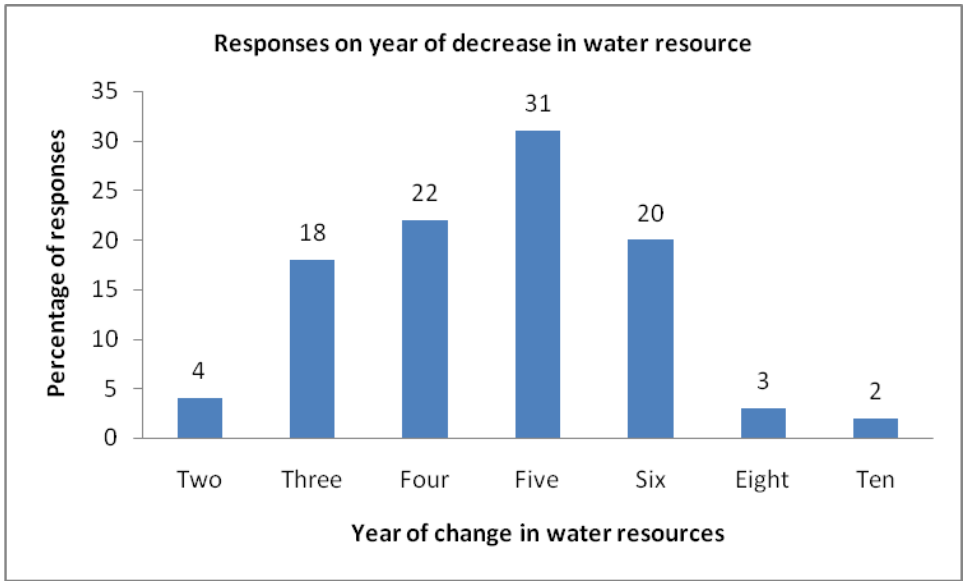


Figure: 1 4 Year of change in water resources

5.3.3 Understanding of Change in Weather Related Disaster

According to respondents most common weather related disasters in the area are droughts, floods, landslides, snowfall, hailstorm and fires. Almost all the respondents confirmed that frequency of weather related disasters have increased.

Timeline of natural disasters and its impact

Neither a measurement system nor the systematic documentation of disasters and their impacts existed in the study area. Memory of respondents was the only source to estimate the frequency and magnitude of weather extremes and the severity of their impacts. Landslides, floods and droughts were the main weather related disasters realized by the people in Fulkharka VDC. The chronology of the weather related disasters in the study area that were recalled as 'devastating' to many people are given in Table 3.

Table14: Timeline representing natural disasters and its impacts

Year	Disasters	Impacts
1934	Earthquake	Most of houses were damaged and many livestock killed.
1950	Prolonged drought	People could not plant their crops on the rain-fed lands, which constituted a majority of agricultural land available in the area, and the crop production decreased by more than two thirds.
1954	Destroy insect	One insect species *Fatangra* destroy all crop and green part of the plants
1961	Disease	Cholera and dysentery occurred more than 5 person killed and many people affected.
1967	Landslides and floods	3 day-long intensive rainfall triggered landslides and floods in many parts of the VDC, damaged crops and agricultural land.
1974	Landslides and floods	A big landslide caused 2 households to migrate permanently out of the village, and damaged crops and agricultural land.

1978	Prolonged drought	Early crops were damaged; late crops could not be planted in rain-fed areas, crop production decreased by half and water resources were deceased.
1991	Prolonged droughts	Farmers could not plant winter and early crops and affected subsistence living.
1993	Landslides and floods	Following a prolonged drought, a heavy rainfall occurred in the late rainy season, which triggered landslides and floods in many parts of the area,
1999	Landslides and floods	Following a prolonged drought, a heavy rainfall occurred in the late rainy season, which triggered landslides and floods in many parts of the area,
2005	Hailstorms	An intensive hailstorm, which had lasted not more than half an hour, completely damaged crops in some areas of the VDC. All the trees had been defoliated, which created shortage of fodder for livestock.
2007	Drought	Heavy drought which occurred in late summer damaged summer crops and trees. It was so unexpected but not a new experience to most of the people. According to some elderly informants, they had experienced many in this area more than 60 years back.
2009	Prolonged droughts	Nine month long drought occurred in this area and farmers could not plant winter and early crops and affected subsistence living.

Source: Field Survey 2011

There was no specific trend of any type of disasters in the study area. . In the last seventy five years, four damaging events of landslides and floods, four events of prolonged droughts and one each of hailstorm, and snowfall were reported, that caused many families to migrate and affected livelihoods of a large section of the population. Recently, a nine month long drought occurred from October 2008 to June 2009. This increased drought has resulted in the increase in forest fires. As stated by the respondents, the intensity of hailstorm has also increased which has resulted in increased damage of agricultural crops.

5.3.4 General Understanding

Regarding the responses on knowledge of climate only 41% respondents said that they were familiar with the concepts and remaining said that they have got no idea on climate change. Those who were familiar with climate change got knowledge about it from radio, television, newspapers, and magazines. According to these people, increase in population, deforestation, industrialization, uses of Air conditioner/refrigerator and unmanaged urbanization, use of chemical fertilizers and fires are the main triggers of climate change. Even though remaining 59% said that they had not heard or learnt about climate change but they understood that their local climate is changing in some or other way.

As illustrated in the figure 15 below, awareness on the climate change is proportionate to the literacy of the respondents.

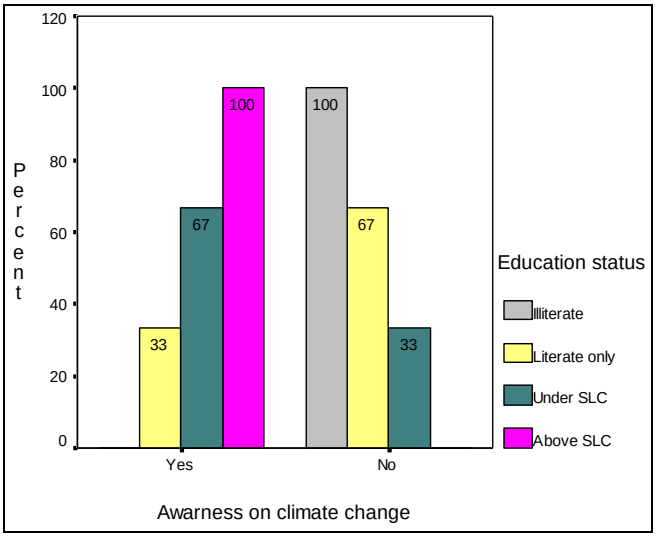


Figure15: Awareness on climate change

5.4 Impact of Climate Change

Climate change is already happening. Locals have perceived changed in their local environment. Most importantly the impacts

Case Study 1

Mr. Bhadra Bahadur Ghale, 82, Fulkharka-9 feels that the climate has changed tremendously. Increasing trend of drought, ill timed rainfall are the main cause for decreasing land productivity. He claims that no rainfall has occurred in winter season for last few years which has made immense negative impact on the production of crops. He remembers planting maize after three consecutive flooding in past years but these floods do not occur in the way that used to occur. He asserts that in an average the cropping time has shifted to 15-20 days later than the previous years.

have been seen in agriculture, water resource, health and biodiversity. Impacts on various factors have been discussed in subsequent paragraph.

5.4.1 Agriculture

Respondents have noticed decrease in agricultural production in recent years in comparison to last 25 years. The 98% respondents said that agricultural production has reduced. Out of them, 50% said that crop production has gone down slightly and remaining claimed that it has reduced hugely. With these facts in hand it can be asserted that climate change has impacted in the agricultural production. Main reasons for this decrease in production is ill-timed rainfall and increased drought period. According to respondents, the time of rainfall changed because of which they couldn't plant rice in the month of June. With the delay in rice plantation time, the season of planting of other agricultural crops also delayed. Because of this they could only plant two crops which used to be three crops in previous years. Respondents have also observed growth of rice in higher altitude then before. For detail see Figure 16.

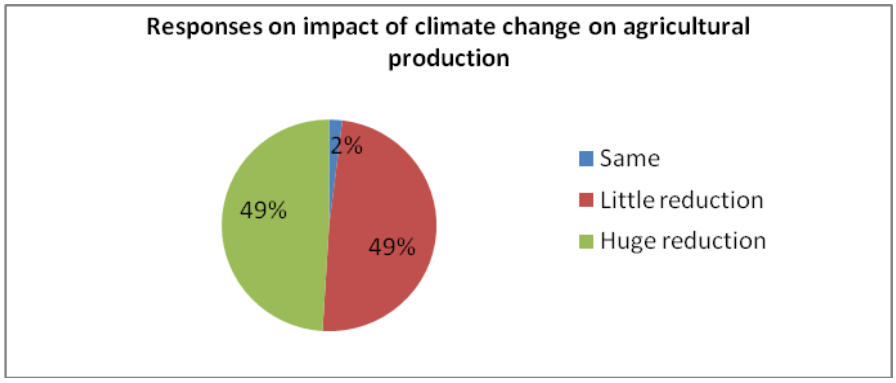


Figure 16: Responses on impact of climate change on agricultural production

Similarly, in case of fruits, the time and productivity has changed. According, for example early ripening of fruits like pear, mango, aiselu, khurpani, kafal, and rhododendron has been observed by respondents (Detail is given in Table 17). Guava was drying up and dying due to occurrence of drought in the area. Similarly, banana, apple and orange have started falling before ripening. The fruits production was low and quality

Case Study 2

Mr Krishna Bahadur BK ,63,Fulkharkat VDC-2 has noticed that crop ripening has shifted earlier then previous years .He finds an example of Kafal, peach, pears and mango being ripened earlier but the quality of these fruits are lower. He also noticed the increased amount of diseases in the fruits.

of fruit also degraded. Apart from that respondents have complained about the increase in the pest in fruit trees. This year they harvested cucumber some two weeks earlier.

Table 15: Changing ripening time of various fruits

Fruit	**Previous ripening time**	**Current ripening time**
Pear	August-September	July-August
Mango	July-August	June-July
Kafal	March-April	Feb-March
Rhododendron	April-May	Feb-March

Source: Group discussion, 2011

Change in agricultural cropping pattern

Seasonal calendar has changed in recent years. According to respondents, the calendar has shifted 15 to 20 days later than 20 to 25 years before. Calendar presented in Table 5 shows the cropping season of locals. However, the changes in cropping pattern are not significant in seasonal calendar. Generally respondents cultivated three crops like rice, wheat and maize along with vegetables. Respondents recall their parents cultivated maize after 3 consecutive floods. Disaster like drought, forest fire, flood, storm, hailstorm, snowfall occurred in the study area. Drought and forest fire took place in *falgun* to *jestha*, flood came about in *asad* to *bhadra*, hailstorm occurred in *aswin* to *mangsir*, and snowfall took place in *poush magh.*

Table 16: Season calendar and disaster

Calendar	**Activities**	**Disaster**
Baishak/ Jestha	Maize weeding, seed sowing of rice/millet and Ploughing bare land for	Drought, Forest fire

	rice cultivation	
Asad/Srawan/Bhadra	Maize collection and storage, rice and millet cultivation, weeding rice and millet	Flood
Aswin/Kartik/Mangsir	Rice/millet harvesting	Hailstroms
Mansir	Wheat cultivation	Hailstroms
Pous/Magh	Ploughing ,Forest management	Snowfall
Falgun/Chaitra	Wheat harvesting, Maize cultivation	Forest fire, Drought

Source : Group discussion,2011

5.4.2 Water Resource

Water resource in the research area has highly decreased. About 73% of the respondents responded that water resource highly decreased followed by slightly decrease (25%) and only 2% said that water resource has not changed (for detail see Figure 17). As already discussed above streams, ponds, and springs have dried. This decrease in water has significantly affected irrigation of the local area. Apart from that now a day local have to travel further away from previous source. to get water for household purpose.

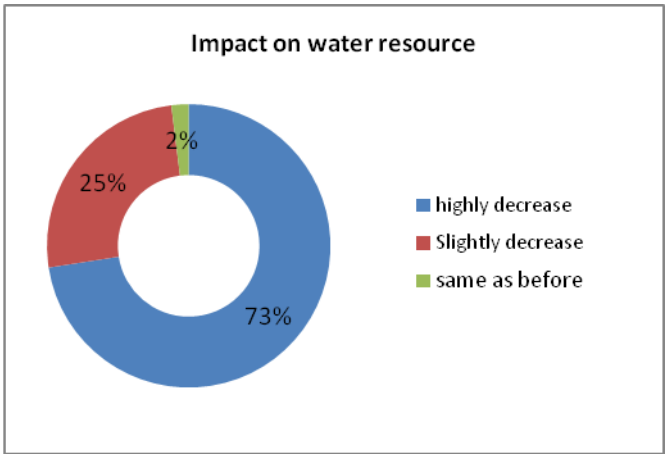


Figure 17 : Responses on impact on water resources

5.4.3 Health

Responses from the household survey reveal that health hazards have increased. According to them frequency of diseases like fever, jaundice, conjunctivitis, common cold, etc have increased and incidents of new disease was also observed. One of the main reasons for the increase in health hazard is increase

mosquito number in the study area. 88% of the respondents said that number of mosquitoes have significantly increased in the area. Remaining responded that mosquitoes have increased but only slightly. According to the respondents, the main reason behind the increase in mosquito is rise in temperature of the local area(for detail see Figure 18). As already discussed above, the temperature has perceivably increased since last five years.

Case Study 3

Mr Dipak Adhikari CMA,32 is a permanent residence of Fulkharka -3. He feels that amount of mist (Tuwalo) has increased in recent years due to increased amount of forest fire. He feels that disease related to eyes have increased such as eye infections and conjunctivitis. Jaundice and fever are also increasing in frequencies level due to deficiency of pure drinking water and water resources.

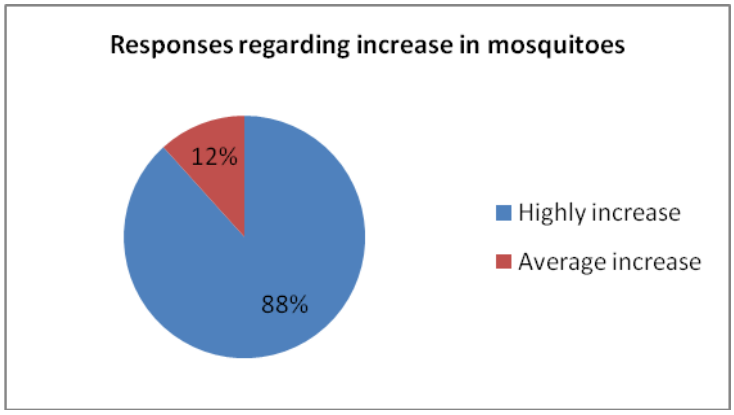


Figure 18: Responses on increase in mosquitoes

5.4.4 Biodiversity

Respondents have perceived that wildlife population have decreased. 69% of the respondents said that wildlife population has decreased. Similarly, 25% of the responded that wildlife population has not changed and 6% opined that animal population has gone up. As per the general observation of local respondents, number of monkey, jackal, vulture, dove, snake, frog, black crow and common myna has decreased. However, the number of white crow has increased in the study area. According to the locals, with the changing climate drought incidents and drying up of the water sources increased. With increase in such incidents, the habitat for the

wildlife population decreased thus decreased the wildlife population of the area. (For detail see Figure 19).

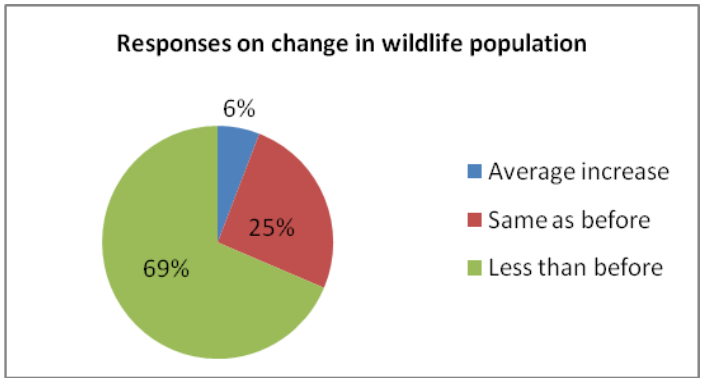


Figure19: Responses on changing wildlife population

Case Study 4

Mr Jit Bahadur Simkhada 55, Fulkharka-7 realized increased trend of fog in the study area from last 8 years .He also noticed the growing mosquito population in the area with rising in temperature. Drought is also increasing in recent years. As a consequence, the forest fire incidence is going up hence damaging huge amount of livestock and natural capital this year. Similarly, different wildlife such as monkey, jackal, vulture, jungle crow has decreased. He also observed increased spread of Banmara and Halhale Jhar. These species are hard to uproot and has a negative influence in the crop field. These plants have negative impact on animal health too as eating of this species by animals have increased the rate of miscarriage among animals.

People perceive that Tooni (*Toona ciliata*) has shifted its habitat from lower altitude to higher altiude due to rise in temperature. Two types of *Banmara* weeds and *Halhale jhar* (Nilo fulne Jhar) have increased significantly.

One of the other impacts of the climate change includes forest fire. 84% of the respondents agreed that forest fire have highly increased and 16% said that it has increased slightly due to increased drought period (for detail see Figure 20). Last year the drought period was as long as nine months. This has led to increase in incidence of fire and finally decreasing the number of animal population in the area.

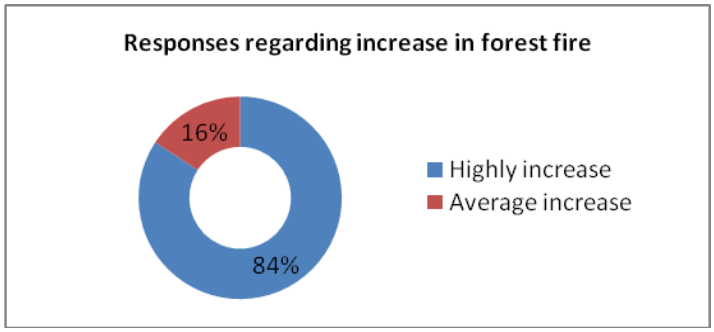


Figure 20: Responses on increased forest fire

5.4.5 Human Assets

Human property like house, shed, and agriculture land are mostly been destructed by weather related disasters like landslide and flooding. 20% respondents felt that intensity of damage in physical asset is greater than past time. Similarly, 49% respondents opined that the intensity of physical damage is same as before and 31% said that it is less severe these days. Detail information is given in Figure 21.

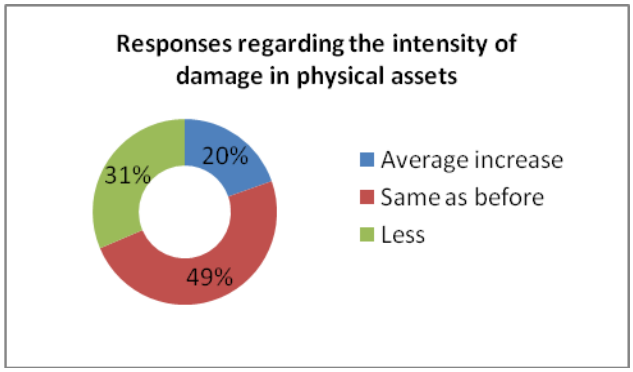


Figure 21: Responses on intensity of physical damage

5.4 Adaptation at Local Level

As people have already perceived that climate change is happening they have adapted some strategies. Some of the important strategies are change in crop planting time, type of crop, plantations of various plants in home garden, using improved stove, collection of rain water, protection of forest, and soil conservation. Percentage of respondents adapting various strategies is presented in Table 17.

Case study 5

Mrs. Uma Devi Neupane 60, has been residing in Fulkharka VDC- 1, Dhading since 35 year. Formerly she was permanent resident of Arughat Gorkha living with 21 goats,7 Cows and 10 ropanies of land, everything tenured. She till gets shocked when she remembers Shrawan 20 of 2033 BS, the most heartbreaking day of her life. It is the day when a cruel landslide brushed away her entire livestock, house and lands which occurred in the middle of night leaving no opportunities to save her any property. Whole night she along with her four family members struggled just to save their life and very next day they found three goats and a cow buried and dead in landslide. After searching for some three days they found remaining animals which they handed over to its owner. After this bitter night, they in search of shelter and food migrated to Fulkharka VDC. Now a day she works as ward communicator.

Table17: Responses on adaptation strategy

Adaptation strategy	Percentage of respondents
Change in crop planting time	55
Change in type of crop	45
Plantation of plants in house garden	33
Improved stove	63
Collection of water in rainy season	18
Forest protection	92
Soil conservation	14

Source: Group discussion, 2011

As reported by the respondents, seed sowing, planting, and harvesting time of rice, wheat and maize have shifted 15 to 20 days earlier than 25 years ago. The main reasons for changing crop time are change in rainfall pattern and increase in drought. However, in 2009 production of wheat and maize was poor and rice planting time was delayed around a month due to long drought of nine months. Before 25 years, the local varieties of crops were planted. These crops are slowly being displaced by hybrid and improved varieties of crops. Respondents have seized to plant some of the varieties (refer table 7) because of lengthening of drought season, change in rainfall pattern and increase use of fertilizers thus decreasing the productivity of those local varieties. Similarly, *Darmali* rice and *Jhina masino* rice are also not cultivated. Instead of that hybrid and improved varieties like *Bikase* and *Gudura* rice are planted these days. 12% of respondents have planted cash crops like vegetables, fruits, etc in place of traditional crops because productivity of traditional crops have decreased in recent years due to climate change. Some respondents (18%) have started non-agricultural jobs like labors, services, and business for their livelihood as the productivity of agriculture is becoming insufficient for their subsistence.

Table 18: Responses on crops not planted now

Crops now not planted	Percentage of respondents
Fapar	45
Junelo	45
Gahat	45
Bodi	29
Syaltun	29
Peanuts	6
Banana	4
Guava	4

Source: Group discussion, 2011

Some of the respondents (18%) have started collecting rain water for agriculture and household purposes for the future use. They collect water in tanks and reserve ponds.

Mitigation strategies adapted in the study area

Plantation and protection of forest and soil

In current years, the respondents have started protection of forest as the adaptation against the changing climate. They have started the protection and plantation of forest with the concept that forest would reduce drought, increase rainfall and maintain the rainfall time. Community forests present in the study area have also supported in their endeavor to protect and conserve forest. Along with this, people have started planting trees and other plants in their home garden too.

Installation of improve Cooking stove

The locals in the study area have installed improved stove in their houses. At least 63% of the respondent agreed that installation of improved stove have helped in mitigating climate change. According to them, improved stoves have reduced the amount of smoke in comparison to traditional stoves; also fuel-wood consumption has been reduced.

Chapter 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

- Most of the respondents have felt difference in precipitation pattern, occurrence of drought, temperature, and fog and dew formation. While discussing on the precipitation pattern, respondents revealed that the time of rain, amount of rain, and intensity of rain has changed than before.
- Only 41% respondents were familiar with the concepts and remaining had no idea on climate change but they understood that their local climate was changing in some or the other way. In general educated people were familiar with climate change and got knowledge about it from Medias. According to these people, increase in population, deforestation, industrialization, use of Air conditioner/refrigerator and unmanaged urbanization, use of chemical fertilizers and fires are the main triggers of climate change. Climatic data from the meteorological station at Dhading Beshi verifies the people's perception towards changing climate which is equal to 0.062^{o}C rise.
- Landslides, floods and droughts were the main weather related disasters realized by the people. In the last seventy five years, four damaging events of landslides and floods, four events of prolonged droughts and one each of hailstorm, and snowfall were reported, that caused many families to migrate and affected livelihoods of a large section of the population.
- Locals have perceived change in their local environment. Most importantly the impacts have been seen in agriculture, water resource, health and biodiversity.
- Decrease in agricultural production in recent years in comparison to last 25 years has been perceived by respondents. Main reasons for this decrease in production is ill-timed rainfall and increased drought period. Respondents have also observed growth

of rice in higher altitude then before. Most of the respondents disclosed that seasonal calendar has changed in recent years. The calendar is shifted 15 to 20 days later than 20 to 25 years.

- Similarly, in case of fruits, the time and productivity has changed. For example early ripening of fruits like pear, mango, *aiselu, khurpani, kafal*, and rhododendron has been observed. The fruits production was low and quality of fruit also degraded.
- The decrease in water level has been observed in streams, ponds, and springs by the locals and it has significantly affected irrigation of the local area. Apart from that now a day locals have to travel further away from previous source to get water for household purpose.
- The frequency of diseases like fever, typhoid, jaundice, conjunctivitis, common cold, etc have increased due to increase in number of mosquitoes and frequent forest fire. The number of mosquitoes has increased significantly in the area due to rise in local temperature.
- Biodiversity has also been affected by climate change. Most of the respondents have reported that wildlife population for example the number of monkey, jackal, vulture, dove, snake, frog, black crow and common myna have decreased. With the changing climate, drought incidents and drying up of the water sources increased thus the habitat for the wildlife has altered resulting in decrease in its population. Similarly, Tooni (*Toona ciliata*) has shifted its habitat from lower altitude to higher altitude. Two types of *Banmara .Halhale* (Nilo fulne Jhar) have increased significantly.
- Locals have supposed that increase in drought has resulted in increasing number of fire incidents.
- Some of the important strategies adapted by locals are change in crop planting time, type of crop, plantations of various plants in home garden, using improved stove, collection of rain water, protection of forest, and soil conservation.
- In current years, the respondents have started protection of forest as the mitigation measures against the changing climate. They have started the protection and plantation of forest with the concept that forest would reduce drought, increase rainfall and maintain the rainfall time. Community forests present in the study area have also supported in their endeavor to protect and conserve forest.

- Hence, it can be inferred that climate change has been occurring in the study area. Most of the people have perceived about the change even though they have not got any formal information on climate change. Climate change has impacted on rural livelihood factors like agriculture, forests, water resource, and health. In general, they have also started using the adaptation strategies changing cropping time, crop type, and collecting water in rainy season. The locals are also applying mitigation measures like using improved stove, protecting forests, and planting trees in houses.

6.2 Recommendation

- Educated people were more conscious to climate change than illiterate, thus education level should be increased by giving awareness/training/adult education focused on future courses of action for poor, women, *dalits* and disadvantaged groups.
- Local people are facing problems as impacts of climate change were observed more on agriculture and forestry. Thus detailed study is required to understand the relationship between agriculture production and climate change. It is recommended that local cropping calendars should be updated to suit the changing weather pattern and disseminate to the community. New agriculture technology and suitable crops/plants need to be identified.
- Plantation programs should be prioritized in the disaster prone areas which ultimately help to reduce the climate change. Community- based action plan should be prepared in yearly basis so that local people could initiate the environment friendly activities.
- Appropriate policy plays the pivotal role to reduce the adverse climate change in both local and national levels. There is an urgent need to formulate adaptive strategies for changing climate in the agricultural field, health, water resources and biodiversity sector from concerned authorities. Governmental policy has to be developed at national level for managing future risks and for integrating climate risk management into development strategies.
- New technologies based on traditional systems should be upgraded to mitigate the increasing effects of climate change like bio-fuel, improved cook stoves, and rain water harvesting system in a reserve ponds or tanks for future use.

- There are very few research activities in Nepal concerning climate change. Action research should be promoted and conducted in the future. Research and extension are the key methods to create the community awareness on climate change among the privileged and deprived communities. Coordination and cooperation among the line agencies should be established for combine effort.

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