IMPACT OF CLIMATE CHANGE AND ADAPTATION PRACTICE IN AGRICULTURE:

A Study of Phalelung Rural Municipality Ward No. 5, Panchthar, Nepal

A Thesis Submitted to
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Declaration

I hereby declare that the thesis entitled Impact of"**Climate Change and Adaptation Practice in Agriculture: A Study of Phalelung Rural Municipality Ward No.5, Panchthar, Nepal**"submitted to the Department of Rural Development, MahendraRatna Multiple Campus Ilam. This thesis is entirely original work prepared under the guidance and supervision of my thesis supervisor. I have made due acknowledgements to all ideas and information borrowed from different sources in the course of preparing this thesis. The result of this thesis has not been presented or submitted anywhere else for the award of any degree or for any other purposes.

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Recommendation Letter

The thesis entitled **Climate Change and Adaptation Practice in Agriculture: A Study of Phalelung Rural Municipality Ward No. 5, Panchthar, Nepal** has been prepared by **Mohan Kumar Khapangi** under my guidance and Supervision for his partial fulfillment of the requirements for the Degree of Master of Arts in Rural Development. This is his innovative work. I, therefore, recommend this thesis for final evaluation and approval.

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APPROVAL LETTER

This thesis entitled **IMPACT OF CLIMATE CHANGE AND ADAPTATION PRACTICE IN AGRICULTURE: "A STUDY OF PHALELUNG RURAL MUNICPALITY WARD NO. 5**submitted by Mohan Kumar Khapangi in partial fulfillment of the requirements for the master‟s degree (MA) in Rural Development.

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This study entitled **Impact OF Climate Change and Adaptation Practice in Agriculture: A Study of Phalelung Rural Municipality Ward No.5, Panchthar, Nepal** has been under taken as the Partial Fulfillment of Master Degree of Humanities and Social Sciences at Department of Rural Development, Tribhuvan University, Mahendra Ratna Multiple Campus, Ilam

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Abstract

Global climate change is a change in the long-term weather patterns that characterize the regions of the world. The term "weather" refers to the short-term (daily) changes in temperature, wind, and/or precipitation of a region (Merritts et al. 1998). In the long run, the climatic change could affect agriculture in several ways such as quantity and quality of crops in terms of productivity, growth rates, photosynthesis and transpiration rates, moisture availability etc. Climate change is likely to directly impact food production across the globe. Increase in the mean seasonal temperature can reduce the duration of many crops and hence reduce the yield. In areas where temperatures are already close to the physiological maxima for crops, warming will impact yields more immediately (IPCC, 2007). Drivers of climate change through alterations in atmospheric composition can also influence food production directly by its impacts on plant physiology. The consequences of agriculture's contribution to climate change, and of climate change's negative impact on agriculture, are severe which is projected to have a great impact on food production and may threaten the food security and hence, require special agricultural measures to combat with.

Climate change is contemporary global threat to the agriculture. Greenhouse gases are resulting global warming which is creating different impacts in the world. Because of human activities greenhouse gases are increasing. Nepal's temperature is increasing at an alarming rate. Increasing temperature is creating different impacts on biodiversity, health the environment and other aspects of life of the animal world. Nepal is also facing the threat of climate change. This study was conducted on Phalelung rural municipality of Panchthar district during the period of February to September 2022 The main objective of the study was to assess the impact of climate change on agriculture; people's health; economy and on biodiversity. Interview survey, key informant interview, focus group discussion were conducted in collecting primary information. Fifteen households were sampled out of total 80 households with random sampling for interviews survey. The data were analyzed using SPSS computer software. It was found that some special signs of climate change are experienced by rural communities of the study area. Local communities experienced increasing warm days and shortening cold/winter days. The pattern, intensity and amount of rainfall also changed, resulting in the scarcity of water. More over people started feeling of scarcity of water for irrigation and drinking. Climate change was affecting agriculture; production of main crops and cash crops has decreased. Different invasive species, pests and insects were increasing in farm. Many species of main crops such as rice, maize and millet species are in threat. Livestock are also affected from climate change, because of less germination of fodder. Number of livestock had decreased, resulting in declining incomes from livestock and related activities. Community members had experienced different new diseases resulting from including mosquitoes. Different health problems were increasing; especially women and children have been affected from itching problem, skin diseases, menstruation cycle, uterus infection (disease) and eye infection problem. On the other hand, flowering time of different species

including shorearobusta, Aamala, maize etc. was changed and so were the germination, harvesting and maturing times of different crops had changed. Income level from agriculture and livestock had decreased, so people are separating from their traditional occupation, way of life and they are seeking alternative professions. It is concluded that climate change is creating multidimensional impacts on the life of rural communities. Adaptation practices must be developed and awareness level of the people on climate change must be increased.

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Acronyms/Abbreviations

AAN	= Action Aid Nepal
ARI	= Acute Respiratory Infection
CC	= Climate Change
CDRD	= Central Department of Rural Development
CFUG	= Community Forestry User Group
CH4	= Methane
CIG	= Climate Change Group
CLI	=Climate Leadership Initiative
CO2	= Carbon dioxide
DCs	= Developed Countries
DFID	= Department for International Development
FAO	= Food and Agriculture Organization
FECOFUN	=Federation of Community Forestry Users' Groups, Nepal
GCM	= Global Climate Models
GDP	= Gross domestic product
GHG	= Green House Gases
GLOF	=glacial lake out burst flood
HFCs	= Hydrofloro Carbon
IFC	= International Finance Corporation
IISD	= International Institute for Sustainable Development
IPCC	=Intergovernmental Panel for Climate Change
LDC	= Least Developed Countries
MDG	= Millennium Development Goals
MOA	= Ministry of Agriculture
MTEF	= Medium Term Expenditure Framework
NAPA	= *National Adaptation Programme of Action*
NGOs	= Non-Governmental Organization
NO2	= Nitrous Oxide
PFCs	= Perfluoro Carbon
SF6	= SulphurHexa Fluoride

SOCP	= soil organic carbon pool
SPSS	= Statistical Package for the Social Sciences
UDC	= Under Developed Countries
UN	= United Nations
UNFCCC	= United Nations Framework Convention on Climate Change
UNDP	= United Nations Development ProgrammeWFP = World Food Programme
USAID	=United States Agency for International Development
WHO	= World Health Organization

CHAPTER-I

INTRODUCTION

1. Introduction

Nepalese agriculture is predominantly small-scale farming, around half of which is dependent on natural rainfall. Rainfall and other climatic factors are critical to crop yields because only 46.5% of overall cultivated area is irrigable of which 69.5% is actually irrigated (MoA, 2012). Empirical study in recent years indicate that 70% of the performance of crop production can be explained by the climatic variability linked with the temporal weather conditions (Sherchand et.al, 2007). Agriculture sector has been affected by floods, droughts and erratic rainfall. Climate change is expected to lead to increasing dryness in drought-prone areas and to wetter conditions in wet areas and there have already been alarming signs of sharp and sustained decline in food security in Nepal. For example, winter food crop harvests for 2009 in all regions of Nepal have declined (Regmi et.al, 2009). The extreme weather phenomenon, including droughts and floods, is expected to induce food vulnerability to the already food insecure 3.4 million people in Nepal and this will affect adaptation measures (WFP, 2009). The projected changes in climatic conditions of Nepal will adversely affect agriculture production.

Climate change is a global problem that affects all of us. Nepal's average temperature is rising at the rate of 0.03C-0.06C per annum between 1977 and 1994 with a higherrate in the mountains than in low lands (Gurung and Bhandari 2009). Nepal is warming at a significantly higher rate compared to the global average of 0.74C, recorded in twentieth century. In addition to increase in extreme temperature, weather has been observed changing in recent years. Because of the extreme temperature there has been change in weather conditions. Number of monsoon days has been shortening, with early onset and late withdrawal, and the intensity of monsoon rain has shown increasing trend (Gurung and Bhandari 2009). Livelihood of third world's people has been changing and threatening from climate change. Climate change brings out wide-ranging effects on the environment, and on socioeconomic and related sectors, including water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity. Changes in rainfall

pattern are likely to lead to severe water shortages and flooding. Melting of glacier can cause flooding and soil erosion. (UNFCCC, 2007). Developing countries are most vulnerable to the impacts of climate change. Nepal is one of the most vulnerablecountriesaffected from Climate change(UNFCCC, 2007).

Nepal is a beautiful country situated on the lap of Himalayas. This is surrounded by India in the east, south and west and by China (Tibet) in the north. The total territory is 147,181sq km which is 0.03% and 0.3% of total land area of the world and Asia respectively. It is laid from east to west with mean length of 885 km and from south to north and the mean breadth of 193 km. Geographical location of Nepal is 26022' to 30027' latitude and 8004' to 88012' longitude (DoI, 2061).

Climate change is nowadays recognized as one of the most challenging and complex problem facing the globe. The stakes very high and the impacts would add significantly to the development challenges of ensuring food security and poverty reduction in most Sub-Saharan African countries in general (Watson 2001) and the Sudano- Sahel of Cameroon in particular. This is a region in the world that has become poorer in the last generations (Ravallon and Chan 2004). While human population globally is growing by 3% per annum and 2.6% in Cameroon, the yields of major food crops grow at just a percentage (Inter-Academy Council 2004).

Climate change affects agriculture in several ways, one of which is its direct impact on crop productivity (Ziervogel et al. 2006) and as a consequence hindering the prospects of achieving some of the Millennium Development Goals (MDG): to eradicate poverty and hunger; health improvement and sustainability (UNDP 2010). Several factors have contributed to the deepening poverty and underdevelopment. These include the difficulty in coping with climate variability in a continent subjected to frequent droughts, floods, extreme high temperatures and land degradation. In addition, various socioeconomic, demographic, political, institutional, and policy trends have limited the abilities to adapt to climatic variations (Rosenweig and Hillel 1998; Adger et al. 2007)

The African continent as a whole contributes very little to global climate change, with low carbon dioxide emissions from fossil fuel use and industrial production in both

absolute and per capita terms. It accounts for 2–3% world's carbon dioxide emissions from energy and industrial sources, and 7% when the emissions from land use (forests) are taken into account (Darwin et al. 1995). These greenhouse gases (GHG) emitted have been identified as the prime cause of global warming. Ironically it is these poor countries and people who have contributed least to the problem of climate change; due to their very low greenhouse gas emissions who suffer most from its consequences. Even if emissions are severely curbed, climate change will still occur. The IPCC latest reports (AR4) states clearly that climate change is already having discernible impacts.

The impact of climate change (CC) on water resources is likely to affect agricultural systems and food security. This is especially critical in a least developed country (LDC) like Nepal where a high percentage of the population is dependent on agriculture for its livelihoods. It is, therefore, crucial for Nepal's leaders and resource managers to draft and begin implementing national adaptation plans. In order for such planning to be effective, it is critical to gain a more comprehensive understanding of the anticipated impacts of CC and the institutions potentially involved in the adaptation process. This working paper aims to create a more comprehensive understanding of how the impacts of CC will be realized at different scales in Nepal, from household livelihoods to national food security, and the many institutions governing the ultimate adaptation process. Recommendations for adaptation to be effective include a need for a comprehensive effort, involving integrated national planning across all sectors and new infrastructure development (e.g., irrigation, hydropower) to account for longer term impacts of CC. For autonomous adaptation, the focus must be on building and expanding basic infrastructure at the local level which will help provide greater income diversification and access to markets. Such infrastructure will also allow for greater interconnectedness between isolated communities, national government institutions and non-governmental organizations (NGOs). For many local communities, adaptation and development will thus be synonymous because as incomes become more diverse and livelihoods improve, so will resilience towards climate shocks.

1.1 Climate Change and Nepal

Nepal's contribution for causing climate change is negligibly small: today Nepali citizens comprise less than 0.4% of the word population and are responsible for only about 0.025% of annual greenhouse emissions. Nepal's vulnerability to damage from climate change, however, is large. Temperature is likely to increase more in high mountain areas than elsewhere. Glaciers and snowfields will reduce and may even disappear, reducing Nepal's dry season river water source. This will impact irrigation and drinking water supply and as well as the reliability of hydroelectricity. Global climate change will also likely shift monsoon rainfall patterns in ways that threatens Nepal's current agricultural practices, as well as threaten infrastructure. Changing temperature and moisture pattern will threaten biodiversity, especially in mountain areas where migration of species is physically restricted (GON, 2003). According to the study carried out by Metrological Department of Nepal, there is increasing phenomenon of melting of glacier and Glacier Lake may cause outburst and increases flooding. According to the report 0.12 degree Celsius in Himalaya, 0.03degree Celsius in Hill and 0.06degree Celsius in Terai temperature is increasing annually. (Sapkota,2064).

Climate change is a global problem that affects all of us. Nepal's average temperature is rising at the rate of 0.03degree Celsius-0.06degree Celsius per annum between 1977 and 1994 with a higher rate in the mountains than in low lands (Gurung and Bhandari 2009). Nepal is warming at a significantly higher rate compared to the global average of 0.74degree Celsius, recorded in twentieth century. In addition to increase in extreme temperature, weather has been observed changing in recent years. Because of the extreme temperature there has been change in weather conditions. Number of monsoon days has been shortening, with early onset and late withdrawal, and the intensity of monsoon rain has shown increasing trend (Gurung and Bhandari 2009). Livelihood of third world's people has been changing and threatening from climate change. Climate change brings out wide-ranging effects on the environment, and on socioeconomic and related sectors, including water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity. Changes in rainfall pattern are likely to lead to severe water shortages and flooding. Melting of glacier can cause flooding and soil erosion. (UNFCCC,2007). Developing countries are most vulnerable to the impacts of climate change. Nepal is one of the most vulnerable

countries affected from Climate change (UNFCCC, 2007). Nepal is a beautiful country situated on the lap of Himalayas. This is surrounded by India in the east, south and west and by China (Tibet) in the north. The total territory is 147,181sq km which is 0.03% and 0.3% of total land area of the world and Asia respectively. It is laid from east to west with mean length of 885 km and from south to north and the mean breadth of 193 km. Geographical location of Nepal is 260 22' to 300 27' latitude and 800 4' to 880 12' longitude (DoI, 2061). 2 Topographically, the country is divided into three ecological zones named Mountains, Hills and Terai. They cover 15%, 68% and 17% of the total land area of the country respectively. Economically, Nepal is known as a least developed country (LDC). The World Development Report, 2007 ranked Nepal in 142nd place of developed countries out of 177 countries. Its per capita income is about $400 per year. Total domestic production increase rate is 4.7% per annum (2007). Contribution of industrial sector to the economy is only 7%. Nearly one third of the population (30.8%) lives below poverty line and the Ginny Coefficient is 41.4 (CBS, 2003/04). The annual growth rate of population is 2.24 percent and the total population of the country in 2007 has reached about 270 million of which the proportion of male and female is almost equal. Likewise, forty eight percent of the population lives in the Terai region, 44.2% in Hills and rest 7.3% in Mountain region respectively (CBS, 2001).

More than 85% of the population is still living in the rural areas. Agricultural practices are still at subsistence level. More than 76% of people are depending on agriculture. Large segment of population is unemployed or seasonally unemployed. More than 40% of the population is still illiterate. People of the productive age are leaving the nation to search for employment. The nation is earning remittance of 200 million per annum through foreign employment. The topographic condition of Nepal is diverse; it varies from 60 meter from sea level to 8848-meter Mount Everest. Although, Nepal is small in land size, it is very rich in biodiversity, diverse climate and with topographical spatial diversity. Different Flora and Fauna has earned its specific importance. All the topographical variations have their specific quality which provides natural resources to the community among different locations. By managing those natural resources, people are earning livelihood and preserving natural resources as well as conserving biodiversity. The variation of topography brings out the diversity on climate. The livelihood pattern varies according to social, cultural and

economic status of the people which is determined by the environment. All the human activities are related to the environment. Environment is determined by its own factors, like temperature, 3 humidity, rainfall etc. Change in the component of environment also affects livelihood of the people.

Panchthar district, a district of Province 1, is one of districtamong of seventy-seven districts of Nepal. Phidim is the district headquarters of Panchthar district. The study area is Phalelung Rural Municipality ward no. 5, which is one ward among the 60 wards of the Panchthardistrict. The study area is ward 5 TuniboteTole where 65 households were counted.

1.2 Statement of the Problem

Agriculture plays a very important role in the livelihood of the communities living in Cameroon accounting for more than a third of the country's GDP. The availability of food depends on agricultural production. Yearly-seasonal and geographical crop yield availability depends on space and timely rainfall distribution. Climate is a primary determinant of agricultural production and any adverse changes in climate would likely have a devastating effect on this sector thus threatening crop failures. Such changes would concomitantly affect the livelihood of the majority of the population since they hinge on rain-fed agriculture for their mainstay where about 97% of the agricultural land is used. Despite the reliance of the large proportion of the population on agriculture, agricultural development has historically not been a priority of the governments, with 1 or less of the average national budgets going to agriculture, particularly commercialized agriculture. (FAO2003). Ironically,subsistence agriculture that accounts for the bulk of agricultural type practiced has been relegated to the backyard.

Issues on climate are only marginally entering into the development planning in the northern region of and societal resilience so far is not improving. Most climate change impacts research studies have been focusing on commercial crops while impact studies of climate change on subsistence staple crop production remains a poorly investigated area in research. These partial assessments, most often consider climatic change effects in isolation, providing little insight into the level of awareness of the local farmers on the issue, what and how they are doing to cope with the changes. Subsistence agriculture in the Sudano-Sahel is highly dependent on climate variability

(Salinger etal.2005) with prolonged droughts being one of the most serious climatic hazards affecting the agricultural sector.

Adaptation to climatic variability and change is not a new issue, but the idea of incorporating the present and future climate risk into policy-making is. Although subsistence farming thus far has a long history of coping and adapting to some of these changes, effective adaptation strategies

and actions should therefore be aimed at securing the well-being of subsistence farmers in the face of climatic variability. The importance of indigenous local knowledge in the facilitation of adaptation to climate change within rural subsistence communities cannot be underestimated. Community based adaptation is thus capable of reducing vulnerability as well as improving on the resilience of the local people to climatic variability and change. However, until recently, most adaptation efforts have been top-down, and little attention has been paid to communities' experiences of climate change and their efforts to cope with their changing environments.

Adaptation strategies should be geared towards a blend of the top-down and bottom-up platforms; starting from a sequence of analytical steps in the climate system, moving through biophysical impacts and terminating at the socio-economic response to climate which tend to be location specific (Dessai and Hulme 2004). Effective adaptation strategies aimed at securing the well-being of subsistent farming communities requires the involvement of multiple stakeholders ranging from policy makers, extension agents, NGOs, researchers, communities and to a greater extend the subsistence farmers.

- What are trends of climate change and farmer's perception of the change?
- What is the status of soil resources and land management?
- What is the impact of climate change on agriculture in the study area?
- What impact of climate change on agriculture productivity differ from region to region?

1.3 Objectives of the Study

The overarching goal of this research is to gain a better understanding of climatic change impacts on some subsistence crops; and how subsistence farmers have responded and adapted to these changes.

The specific objectives are to: -

- To access the farmer's perception on climate changes,
- To identify the major problems caused by the climate change,
- To find out the major techniques adopted by farmer in response to climate change,

1.4 Rationale for the Study

Mountain agriculture of Nepal has been subjected to climate variability in the form of irregular precipitation and gradual increase in temperature. Mountain people are socially backward and the topography is very fragile. Farmers of this region cultivate most subsistence crops. Maize is the major crop of the mountain agriculture system and has been affected by unpredictable rainfall during the sowing time and other critical periods of moisture requirement. Several factors like loss of biodiversity and common property resources, growing water stress for irrigation, recurrent crop damage due to natural hazards, soil vulnerability, poor infrastructure and inadequate institutional support, such as credit, crop insurance, and storage and processing facilities. Climate change is emerging issue in the world, which is one of the greatest threats to environment conservation and living security. Increasing emission of greenhouse gases into atmosphere, human intervention to environment is further compounding this problem. Although the contribution of underdeveloped countries in climate change is minute, they are most vulnerable to climate change impact. Nepal's contribution to global greenhouse gas emission is only 0.025%; it is among the most vulnerable countries to climate change. Nepal's atmospheric temperature is increasing at an alarming rate (0.060 C per year). With the change in temperature there is increasing number of natural hazards. Rainfall pattern is changing; the problem of tropical diseases can be seen in Hills and Himalaya also. Glacier lake outburst, avalanches, flood, drought etc are increasing. Flood related natural hazards increased the loss of human being and wealth. Agricultural production and productivity are decreasing because of climate change. Our agricultural practice is depending upon rainfall pattern. Rainfall pattern is changing due to climate change. In this regard,

climate change is most prominent issue in Nepal. This study assessed the problem faced by the people in study area. The emerging issue of the climate change and its impacts to livelihood and biodiversity is the main focus of this study.

1.5 Limitation of the Study

This research was conducted in remote part of Nepal. This area lacks baseline data and previous data on crop productivity was not accessible. Similarly, no soil fertility data were available. During the transport of sample from field to lab, soil sample might have been subjected to some error. Only two climatic parameters (temperature and rainfall) were analysed for assessing the climate change occurring scenario in the study area.

1.6 Organization of the Study

This study has been divided into five chapters these are as follow:

The first chapter deals with background, introduction of climate change, statement of the problem, rational of the study, objective of the study, scope and limitation of the study and organization of the study. The second chapter deals with introduction of climate change, causes of climate change, climate change and Nepal, impacts of climate change in Nepal, impact of climate change on agriculture, people's health and overall impact on economy and biodiversity of rural communities.

The third chapter contains research methodology adopted for the study. In this chapter research design, sources of data collection, rationale for the selection of the study area, sampling size and procedure, data collection techniques and tools, interview survey, key informants interview, field visit and observation, data tabulation and analysis.

The fourth chapter deals with introduction of the study area, background, agriculture, natural resources, demographic scenario etc.

In fifth this chapter contains findings from study area, local people's perception of climate change, Impact of climate change on agriculture, effect of unusual rainfall on agriculture, effect of risen temperature on agriculture, impact of climate change on people's health, biodiversity, livestock and overall economy and impact on income due to change in livestock pattern.

The fifth chapter contain summary and conclusion of the study. After that some necessary recommendations are presented.

CHAPTER-II

LITERATURE REVIEW

2.1 Climate Change in Nepal

Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity (IPCC, 2007). It is a long-term change in the statistical distribution of weather pattern, including average temperature and rainfall over periods of time. Climate change is increasingly accepted as the major issue facing the globe. Climate change is a phenomenon due to emissions of greenhouse gases from fuel combustion, deforestation, urbanization and industrialization (Upreti, 1999) resulting variations in solar energy, temperature and precipitation. According to the measurement taken by thousands of weather stations all over the world, global temperature has been increased by 0.7C on an average since 1960s (Friis-Christensen et.al.1991). During last 32 years temperature of Nepal has been increased by 1.8C and the average temperature increase was recorded as 0.06C per year (Baidyaet.al., 2008). The rainfall pattern across Nepal has been experienced as inconsistent with higher intensities of rain and a smaller number of rainy days (Malla, 2008) creating long drought for some time and heavy rain in some other periods. In the context of climate change Nepal is facing major challenges like changes in hydrological cycles and depletion of water resources.

Nepal's contribution for causing climate change is negligibly small: today Nepali citizens comprise less than 0.4% of the word population and are responsible for only about 0.025% of annual greenhouse emissions. Nepal's vulnerability to damage from climate change, however, is large. Temperature is likely to increase more in high mountain areas than elsewhere. Glaciers and snowfields will reduce and may even disappear, reducing Nepal's dry season river water source. This will impact irrigation and drinking water supply and as well as the reliability of hydroelectricity. Global climate change will also likely shift monsoon rainfall patterns in ways that threatens Nepal's current agricultural practices, as well as threaten infrastructure. Changing temperature and moisture pattern will threaten biodiversity, especially in mountain areas where migration of species is physically restricted (GON, 2003). According to the study carried out by Metrological Department of Nepal, there is increasing

phenomenon of melting of glacier and Glacier Lake may cause outburst and increases flooding. According to the report 0.120 C in Himalaya, 0.030 C in Hill and 0.060 C in Terai temperature is increasing annually. (Sapkota,2064). Figure 2 shows the increasing trend of temperature in Nepal. Figure 2: Trend of Temperature in Nepal Source: Department of Hydrology and Meteorology, Nepal. Climate change is contemporary issue for Nepal. The following impact will be seen from climate change (Sedhai, 2064). 10 1. Increase in temperature causes the spread of tropical insect mosquitoes, flies and other diseases in upper part that will cause epidemics. 2. The pasture land of Himalayas will be cover of bushes that lead to scarcity of pasture land and negative impacts on livestock rearing. 3. Scarcity of water, poverty, decrease in agricultural productivity, effects negatively on sustainable tourism development. Strange climate is being observed in Himalayan area of Nepal due to global climate change. Opposite character of the climate is seen in some topographical areas of Manang and Mustang. Rainfall pattern is changing, the area where minimum rainfall occurred during same season last year's maximum rainfall occurred this year and vice versa. 17ml of rainfall was recorded on May at Mustang in 2008. Threefold quantity of rainfall (53.5 ml) is recorded in the same period this year. In the same period, in Manang last year 356.6 ml of rainfall was recorded this year only 7ml was recorded. Dramatic change in temperature also recorded in these districts during that season. 40 C temperature rise is recorded in Manang in one year (Nagarik, Shrawn 8th 2066). Because of increase in rainfall and decrease in snow fall traditional mud house structure is being damaged, local dwellers of Mustang have started to house roof with corrugated sheet. (Dahal, 2008). Periodic monsoon pattern has been changing and monsoon period shortened. Thousands hector of land is being barren due to lack of irrigation, which are depending upon rainfall. Epidemics and tropical disease outburst are taking place due to lack of monsoon in season (Kantipur 2066-05-11)

2.2 An Overview of Climate Change

For a deeper understanding of climate change, it is essential to distinguish between weather and climate as they are mutually exclusive events that affect in a complex way human presence and activities on the earth. Weather is the state of the atmosphere above a given place at a specific time. It is the day-to-day state of the atmosphere in terms of air temperature and moisture, cloud covering, relative

humidity. Weather is derived from the chaotic nature of the atmosphere and is unstable as it is affected by perturbations.

Climate on the other hand is described as average weather over a defined time period. Weather is a scientific concept. It deals with statistics such as the average of all-weather events, or over a long period of time (normally 30 years). Weather has a very limited predictability effect and could be directly perceived by people while climate cannot (Kropp and Scholze 2009). Or a popular phrase puts it: climate is what you expect and weather is what you get. Climate varies from place to place, depending on latitude, distance to the sea vegetation, presence or absence of mountains or other geographic factors. Climate also varies in time, from season to season, year to year, decade to decade or on much longer scales such as the ice ages. The statistically significant variations of the mean state of the climate or of its variability, typically persisting for decades or longer have been referred to as “climate change” (B aede et al. 2001)

2.3 The earth´s Climate System

The complete earth climate system can be considered to be a five-part system (IPCC 2001) consisting of: (1) the atmosphere, which is composed mainly of nitrogen (N_2, 78.1% volume mixing ratio), oxygen (O_2, 20.9% volume mixing ratio) and argon (Ar, 0.93% volume mixing ratio), (2) the hydrosphere, which is the component comprising all surface and subterranean water in liquid phase, both fresh and saline, (3) the cry sphere, consisting of every form of ice: glaciers, snow fields, sea ice and permafrost, (4) land surface and (5) biosphere, both marine and terrestrial. The physics underlying the climate system is well known and widely understood and is determined by many factors, processes and interaction at global scale and are have been illustrated in figure 4. These components interact with one another and with aspects of the earth's biosphere to determine not only the day-to-day weather, but also the long-term averages that we refer to as 'climate'.

The climate system is driven by energy received from the sun (sunlight). Some of this energy is reflected back into space, but the rest is absorbed by the land and ocean and re-emitted as radiant heat. Some of this radiant heat is absorbed and re-emitted by the lower atmosphere in a process known as the greenhouse effect. The earth's average temperature is determined by the overall balance between the amount of incoming

energy from the sun and the amount of radiant heat that makes it through the atmosphere and is emitted to space.

The global climate system is driven mostly by energy from the sun. It is also influenced slightly by the gravitational pull of the moon and heat from the Earth's core.

The sun provides an almost constant source of energy for Earth. About 30% of this energy is reflected back into space by the atmosphere and some surfaces of the Earth. The remaining 70% of the energy is absorbed, mainly by oceans and gases in the atmosphere, with a small amount being released back into space. Different surfaces, greenhouse gases and airborne particles can all affect how much energy is reflected and absorbed.

If Earth is absorbing and reflecting energy in equal amounts, the Earth's temperature will remain the same. If more energy is absorbed than reflected, then the Earth begins to warm.

The global climate system arises from the interaction of 5 systems interacting together. To understand our climate and how it is changing, we first need to understand these 5 systems:

- The atmosphere (the thin layer of gases surrounding the earth)
- The lithosphere (the land surfaces such as soil and rocks, and human-made surfaces such as roads and buildings)
- The hydrosphere (the Earth's liquid water in oceans, rivers, lakes and underground)
- The cryosphere (the frozen water in ice and snow)
- The biosphere (the living things such as plants and animals including humans).

2.4 Vegetation and Agricultural Farming Systems

The vegetation is semi-xerophytic and is transitional between the Sudan Savanna woody grassland to the south and the open desert to the north. In the southern parts where the Sahel merges with the Sudan zone, savanna makes up the vegetation. The vegetation consists mostly of open grassland and thorny woody species. Annual

grasslands dominate the northern Sahel, while wooded grasslands occur on sandy soils in the southern part. Among the most important woody plant species are various species of acacia, and baobab. In some locations, the vegetation is concentrated in strips separated by patches of bare soil. Grasses are dominant of plant life with some scrubby bushes with corresponding vegetation varying from steppes to tall grasses and scattered trees.

Diversity is the norm in Sudano-Sahelian farming systems. Subsistence and commercial farming are practiced. Stephenne and Lambin (2001) put forward land-uses that generate basic resource of the population in the Sudano-Sahel. These include: - food for subsistence, fuel wood in the natural vegetation areas, market needs in croplands, fallowing, and livestock in the pastoral land. The agricultural system practiced is characterized by shifting cultivation (slash and burns or swidden agriculture). Crops and livestock are of similar importance and the pressure on arable land is high. Sedentary farming combined free roaming livestock with rain-fed agriculture. The population tends to live on permanent villages although part of their herd may continue to migrate seasonally with herd boys and through entrusted arrangements.

2.5 The Role of Agriculture in the Economy

Having a rich and diversified commodity-based economy, agriculture was the sole engine of growth and foreign exchange earnings until the early 1980s when oil became the primary engine of growth. Despite being the fifth biggest oil producer in sub-Saharan Africa, the backbone of Cameroon's economy is agriculture. Out of a total surface area of 475 412 km^2, 68 125 Km^2 are agricultural lands and only 28.9 % are actually cultivated (Pamo 2008). It has a dual agricultural economy comprising of a commercial sector and a predominant subsistence sector consisting of cattle ranching, crop cultivation and mixed farming (figure 21 showing agricultural map of Cameroon). These all play a dominant role in supporting livelihoods and economic growth to the whole region as they provide food, income, power, stability and resilience to rural livelihoods. With agro-processing an important part of Cameroon's industry, agriculture is the livelihood basis for over 70 % of its workforce, while providing 42 percent of its GDP (table 3) and 30 percent of its export revenue (MINEFI 2010).

2.6 Agricultural Extension and Research

This encompasses a wide range of communication and learning activities organized for rural people by professionals. It entails the application of scientific research and new technologies to agricultural practices through farmer education. Agricultural research agendas remain largely academic unless extension workers provide input in terms of the identified and as-yet unsolved field problems of the farmers. Research focusing on the technological aspects generates useful technologies while extension focuses on the acceptance and adoption of these technologies.

2.7 Climatic Change its Impact Agricultural Crop Production

Crop production is inherently sensitive to variability in climate. Crop production in a natural setting is dependent on weather events as plants require a certain amount of water, warmth and sun to develop. With crop production in Cameroon basically subsistence and rain-fed, the weather assumes significance in nearly every phase of agricultural activity from the preparatory tillage to harvesting and storage in the region. The IPCC analysis on climate change impacts (Third Assessment Report) estimates a general reduction of potential crop yields and a decrease in water availability for agriculture and population in many parts of the developing world. Crop production is affected biophysically by changing meteorological variables, including rising temperatures, changing precipitation regimes, and increasing levels of atmospheric carbon dioxide. Biophysical effects of climate change on agricultural production depend on the region and the agricultural system, and the effects vary through time.

Climate change will have far-reaching consequences for agriculture that will disproportionately affect the poor. Greater risk of crops and livestock death are already imposing economic losses and undermining food security and they are likely to get far more severe as global warming continues. Climate change threat to agriculture is now unambiguous, but the exact magnitude is uncertain because of complex interactions and feedback process in the ecosystem and the economy. Five main factors will affect agricultural productivity: change in temperature, precipitation, carbon dioxide fertilization, climate variability, and surface water runoff.

For temperature increase above 30C, yield losses are expected to occur everywhere and be particularly severe in tropical regions. In parts of Africa, Asia and Central America yields of wheat and maize could decline by around 20 to 40 percent as temperature rises by 3 to 40C, even assuming from-level adjustment to higher temperature. With full CO2 fertilization the losses would be about half as large. Rice yields would also decline, though less than wheat and maize yields (WDR, 2008). As a result of climate change, rainfall levels in many parts of the developing world are falling. This creates a 'domino effect'; with less rain, water levels drop in reservoirs or rivers and people have less water to use. The quality of that water deteriorates as sewage and industrial effluent becomes more concentrated; as a resultwaterborne disease is rife. With a lack of water, vegetation doesn't grow so livestock have less to graze on. There is also less wood for cooking, so women have to spend more time searching for fuel to cook for the family.

Our greatest concern about climate change is the damage it is causing to our agriculture. Sudan’s economy, like that of many developing countries, is heavily based on farming and livestock keeping, the major employment sectors of the country. More than 70% of the population relies on traditional and subsistence agriculture, the majority of which are dependent on rain-fed agriculture and pastures. This all makes our economy extremely vulnerable to any slight changes in the weather. These changes are happening now and many people’s livelihood is under threat (Abdalla, 2009).

According to IPCC the following are some important factors directly connected to climate change and agricultural productivity:

Average temperature increase: An increase in average temperature can 1) lengthen the growing season in regions with a relatively cool spring and fall; 2) adversely affect crops in regions where summer heat already limits production; 3) increase soil evaporation rates, and 4) increase the chances of severe droughts.

Change in rainfall amount and patterns: Changes in rainfall can affect soil erosion rates and soil moisture, both of which are important for crop yields. The IPCC predicts that precipitation will increase in high latitudes, and decrease in most subtropical land regions some by as much as about 20 percent. While

regional precipitation will vary the number of extreme precipitation events is predicted to increase (IPCC, 2007).

Rising atmospheric concentrations of CO2: Increasing atmospheric CO2 levels, driven by emissions from human activities, can act as a fertilizer and enhance the growth of some crops such as wheat, rice and soybeans. CO2 can be one of a number of limiting factors that, when increased, can enhance crop growth. Other limiting factors include water and nutrient availability. While it is expected that CO2 fertilization will have a positive impact on some crops, other aspects of climate change (e.g., temperature and precipitation changes) may temper any beneficial CO2 fertilization effect (IPCC, 2007).

Pollution levels such as troposphere ozone: Higher levels of ground level ozone limit the growth of crops. Since ozone levels in the lower atmosphere are shaped by both emissions and temperature, climate change will most likely increase ozone concentrations. Such changes may offset any beneficial yield effects that result from elevated CO2 levels.

Change in climatic variability and extreme events: Changes in the frequency and severity of heat waves, drought, floods and hurricanes, remain a key uncertainty in future climate change. Such changes are anticipated by global climate models, but regional changes and the potential effects on agriculture are more difficult to forecast.

Experience of Nepali farmers is similar to Uganda, Malawi, Haiti, Bolivia, Vietnam and South Africa. Farmers are in the trap of decreasing production and productivity of crops. Farmers of BaitadiRoshi have not seen any drop of water in monsoon season and say "In this year production of Barley is reduced, and production of other crops is also decreasing. DilaPulami of Surkhet was not successful to preserve seed because of less rainfall. She says in past year we were successful to predict on rainfall but this year we are not able, so that we are not able to preserve seed and plant. Local farmers' ability to prediction of weather system is distorted because of uncertainty in season and rainfall. Rainfall pattern is opposite in comparison with past years (Tandan, 2066).

Over two-thirds of Nepal's population depends on agriculture for their livelihood. Farmers follow traditional agricultural patterns, relying on rainwater and seasons. Changes in local and regional temperatures, the form and amount of precipitation, rainfall patterns, soil moisture content, and sunshine and cloudiness threaten traditional agriculture in Nepal. Moreover, climate change will increase the occurrence of extreme events like floods, droughts and hailstorms, which can also have a drastic effect on agriculture. Rising temperatures and increased rainfall may also lead to more pests and weeds, which will reduce agricultural productivity. (www.climate4life.org)

2.8 Sustainable Livelihoods

A livelihood comprises the capabilities, assets, and activities required for a means of living. It is deemed sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities, assets, and activities both now and in the future, while not undermining the natural resource base (DFID, 1999). Conceptually, livelihoods‖ connote the means, activities, entitlements and assets by which people make a living. Assets, in this particular context, are defined as not only natural/biological (i.e., land, water, common property resources, flora, fauna), but also social (i.e., community, family, social networks, participation, empowerment), human (i.e., knowledge, creation by skills) and physical (i.e., roads, markets, clinics, schools, bridges). The Brundtland Commission in 1987 introduced SL in terms of resource ownership and access to basic needs and livelihood security, especially in rural areas. The International Institute for Sustainable Development (IISD) defines sustainable livelihoods as being ―concerned with people's capacities to generate and maintain their means of living, enhance their well-being, and that of future generations The definition used by the UK's Department of Foreign and International Development (DFID) incorporates these sentiments. 'A livelihood comprises the capabilities, assets (including both material and social resources), and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base (Cannon et al., 1992).

2.9 Climate Change Vulnerability Assessment

Vulnerability assessment describes a diverse set of methods used to systematically integrate and examine interactions between humans and their physical and social surroundings. Vulnerability assessments have been used in a variety of contexts including the USAID Famine Early Warning System Network (FEWS-Net) (USAID, 2007), the World Food Program ‘s Vulnerability Analysis and applying tool for targeting food aid (WFP, 2007), and a variety of geographic analyses combining data on poverty, health status, biodiversity, and globalization (UNEP, 2004). A common thread is an attempt to quantify multidimensional issues using indicators as proxies. These are often combined into a composite index allowing diverse variables to be integrated. The Human Development Index, for example, incorporates life expectancy, education, and standard of living indicators for an overall picture of national wellbeing (UNDP, 2007). Several methods have been used to combine indicators. The gap method (Gillis et al., 1987) was used by Sullivan (2002, p. 1204) to assess by how much water provision and use deviates from a predetermined standard ‘‘for the Water Poverty Index. Both the Human Development Index and the Water Poverty Index are examples of composite indices calculated using weighted averages of individual indicators. Weighting methods vary. Eakin and Bojorquez-Tapia (2008) note that equal weighting makes an implicit judgmentabout the degree of influence of each indicator and propose a complex fuzzy logic-based weighting method as a more objective approach. Vincent (2004, 2007) and Sullivan et al. (2002) suggest expert opinion and stakeholder discussion, respectively, to determine weighting schemes.

The field of climate vulnerability assessment has emerged to address the need to quantify how communities will adapt to changing environmental conditions. Various researchers have tried to bridge the gap between the social, natural, and physical sciences and contributed new methodologies that confront this challenge (Polsky et al.,2007). Many of these rely heavily on the IPCC working definition of vulnerability, a function of exposure, sensitivity, and adaptive capacity (IPCC, 2001). Exposure in this case is the magnitude and duration of the climate related exposure such as a drought or change in precipitation, sensitivity is the degree to which the system is affected by the exposure, and adaptive capacity is the system ability to with stand or recover from the exposure (Ebi et al., 2006). Fussel and Klein (2006) divide available

studies into first generation vulnerability assessments based on climate impact assessments relative to baseline conditions, and second-generation assessments that incorporate adaptive capacity. Of the second-generation studies, there are a multitude of interpretations about how best to apply exposure, sensitivity, and adaptive capacity concepts to quantify vulnerability (Sullivan, 2002). Key differences among studies include scale, methods used to select, group, and aggregate indicators, and methods used to display results. There are also common limitations. Studies relying on climate scenario projections from General Circulation Models (GCMs) for example suffer from the uncertainty associated with these models and how results are mapped (Thornton et al., 2006). Studies relying on secondary data have to structure their analytical framework around available data, contend with inconsistent or missing data, and sometimes must combine data collected at different temporal or spatial scales (Sullivan et al., 2002). Information on sources of measurement error in secondary data sets is often lacking making sensitivity analysis difficult. Methods relying on sophisticated climate projections and multiple international and national databases may be impractical for health and development planners working at the community level (Hahn et al., 2009).

2.10 Impacts of Climate change in Livelihood Framework

People centred approach is considered in livelihood framework. And for people's livelihood different assets are required. Climate change increases difficulty in the livelihoods of the people Vulnerability is the degree to which a system (household or community) is susceptible to, and unable to cope with adverse effect of climate hazards (IPCC, 2001). Climate change increases the depth of vulnerability. The transformation in external environment changes the natural, social, economic, health condition which makes people/community unable to cope with the events. To change the level of vulnerability is the most challenging job. Influencing policies, institutions and process will help in reducing the vulnerability of the people regarding the climate change.

Though people have poor knowledge on the technical matters of climate change but there are several evidences which demonstrate that they have perceived, felt and experienced about its effects more on their livelihood. Therefore, because of climate change and the rising temperatures, Nepal could face drier phases during dry seasons

with wetter monsoon (as much as three times the current level of rainfall) with chances of flooding and landslides during rainy seasons with subsequent impacts on agriculture and livelihoods (Alam&Regmi, 2005). There are many evidences that show that how climate change is affecting peoples' lives and livelihood. The rain pattern over the years is a live experience. People have been facing longer and frequent droughts, erratic rainfall, storms, thunderstorm and hailstone (Action Aid Nepal (AAN), 2007). As a result, crop failures are common; the cases of landslide, flooding/inundation, river side erosion are other phenomenon and further these are in increasing order.

The spread of new water and vector borne diseases are other impacts of climate change. The most vulnerable ecological and socio-economic systems are those with the greatest sensitivity to climate change and the least ability to adapt. (Cruz et al. 2007) describes the evidence of prominent increases in the intensity and frequency of many extreme weather events such as heat waves, tropical cyclones, prolonged dry spells, intense rainfall, tornadoes, snow avalanches, thunderstorms, and severe dust storms in the region. The impacts of such extreme events range from hunger and susceptibility to disease, to loss of income and livelihoods, affecting human survival and well-being.

Gautam et al, (2007) reveal that due to changing patterns of rain, people are water-induced disasters. More cases of landslides, soil erosion arerecorded in the hilly region whereas the Terais affected by the flooding, inundation, river side cutting/erosion, sedimentations, etc. These events have resulted crisis for livelihoods of small holder farmers as the flood impact more on the live and livelihood of rural poor. Adger et al, (2003) explains that the communities are faced with many risks from climate change. The risks are apparent in agriculture, fisheries and many other components that constitute the livelihood of rural populations in developing countries. As mentioned by Senbeta (2009) in his study in Ethiopia disclose the fact that drought and delay in the onset of rain led to poor grass regeneration/forage deficit, water shortage and heat stress on livestock, and consequently increased the mortality of the livestock, vulnerability to diseases and physical deterioration due to long distance travel for water and pastures.

Climate change has increased different types of diseases which have affected human health. Predicted adverse health risks will affect the poor in particular throughout the developing world. These risks are in particular those associated with water-borne (such as dysentery or cholera) vector-borne (such as malaria) diseases as well as heat stress, cold waves, morbidity and mortality (IUCN 2003). These health impacts pose a double jeopardy for poor people's livelihoods: the contribution of key productive members of the household is lost and the cost of health care is expensive and time consuming. Such risks will be widespread, but the death of medical care systems in many more remote, poorer areas of Africa and Asia in particular mean that the poor in these areas are the most vulnerable to these risks.

2.11 Impact of Climate Change on Agriculture

Solar energy, air, precipitation are the important factors for the agriculture production. Change in the factors responsible for agriculture production may cause deficiency in the agriculture production. Climatic hazards like floods, drought, cold wave and new disease are the challenges for the agriculture sector. During drought and delay in the onset of rain land becomes dry and lack of precipitation hinders seed cultivation and germination of cultivated seeds. Even weeks delay in the onset of rain was found to have significant difference on the harvest and has deprivation of households' livelihood. People of the study area has low land holding and they work as a daily labour in the field of elites. Due to less rain during the time of cultivation they have not much to do in the field which directly obstructs their income level. In the district experts opines agriculture sector is mostly affected by the rise of temperature in the summer and decrease of it during the winter especially due to cold waves.

Other than this flood and river cutting in the area also cause deficits in the production. According to the community long term drought, high temperature, cold wave and erratic rainfall are the other causes of decrease in the agriculture output. This decrease in agriculture output has effect on issues like malnutrition, disease, and food security.
Live stock is one of the important livelihoods in the community of Phalelung rural municipality. Pig rearing, goats, cow are among the livestock pattern they depend on. In the present scenario different illness among the livestock, drought and flood, shortage of forage and fodder and pasture land, lack of water are among the challenge

for the livestock rearing. Different disease like uterus prolapsed; diarrhoea, vomiting, mastitis etc are seen in the domestic animals in the study area.

2.12 Changes in Rainfall Amount and Patterns:

Changes in rainfall can affect soil erosion rates and soil moisture, both of which are important for crop yields. The IPCC predicts that precipitation will increase in high latitudes, and decrease in most subtropical land regions some by as much as about 20 percent. While regional precipitation will vary the number of extreme precipitation events is predicted to increase (IPCC, 2007).

2.12.1 Rising Atmospheric Concentrations of CO2:

Increasing atmospheric CO2 levels, driven by emissions from human activities, can act as a fertilizer and enhance the growth of some crops such as wheat, rice and soybeans. CO2 can be one of a number of limiting factors that, when increased, can enhance crop growth. Other limiting factors include water and nutrient availability. While it is expected that CO2 fertilization will have a positive impact on some crops, other aspects of climate change (e.g., temperature and precipitation changes) may temper any beneficial CO2 fertilization effect (IPCC, 2007).

2.12.2 Pollution Levels such as Troposphere Ozone:

Higher levels of ground level ozone limit the growth of crops. Since ozone levels in the lower atmosphere are shaped by both emissions and temperature, climate change will most likely increase ozone concentrations. Such changes may offset any beneficial yield effects that result from elevated CO2 levels.

2.12.3 Change in Climatic Variability and Extreme Events:

Changes in the frequency and severity of heat waves, drought, floods and hurricanes, remain a key uncertainty in future climate change. Such changes are anticipated by global climate models, but regional changes and the potential effects on agriculture are more difficult to forecast. Experience of Nepali farmers is similar to Uganda, Malawi, Haiti, Bolivia, Vietnam

and South Africa. Farmers are in the trap of decreasing production and productivity of crops. Farmers of BaitadiRoshi have not seen any drop of water in monsoon season

and say "In this year production of Barley is reduced, and production of other crops is also decreasing. DilaPulami of Surkhet was not successful to preserve seed because of less rainfall. She says in past year we were successful to predict on rainfall but this year we are not able, so that we are not able to preserve seed and plant. Local farmers' ability to prediction of weather system is distorted because of uncertainty in season and rainfall. Rainfall pattern is opposite in comparison with past years (Tandan, 2066). Over two-thirds of Nepal's population depends on agriculture for their livelihood. Farmers follow traditional agricultural patterns, relying on rainwater and seasons. Changes in local and regional temperatures, the form and amount of precipitation, rainfall patterns, soil moisture content, and sunshine and cloudiness threaten traditional agriculture in Nepal. Moreover, climate change will increase the occurrence of extreme events like floods, droughts and hailstorms, which can also have a drastic effect on agriculture. Rising temperatures and increased rainfall may also lead to more pests and weeds, which will reduce agricultural productivity. (www.climate4life.org).

2.13 Impact on Water Resources

Change in precipitation and temperature has deep rooted relation with the water cycle. Due to increase in temperature after the rainfall water is absorbed by the top soil and there is increase in cut off the land gradually.

2.14 Impact on Forest Resources

For photosynthesis carbon dioxide is absorbed by plant and helps in controlling the amount of greenhouse gases in the atmosphere but this phenomenon is obstructed due to depletion in the forest resources and is coming out as a major challenge which is intensifying the amount of carbon dioxide and other greenhouse gases in the atmosphere. Vegetation patterns would be altered by changes in temperature and precipitation, which in turn would affect biodiversity in forests.

2.15 Impact on Infrastructure and Settlements

Every year due to the hilly area is gradually cutting the top soil so that the infrastructure a and settlement area will be in problem.

2.16 Impact on Public Health

Like in the other places of during the time of summer and cold wave in winter has contributed an increase of different diseases like heart problems, Trends of diseases Kalajar Japanese Encephalitis, asthma, the elderly, the very young and the homeless can be especially vulnerable to extreme heat (IPCC, 2007), diarrhoea, tuberculosis and Acute Respiratory Infection (ARI) the people of the area are infected mostly.
Climate change is expected to have many consequences for human health. Diseases such as malaria and Japanese encephalitis have spread to new areas. Temperature 22-23degree Celsius fevers development of mosquitoes and completion of its cycle, increasingaverage temperature making favourable environment for different kinds of diseases.(CARE,2009:22).

Health hazards from climate change are diverse, global and difficult to reverse over human time scales. They range from increased risks of extreme weather events, to effects on infectious disease dynamics and sea level rise leading to salinization of land and water sources. Based on WHO estimates around 150,000 deaths now occur in low-income countries each year due to climate change from four climate-sensitive health outcomes – crop failure and malnutrition, diarrheal disease, malaria and flooding. Almost 85% of these excess deaths are in young children. (www.who.int) Projected climate change-related exposures are likely to affect the health status of millions of people through increases in malnutrition, heat waves, floods, storms, fires and droughts; the increased frequency of cardio-respiratory diseases due to higher concentrations of ground level ozone related to climate change; and, the migration of some infectious diseases.

Climate change may directly affect human health through increase in average temperature. Such increase may lead to more extreme heat waves during the summer while producing less extreme cold spells during the winter. Rising average temperature is predicted to increase the incidence of heat waves and hot extremes. In the United States, Chicago is projected to experience 25 percent more frequent heat waves and Los Angeles a four-to-eight-fold increase in heat wave days by the end of the century Particular segments of the population such as those with heart problems, asthma, the elderly, the very young and the homeless can be especially vulnerable to extreme heat (IPCC, 2007)

2.17 Impact of Climate Change on Overall Economy

A recent study conducted by the Climate Change Group (CIG) at the university of Washington and Climate Leadership Initiative (CLI) at University of Oregon on Washington's environment and economy, had revealed that each household in Washington will pay on average an additional $1,250 each year by 2020, $1,800 by 2040 and $2,750 by 2080 due to climate change (CLI, 2009). Developing countries are most vulnerable to the economic impacts of climate change. The increased frequency and severity of extreme weather events can have serious economic consequences. The impact of climate change on agriculture and the fragile ecosystems in Nepal will have a direct impact on agricultural productivity and tourism, and consequently on the country's economy (www.climate4life.org).

2.18 Livelihood Resource Assessment

As per the requirement of the research other tools used in the field was livelihood resource assessment to identify the major livelihood resource of the community. In the discussion and through mapping, and transect walk resource assessment of livelihood was done. In the community mostly depends on the labour, forest and livestock for their livelihood. Other than these resources of livelihood identified were roads, saving and credit co-operative, and community disaster preparedness and response committee. Other livelihoods were also identified but above-mentioned livelihood was agreed on community consensus as they were mostly used by the community. A recent study projected that doubling of atmospheric carbon dioxide (CO2) concentration will reduce Nepal's forest types from 15 to 12, and habitats and ecosystem will be destroyed. Climate change will also affect the productivity of natural ecosystems, particularly provision of environmental services such as clean air, water, food and aesthetic values. Communities of various parts of Nepal have already experienced loss of native plants and species.

2.19 Government Plans and Policies Regarding Climate Change

Chaudhary and Aryal (2009) reveal strong need of government, civil societies, involvement of NGOs for the high quality of outcome in the field of climate change and environment management. Various proven studies including Regmi and Adhikari (2007) suggest that Nepal has started some initiative for environmental protection and management. Debates on the issues of climate change have even been started since

1990(ibid). But now with the preparation of NAPA document it's considered as the priority work for the Nepal government. The following sections highlighted some of the initiatives that Nepal has taken for environmental and climate change sectors.

The Eighth Plan ((1992-1997): - Energy sector was highly prioritized in the eight five-year national development plans. The other appreciable and noticeable achievement during the plan was the formulation of Enactment of Environment Protection Act (1996) and promulgation of Environment and Protection Regulations (1997).

The Ninth-Plan (1997-2002): - Guided by the philosophy: development for the people, with the people and by the people ninth five-year plan was launched. The main objective of the plan is to reduce poverty through prioritizing sectors like agriculture, industrialization, tourism development and environment management.

The Tenth-Plan (2002-2007): The main objective of the Tenth Plan is to alleviate poverty by mobilizing optimum means and resources with the participation of government, local agencies, non-governmental sectors, private sector and civil society to extend economic opportunities. It planned to enlarge employment opportunities and widen the access to means and economic achievements for women, Dalits, peoples of remote areas and poor and backward groups through programmes like empowerment human development, security and targeted projects thereby improving the status of overall economic, human and social indicator. The plan acknowledged the importance of weather for economic performance but was almost silence in climate risks issues.

Medium Term Expenditure Framework (MTEF): - Shardul et al, (2003) finds that vector-borne disease control and emergency preparedness and disaster management, mitigation of floods and erosion in cultivated areas, and water harvesting to provide year-round water supply for irrigation was discussed in MTEF. In addition to these, MTEF paid some attention on climate-related risks. But the framework is almost silent about relation of hydropower plants due to the variability in runoff, floods (including GLOFS), and sedimentation.

2.20 Climate Change and Vulnerability Assessment in Nepal

Nepal has faced trend of annual increase in temperature per decade by 0.41 C which is higher than the global average (Lama et al., 2009). Although the people of mountain

hardly contribute to global warming, the evidence of increasing temperature have put on strong effect on the livelihood of locals due to the high rate of melting ice, glacier retreat, GLOF, drought and floods. There are 40 Himalayan glacial lakes that are close to bursting due to ice melt induced by increase in temperature (Pradhan et. al., 2008). Climate related disasters and shocks are even prominent if we look back to the records in Nepal. Large numbers of human lives have been affected by the floods. It has killed 5,003 people (24% of death from total disasters), left 69,350 homeless (45% of total disaster), and caused damaged amounting to USD 990,613 (75 % of total disaster) during 1954-2002 (Regmi et al., 2007). Large numbers of livelihood assets of poor people have been severely damaged by climate related disasters which is still unreported. It is therefore urgently needed to intervene to the highly vulnerable state of people ‘s livelihood through various adaptation and vulnerability reducing projects in Nepal. For that, it is firstly essential to identify vulnerable places, communities and magnitude and aspects of livelihood vulnerability (Regmi et al., 2007).

2.21 Climate Change and Nepal

Nepal's contribution for causing climate change is negligibly small: today Nepali citizens comprise less than 0.4% of the word population and are responsible for only about 0.025% of annual greenhouse emissions. Nepal's vulnerability to damage from climate change, however, is large. Temperature is likely to increase more in high mountain areas than elsewhere. Glaciers and snowfields will reduce and may even disappear, reducing Nepal's dry season river water source. This will impact irrigation and drinking water supply and as well as the reliability of hydroelectricity. Global climate change will also likely shift monsoon rainfall patterns in ways that threatens Nepal's current agricultural practices, as well as threaten infrastructure. Changing temperature and moisture pattern will threaten biodiversity, especially in mountain areas where migration of species is physically restricted (GON, 2003). According to the study carried out by Metrological Department of Nepal, there is increasing phenomenon of melting of glacier and Glacier Lake may cause outburst and increases flooding. According to the report 0.12C in Himalaya, 0.03C in Hill and 0.06C in Terai temperature is increasing annually. (Sapkota,2064).

As temperatures rise across South Asia, climate and disaster risks in Nepal are expected to increase further, affecting people, the economy, the environment, and development gains. Nepal's temperature is projected to increase by about 0.9 C between 2016 and 2045 under a medium-range emissions pathway. Winters are projected to be drier and monsoon summers wetter, with up to a threefold increase in rainfall. The number of people in Nepal annually affected by river flooding caused by climate change could double to around 350,000 in 2030 (from 157,000 in 2010).
While Nepal has low per capita emissions and is a negligible contributor to global climate change, agricultural and energy-related emissions are also a key source of air pollution, with major negative economic implications. Emissions come primarily from agriculture (54 percent) and energy (28 percent. Between 2012 and 2019, Nepal's emissions increased by 26.9 percent, primarily due to growing energy consumption in energy and industry, which accounted for 28.3 percent and 7.4 percent of Nepal's GHG emissions in 2019. Biomass, transport, open burning, and industrial activities also contribute significantly to air pollution, with sizeable negative impacts on health and productivity.

Climate variability is impacting the Nepali economy through lower agricultural productivity, road damage, and high energy imports during the dry season, among other impacts. Floods and landslides have been the most frequent hazards over the past 40 years; these events are expected to increase as climate change accelerates. While southern and urban municipalities are more likely to experience flooding and heat stress, northern regions are affected by increased erosion, landslides, water stress, and glacial lake overflow. The most vulnerable communities often live in the most extreme environments that are subject to climate impacts and lack social protection programs. Women, indigenous people, and other marginalized communities are disproportionately affected.

Nepal has begun to put in place the necessary policy framework, such as the 2019 National Climate Change Policy, the 2022 Solid Waste Management Policy, the 2022 Forest Regulation, and the 2022 Land Use Regulation. However, implementation of this reform agenda and prioritization of investments is incipient. Moreover, enhanced prioritization and efficiency of public expenditure are required to maximize climate and development benefits.

This Country Climate and Development Report outlines four priority system transitions that are fundamental to addressing the risks that climate change poses to Nepal while also providing opportunities for improving the quality and sustainability of economic development: (a) improving systemic resilience of rural landscapes including food, freshwater, and forest systems to boost adaptation, livelihoods, and food security; (b) harnessing Nepal's significant hydropower opportunities; (c) managing urbanization and environmental quality to build resilience and improve health; and (d) strengthening Nepal's low-carbon, resilient connectivity — particularly roads — to improve the country's growth and services. This report also outlines three key enabling themes to help support the priority system transitions toward a greener future for Nepal: strengthening the resilience of people and community assets through early warning systems, shock-responsive safety nets, and access to quality skills training; embedding disaster risk management at all tiers of government and across all sectors; and prioritizing Nepal's funding needs by convening and coordinating financing for climate action. (IFC)

2.22 Climate Change Impacts on Agriculture

A number of negative effects of Climate change like change in Agricultural Calendar, vegetation shifts, change in routine activities like grazing, harvesting and storing etc. have been observed in Agriculture in Nepal. Over the past three years, the delay in monsoon season experienced in Nepal has changed the cropping pattern and crop maturity period which has delayed the planting and harvesting season by a month, which has in turn affected rotation practices (Dahalet.al.2011). The delaying monsoon season has also made thousands of hectares of farm land fallow and reduced production due to lack of water (Regmi and Adhikari, 2007). A drought in the Eastern region of Nepal decreased the rice production by 30% in 2006 and heavy flooding in the mid-Western and far-Western regions in 2006 and 2008 destroyed crops in many places and there is also evidence that the vector borne diseases in livestock are increasing, forcing the livestock population to move to higher altitudes (PracticalAction,2008).

Gautam and Pokharel (2010) have predicted temperature rise of 0.06°C per annum but the Global Climate Models (GCM) project the increase in temperature by 0.5-

2.0°Cwith a multimodal mean of 1.4 °C by the 2030s, rising to 3.0-6.3 °C with a multimodal mean of 4.7 °C, by the 2090s (NCVST, 2009). In addition, it has been suggested that warming of more than 2.5°C could reduce global food supplies and contribute to higher food prices (UNEP&UNFCCC, 2002). For precipitation GCMs project a wide range of changes, especially in monsoon: -14 to 40 % by the 2030s increasing -52 to +135 % by the 2090s (NCVST, 2009). These projections suggest that Nepal's agriculture will face many challenges over the coming decades due to climate related variability. Existing problems such as soil degradation and increasingly limited water resources are likely to be exacerbated by climate change, increasing the difficulty of achieving food security for the growing population. The recently observed extreme severe weather events between 2006-09 including drought sand floods have significantly affected food production in Nepal (WFP,2009).

Climate change such as rising annual temperature, delayed monsoon season, increased annual rainfall resulting from increased glacial melting and increased occurrence of intense rainfall (Regmi and Adhikari, 2007) among others has affected many rainfed farmer communities in Nepal and it is forecasted by the United nations Framework Convention on Climate Changeand Inter governmental Panel on Climate Change to create even more damage to agricultural production in the coming 20 years (IPCC third assessment report, 2001; UNFCC report 2000). Climate change will have far-reaching consequences for agriculture that will disproportionately affect the poor. Greater risk of crops and livestock death are already imposing economic losses and undermining food security and they are likely to get far more severe as global warming continues. Climate change threat to 12 agriculture is now unambiguous, but the exact magnitude is uncertain because of complex interactions and feedback process in the ecosystem and the economy. Five main factors will affect agricultural productivity: change in temperature, precipitation, carbon dioxide fertilization, climate variability, and surface water runoff. For temperature increase above 30 C, yield losses are expected to occur everywhere and be particularly severe in tropical regions. In parts of Africa, Asia and Central America yields of wheat and maize could decline by around 20 to 40 percent as temperature rises by 3 to 40 C, even assuming from-level adjustment to higher temperature. With full CO2 fertilization the losses would be about half as large. Rice yields would also decline, though less than wheat and maize yields (WDR, 2008). As a result of climate change, rainfall levels in many

parts of the developing world are falling. This creates a 'domino effect'; with less rain, water levels drop in reservoirs or rivers and people have less water to use. The quality of that water deteriorates as sewage and industrial effluent becomes more concentrated; as a result, waterborne disease is rife. With a lack of water, vegetation doesn't grow so livestock have less to graze on. There is also less wood for cooking, so women have to spend more time searching for fuel to cook for the family. Our greatest concern about climate change is the damage it is causing to our agriculture. Sudan's economy, like that of many developing countries, is heavily based on farming and livestock keeping, the major employment sectors of the country. More than 70% of the population relies on traditional and subsistence agriculture, the majority of which are dependent on rain-fed agriculture and pastures. This all makes our economy extremely vulnerable to any slight changes in the weather. These changes are happening now and many people's livelihood is under threat (Abdalla, 2009).

According to IPCC the following are some important factors directly connected to climate change and agricultural productivity: · Average temperature increase: An increase in average temperature can 1) lengthen the growing season in regions with a relatively cool spring and fall; 2) 13 adversely affect crops in regions where summer heat already limits production; 3) increase soil evaporation rates, and 4) increase the chances of severe droughts. · Change in rainfall amount and patterns: Changes in rainfall can affect soil erosion rates and soil moisture, both of which are important for crop yields. The IPCC predicts that precipitation will increase in high latitudes, and decrease in most subtropical land regions some by as much as about 20 percent. While regional precipitation will vary the number of extreme precipitation events is predicted to increase (IPCC, 2007). · Rising atmospheric concentrations of CO2: Increasing atmospheric CO2 levels, driven by emissions from human activities, can act as a fertilizer and enhance the growth of some crops such as wheat, rice and soybeans. CO2 can be one of a number of limiting factors that, when increased, can enhance crop growth. Other limiting factors include water and nutrient availability. While it is expected that CO2 fertilization will have a positive impact on some crops, other aspects of climate change (e.g., temperature and precipitation changes) may temper any beneficial CO2 fertilization effect (IPCC, 2007). · Pollution levels such as troposphere ozone: Higher levels of ground level ozone limit the growth of crops.

Since ozone levels in the lower atmosphere are shaped by both emissions and temperature, climate change will most likely increase ozone concentrations. Such changes may offset any beneficial yield effects that result from elevated CO2 levels. · Change in climatic variability and extreme events: Changes in the frequency and severity of heat waves, drought, floods and hurricanes, remain a key uncertainty in future climate change. Such changes are anticipated by global climate models, but regional changes and the potential effects on agriculture are more difficult to forecast. Experience of Nepali farmers is similar to Uganda, Malawi, Haiti, Bolivia, Vietnam and South Africa. Farmers are in the trap of decreasing production and productivity . Over two-thirds of Nepal's population depends on agriculture for their livelihood. Farmers follow traditional agricultural patterns, relying on rainwater and seasons. Changes in local and regional temperatures, the form and amount of precipitation, rainfall patterns, soil moisture content, and sunshine and cloudiness threaten traditional agriculture in Nepal. Moreover, climate change will increase the occurrence of extreme events like floods, droughts and hailstorms, which can also have a drastic effect on agriculture. Rising temperatures and increased rainfall may also lead to more pests and weeds, which will reduce agricultural productivity. (www.climate4life.org)

2.23 Climate Change Vulnerability of Agriculture

The term vulnerability is used loosely in many different contexts, from medicine to poverty and development literature. In global environmental change studies, the concept of vulnerability is often derived from the social sciences (Chambers, 1989; Liverman, 1992). In hazard research, Chambers (1989) introduced the concept that vulnerability has an internal and external dimension and these relate to the capacity to anticipate, cope, or recover from the impacts of a hazard, and to the exposure to risks of the hazard, respectively. Kasperson and Kasperson (2001) also recognized that interactions exist between the internal capacity of humans to withstand or respond to a risk and the external dimension (risk). Similar interactions occur between the social and economic vulnerability of populations and the degree of resilience of ecological systems. He suggested, therefore, that an integrated approach to both human and natural systems is needed if significant progress is to be made in understanding the different vulnerability of regions, places and people. A widely accepted methodological framework to analyse vulnerability arising from these two concepts

of the internal and external dimensions (and their interplay) has yet to be fully developed.

The Inter-governmental Panel on Climate Change (IPCC), in its Second Assessment Report, defines vulnerability as "the extent to which climate change may damage or harm a system" and it adds that vulnerability "depends not only on a system' sensitivity, but also on its ability to adapt to new climatic conditions" (Watsonetal.1996:23).Looking at vulnerability from the food security point of view, the FAO publication, The State of Food Insecurity in the World (1999), defines vulnerability as "the presence of factors that place people at risk of becoming food insecure or malnourished." Clearly, this definition encompasses causes of food in security other than climate change (e.g., armed conflict, landlessness, etc.). Nevertheless, the concept of vulnerability includes hunger vulnerability—which refers to the vulnerability of individuals or households rather than that of regions or economic sectors. A common theme in the climate change impacts and vulnerability literature is the idea that countries, regions, economic sectors and social groups differ in their degree of vulnerability to climate change (see, for example, Bohle et al. 1994). This is due partly to the fact that changes in temperature and precipitation will occur unevenly and that climate change impacts are unevenly distributed around the globe. It is also due to the fact that resources and wealth are distributed unevenly.

Crop lands in Mountain region of Nepal is environmentally marginal and are likely to be at increased risk of land degradation and biodiversity loss as a result of climate trends. Nepalese farmers are largely poor with limited access to external resources and are likely to be particularly vulnerable to climate change. Vulnerability to climate change is closely related to poverty, as the poor are least able to respond to climatic stimuli (Olmos, 2001). Besides, bio- physical features of the region further increases the vulnerability.

2.24 Climate Change Impacts and Vulnerability of Soil

Soil is an important natural resource which directly or indirectly supports all forms of life on the planet earth. According to Real et al. (1985) soil is holistically defined as a social good; it represents the physical, chemical, biological base of the agricultural production. The declining agricultural productivity may be related to influences

changes in climate elements have on soil quality, especially its overall ability to support life and suitability for sustainable alternative uses. There is a strong inter-dependence between climate factors and soil quality (Jenny,1980). These include rainfall, floods, solar radiation, temperature, evaporation and wind. The vulnerability of soil to climatic influence depends on both the physical and chemical characteristics of soils. Such properties as texture, mineral, population and activities of soil determine the extent of changes in soil characteristics that will occur in response to changing soil forming factors (i.e.,climate) (Brady and Weil,1999).

The impacts of climatic variations and climate change on soils of mountain region of Nepal could be examined in their implication on floods, droughts, desertification, soil erosion etc. Climate is probably the main variable that influences, directly or indirectly the top soil, and particularly the surface layer. The surface processes are caused by the properties of the soil itself (Pla,2002). Land degradation is the loss of utility or potential utility of land or decline in soil quality caused through misuse by human (Barrow,1992).

High rainfall and temperature arising from climate change will increase rock and mineral weathering, as well as leaching of the basic cations (Ca^{2+}, Mg^{2+}, Na^{2+}, and K^{+}) thereby leaving the acidic cations (Al^{3+} and H^{+}), thus increasing soil acidity. Acid rainfall which is a consequence of climate change with its implications of greenhouse gases add to the acidity of the soil. The availability of micronutrient cations is increased by low pH, even to the extent oftoxicity to plants and microorganisms (Brady and Weil, 1999). Soil temperature is the primary determinant of microbial processes and so, increase in temperature will exacerbate the rate of mineralization leading to a decrease in the soil organic carbon pool (SOCP). With climatic change peat and other organic soils are converted to mineral soils. Lal (2004) noted that an increase in temperature would deplete the SOCP in the upper layers by 28% in the humid zone, 20% in the sub humid zone and 15% in the other zone.

Declining soil fertility has been considered one of the major problems in the hill and mountain areas of Nepal as a result of recent changes in agricultural practices and increasing resource constraints. Hartmink*etal.*(2008) documented several constrains in soil fertility management in Nepal because of deforestation and other land use

changes. These changes include non- agricultural uses of fertile land, land fragmentation and cultivation in marginalized areas, cultivation on the slopes, overgrazing, burning of crop residues, imbalanced use of agrochemicals, and declining use of organic manure. In South and South-East Asia, the principal soil degradation processes associated with land use changes include accelerated erosion by water and wind, salinization, flooding, water logging, and soil fertility. The pace of soil degradation issue is the highest in mountains because of the fragile environment and the steep slopes (Acharya and Kafle, 2009). Moreover, due to rugged mountainous topography, active tectonics and concentrated monsoon precipitation, Nepal is naturally highly vulnerable to soil erosion on slopes and flooding in the low-lands

2.25 Impact of Climate Change on Biodiversity

About 20 to 30 percent of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5 to 2.5 degrees C (2.7 to 4.5 degrees F) (UN 2008). A recent study projected that doubling of atmospheric carbon dioxide (CO2) concentration will reduce Nepal's forest types from 15 to 12, and habitats and ecosystem will be destroyed. Climate change will also affect the productivity of natural ecosystems, particularly provision of environmental services such as clean air, water, food and aesthetic values. Communities of various parts of Nepal have already experienced loss of native plants and species. Climate change will alter the world's habitats and ecosystems. Climate change will alter the fragile ecosystems of the Himalayas. As it warms up, vegetation and wildlife will move to higher altitudes. This change will upset the ecosystem balance and seriously endanger the survival of many plant and animal species. Rapid climate change will not give plants and animals enough time to adapt to the new situation. Biodiversity loss, besides the immediate impact on species, will affect the health, wellbeing and livelihood of the people who rely on such resources (www. climate4life.or)

2.26Climate Change and Adaptation of Agriculture

Adaptation is the responsive adjustment in natural or human managed systems to minimize the impacts, effects or expected changes. IPCC has categorized adaptations in two types; spontaneous and planned. Spontaneous adaptation occurs at the level of

individual whereas planned adaptation needs involvement of society with guiding policies (Berry et. al. 2006). According to Smit& Skinner (2002) adaptation on agriculture can be categorized as: technological, on-farm adjustment practices, government policy including insurance as well as diversifying household income sources as financial management strategies. Infect, the farmers who have the resources and access should be able to adapt better as compared to resource poor marginal farmers (Esterling&Apps2005). Famers can adopt to climate change to some extent by adjusting planting time and input use, by altering soil management practices as well as diversifying their farm enterprises (Smitet.al.1996). Lobelletal. (2008) has stressed that agricultural systems in Southern Africa and South Asia face decreases in crop production if sufficient adaptation strategies are not implemented.

In South Asian countries, particularly India, Nepal and Bangladesh, farmers are already adapting to changing conditions by using traditional seed exchange practices that are part of established seed systems(Gautametal.,2008).Farmers can also use their knowledge of abiotic stress tolerance and adaptability in their materials and work with plant breeders to develop varieties that are adapted to changing local conditions and possess improved yield sand quality (Jarvisetal,2007).Many adaptation practices involving crops and livestock have been reported (e.g. Reid and Swiderska,2008).

Climate variability and risks have always been a part of agriculture, due to which farmers have developed many ways of managing risks. Searching and exchanging drought-resistant seeds and other abiotic stress-tolerant crop varieties and adopting and practicing specific soil and water management practices for marginal areas have long been core activities of the farming communities (Gautametal.,2010). Climate change introduces a new dimension to the problem. The continued availability and use of agro-biodiversity in Nepalese farming, particularly by smallholder farmers, is likely to play an important role in adaptation to climate change. Communities maintain rich species and intra-specific crop diversity both to help manage climatic adversity and meet their other needs (Jarvis et al., 2008). The farming in Nepal is characterized by mixed farming and livestock production systems, which have rich diversity. Forest, home gardens, agroforestry (with richness of fodder trees) and productive fields all embed diversity rich maintenance and use practices that increase adaptability and reduce vulnerability.

Traditional farming system management practices and farmers' innovations are clearly a key element in local adaptation to climate change. While scientists and policymakers work to find solutions, local farmers have already amassed considerable experience of how to cope, based on their observation and experimentation in the field (Reid and Swiderska, 2008). So, it is very important to document the adaptation practices that have been evolved in the farmers' fields.

CHAPTER- III

RESEARCH METHODOLOGY

3.1 Research Design

This study was carried out on the basis of exploratory research design because the study is focused on to investigate the impact of climate change on local communities. Moreover,the objective of the study to find out the effects of climate change on livelihood of communities, effects on income and health condition of people. In this regard, it is exploratory research. Besides, the study attempts to describe the effects of climate change on agriculture, livestock on the basis of local people's perception and explored findings is described. Thus, this study is both descriptive and exploratory.

3.2 The Universe and Sample

This study was applied purposive sampling for area selection, whereas sample population of the study wasbe selected on the following basis. The selected area of Phalelung Rural Municipality Ward no. 5 wasbe the universe of the study. Sampling procedure is the simple random selected of the area. Out of 65 household 15 respondents was be selected for the study using simple random basis.

3.3 Techniques of data Collection

The research is field based. To collect the data, the following techniques was used:

3.3.1 The filed Survey

To collect the primary data, field survey was conducted using both structured and unstructured data prepared prior to the field visit. Questionnaire will be filled at the time of discussion from the respondents.

3.3.2 Field visit and Observations

The data were generated from field visit and observation method observing the households, environment, agriculture field and sites.

3.3.3 Group Discussion

To acquire information necessary group discussion was made. Group discussion was carried out with farmers and households of Phalelung rural municipality ward 5.

3.3.4Key Information Interview

To know the facing problems and their solutions from different aspects, structured interview was taken with key information such as related research projects running over there, local clubs etc.

3.4 Data Processing

The collected questionnaires were tabulated by the help of SPSS program statistical analysis software widely used in research and data analysis through computer. All the necessary statistical tools like tables, graphs, means and medium were calculated from the program.

CHAPTER – IV

DATA PRESENTATION AND ANALYSIS

4.1 Introduction of the Study Area

Panchthar District is one of 14 districts of Koshi Province of eastern hilly region of Nepal. It is a Hill district of eastern Nepal.The district covers 1,241 km² of area. The 2021 census counted 174,419 population. Phidim is the district headquarter. There are eight local levels including one municipality and seven rural municipality.

It is bordered with Taplejung district in north, Sikkim and Darjeeling district of Indiaeast Morang and Dhankuta in west and Ilam district in South. It is located between 26’’.28″ to26’’.59’N latitude and 80.02 to 87"30" longitude. It is full of diversity, biodiversity, cultural diversity and vast as well as difficult geographical situation. The study site Phalelung rural municipality ward 5 is situated in the far east part of the Panchtahr district. This is bordered with Sikkim district of India in east, Yangwarak Rural Municipality in north, Phidim Municipality in west and Darjeeling and Ilam in south. The study site is one of Tole of Phalelung ward 5 among the 9 toles. Its height is about 1400m to 3000 meters from sea level. Temperate zone climate can be found in this region. Its south west faced landscape may be suitable for cultivation of crops and cash crops. The total area of the Tole is about 500 hectors. It covers 0.12% of the total land of district.

4.2 Demographic Scenario

Although, the majority of AdibasiJanajati (indigenous) people are residing the Phalelung Rural Municipality, there is heterogeneous society. Different castes of people are residing in the study site. Brahman, Tamang, Chhetri, Gurung, Magar, Rai, Limbu, Sherpa and Dalit Community people are residing in Phalelung Rural Municipality. According to census 2021, 20360 people were residing in Phalelung Rural Municipality.

Some data on demographics scenario is given in Table 4.1:

Table No. 4.1: Demographic Statistics of Phalelung Rural Municipality

S. N.	Facts	2021 Census
1	Total Population	20360
2	Male	10119
3	Female	10242
4	Total household	4915
5	Literacy Rate	75.75%
6	HH Size	4.14
7	Population density	98
8	Growth rate	0.69%

Source: Census, 2021

4.3 Caste of the Respondents

Heterogeneity and multiplicity are the figure of the study area, various castes like Magar, Gurung, Limbo and Rai are in existence in the study are. Among the total population of the study area Janajati are dominant cast group compares to other castes.Nepali languages common communicative language of all caste.

Table No. 4.2 Caste Survey of the Respondents.

S. N.	**Caste**	**No. of Respondents**	**Percentage**
1	Magar	5	33.34
2	Gurung	8	53.33
3	Rai	2	13.33
	Total	15	100

Sources: Field survey, 2023

The table no. 4.2 shows that the Magar are 33.34 percent, Gurung are 53.33 percent and Rai are13.33 precent in the study area.

4.4 Cash Crops and Climate Change

It was found that the major cash crop grown in the ward number 1,2,3,4 and Amriso, tea, cardamom and potato in ward number 5. So, it can be said that the major cash crops grown are Amriso and cardamom, ginger in the Tole. The majority of the

respondents said that they had grown the cash crops for 15 years. Three types of land were found in the study area. They were respectively khet, Bari and cardamom land. The cash crops were grown in Bari land and cardamom land. It was found that the major cash crops grown by respondents were cardamom with 33.33%, and then Amriso with 20 % and rest others are with small area.

Table 4.3 Major Cash Crops Grown by Respondents

S. N.	Cash Crops	Cash Crops Grown in Percentage
1	Amriso	20
2	Amriso, Cauliflower, Cardamom	13.33
3	Ginger	13.33
4	Amriso, Cardamom,	13.33
5	Amriso, Tea, Cardamom	6.66
6	Cardamom	33.33
	Total	100

Sources: Field survey, 2023

Table no.4.3 shows that the majority of respondents i.e. 33.3% told that the main reason for change in flowering, fruiting and harvesting time of cash crops was increased temperature. Cardamom was most affected cash crop from temperature.

4.5 Effect of Irregular and Unseasonal Rainfall on Agriculture

Irregular and unseasonal rainfall has been increasing from last few years, which is affecting cultivation of crops. Among total respondents 7.62% replied they are facing problem on cultivation of crops while 42.86% of respondents replied irregularities on production of crops.

Table 4.4: Effect of Irregular and Unseasonal Rainfall on Agriculture

S. N.	Effects of irregular rainfall	Respondents	
		Number	Percentage
1	Effect on cultivation	2	13.33
2	Flooding	2	13.33
3	Irregularities on production of crops	5	33.33
4	Effect on cultivation, irregularities on production of crops	4	26.67
5	Effect on cultivation, flooding and irregularities on production of crops	2	13.33
	Total	15	100

Sources: Field Survey, 2023

Note: Other includes, decreasing production due to unseasonal rainfall, growth of crops is limited, Cultivation of crops is being impossible of irregular rainfall, more input low output.

4.6 Effect of Rise of Temperature on Agriculture

According to respondents, new insects have appeared and spread on crops as well as fodder and other vegetations. To cure these insects/diseases on key crops uses of pesticides are also increasing. The respondents realized rise in temperature as main cause of early flowering of different species of fruits and crops. Crops' species and fruits which are known as suitable for summer season are also being suitable for winter season. Crops species which are found on tropical region are also found on Himalayan region including in the study area. The rate of spread and growth of these species is very high in comparison to endemic species. Increasing temperature is creating many consequences; decreasing the period of maturation of crops, decreasing the time period of breeding of seed and wide spread of insects and disease etc.

Table 4.5: Effects of Increasing Temperature on Crops

S. N.	Effect of increasing temperature on crops	Respondents	
		Number	Percentage
1	Decreasing the maturation period of crops	3	20
2	Decreasing the time period of germinating seed	2	13.33
3	Wide spread of insect/diseases	4	26.67
4	Decreasing the maturation period of crops, decreasing the time period of germinating seed	4	26.67
5	Decreasing the maturation period of crops, wide spread of insect/diseases	2	13.33

Sources: Field survey, 2023

Note: Others includes, irregularities in flowering of plants species, shedding time of plant is changed, change in harvesting time of crops and increasing different pests and insects.

4.7 Main Income Sources of Households

Agriculture, service, self-oriented business, Foreign Employment are the main occupation/income sources of the survey households. Other occupation includes daily wage, fishing etc. The frequency and the percentage of survey households has presented in the table below Most of the households are depend on foreign employment.

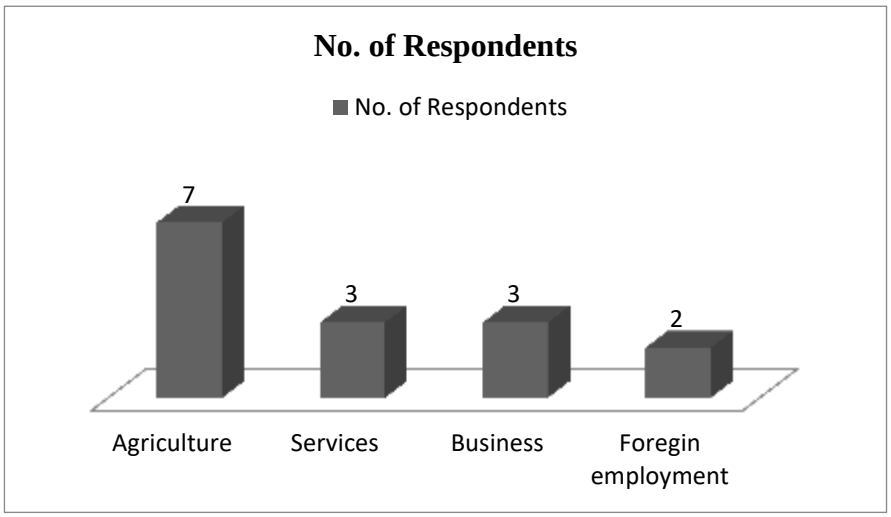
Table 4.6 Main Income Sources of Households

S.N.	Income Sources	No. of Respondents	Percent
1	Agriculture	7	46.67
2	Services	3	20
3	Business	3	20
4	Foreign employment	2	13.33
	Total	15	100

Sources: Field survey, 2023

The table no 4.6 demonstrate that the main income source is agriculture is 46.67 percent, service is 20 percent, business is 20 percent and foreign employment is 13.33 percent.

Figure no 4. 1 Main Income Sources of Households



4.8 Occupation of the Respondents

Primary occupation of most of the respondent is agriculture. Respondents having primary occupation agriculture, they also have assistance occupation. Most of respondent kept livestock as assistance occupation, few involved in business and few involved in services for the assistance occupation. The occupational structure of the respondents is presented in table below,

Table no. 4.7 Occupation of Respondent.

Main occupation	No.of Respondents	Percentage	Assistance occupation	No. of Respondents	Percentage
Agriculture	15	100	Livestock husbandry	10	66.67
			Business	3	20
			Service	2	13.33

Source: Field Survey, 2023

The table 4.7 shows the agriculture is main occupation of the respondents because almost 100 percent respondent's main occupation was agriculture. And most of 70 percent respondents kept some kinds of livestock which is their assistance occupation, in which women are mostly involved as itis not difficult for them because fodder is come from their field such as agricultural residues e.g., straw, wheat straw, rice husk, maize and green maize plant and grasses too. These livestock husbandry help to support their livelihood. Some farmers rear livestock for their own use where as some

rear them for economic purpose. Also, 20 percent respondents involved in business and 13.33 percent respondents involved in service.

4.9 Land Ownership

As agriculture is the main occupation of Nepalese, this study conducted in phalelung also depicts the same result. But the cultivation patterns a little bit different as found in nation-wide cultivation pattern, that is, several studies have shown that farmers do not get their own land for cultivation rather landlords occupy most of the land and farmers get land in rent. But in this study area, cultivation pattern in land is done by own landowner.

Table No. 4.8 Land Ownership of the Study Area

S. N.		Ownership	No. of Respondents	Percentage
1		Cultivated by Own	10	66.67
2		Rented	3	20
3		As a Tenant	2	13.33
		Total	15	100

Source: Field Survey, 2023

Table No 4.8 reflect that among the sampled households, 66.67 percent of household cultivate their own land, 20 percent of sampled household cultivate land taking in rent. Similarly, 13.33 of sampled household cultivate land but as a tenant.

4.10 Adaptation Techniques Adopted by Local Farmers to Minimize Impact of Climate Change

Adaptation technique is very important to cope with and minimize impact of climate change. Reforestation is one of most suitable adaptation technique which should be adopted by those country suffered from climate change include both developed and developing countries. There is also other adaptation technique adopted by farmer to minimize impact of climate change. These are water management techniques, crop rotation, mix cropping, use of local pesticides, use of organic fertilizer and livestock manure instead of use if harmful chemical pesticides and chemical fertilizer.

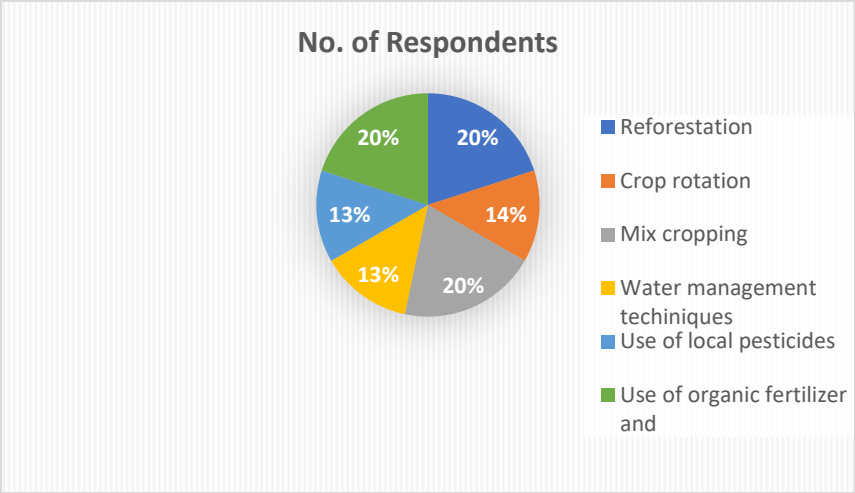
Table 4.9 Adaptation Technique Adopted by Local Farmers

Adaptation techniques	No. of Respondents	Percentage
Reforestation	3	20
Crop rotation	2	13.33
Mix cropping	3	20
Water management techniques	2	13.33
Use of local pesticides	2	13.33
Use of organic fertilizer and livestock's manure	3	20
Total	15	100

Source: Field Survey 2023

The table no 4.9 reflect that the 20 percent respondents involved in reforestation, 13.33 percent respondents involved in crop rotation, 20 percent respondents involved in mix cropping, 13.33 percent respondents involved in providing irrigation water, 13.33 percent respondents involved in use of local pesticides and 20 percent respondents involved in use of organic and livestock's manure as adaptation technique to minimize impact of climate change.

Fig no. 4.2 Adaptation Technique Adopted by Local Farmers



4.11 Agriculture Practice

In response to climate change, rural agriculture has been adopting various adaptation practices to mitigate its impacts and ensure sustainable food production. Some of the

common adaptation practices include:

1. Crop diversification: Farmers are diversifying their crop choices by introducing new varieties or shifting to crops that are more resilient to changing climatic conditions. This approach helps reduce the vulnerability of agriculture to specific climate-related risks, such as drought, heatwaves, or pests.
2. Agro-forestry: Integrating trees into agricultural landscapes through agro-forestry practices provides multiple benefits. Trees can serve as windbreaks, help control soil erosion, improve water retention, and provide shade for crops and livestock. Agro-forestry systems contribute to climate change adaptation by enhancing the resilience of agricultural ecosystems.
3. Conservation agriculture: This approach promotes the use of minimal tillage or no-till farming methods, along with maintaining permanent soil cover and diversified crop rotations. Conservation agriculture practices help improve soil health, water retention, and reduce erosion, thereby enhancing the resilience of farming systems to climate change impacts.
4. Water management techniques: Efficient water management becomes crucial in areas experiencing changing precipitation patterns or increased water scarcity. Farmers are adopting practices such as rainwater harvesting, drip irrigation, and precision agriculture techniques to optimize water use, minimize wastage, and ensure the availability of water for crops.
5. Improved livestock management: Climate change can impact livestock through heat stress, changes in forage availability, and increased disease prevalence. Adaptation measures include providing shade and shelter for animals, improving ventilation in livestock housing, adjusting feeding practices, and promoting disease prevention and control strategies.
6. Climate information and advisory services: Access to timely and accurate climate information is essential for farmers to make informed decisions. Establishing climate information and advisory services helps farmers understand climate forecasts, plan their agricultural activities accordingly, and implement suitable adaptation measures.
7. Farmer capacity building and training: Building the knowledge and skills of farmers through training programs is vital for successful adaptation. Training sessions can cover climate-smart agricultural practices, sustainable land

management techniques, and the use of climate-resilient crop varieties, empowering farmers to make informed choices and adapt to changing conditions. About 79% respondents responded that there has been change in agriculture practice and all agreed that the cropping pattern has changed over time. Traditional practices have been replaced with new practices especially sowing methods, variety types, crop intensity and cropping practices, use of tools and technique in watering, weed clearing etc.

Table 4.10 Response for Agriculture Practice

Practice	Changed	Same	Remarks
Response	10	5	Seed sowing, weeds clearing, watering plants, diversified crops and crops cycle, Improved varieties crops and vegetables One time farming (before), more than one cycle farming (present), crop rotation.
Percent	66.67	33.33	

Source: Field Survey, 2023

The table no. 4.10 shows that the traditional practices have been replaced with new practices has found about 66.67 and rest of them 33.33% are still in practices in traditional pattern in the study area.

CHAPTER-V
SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary

In summary, climate change has significant impacts on rural agriculture, posing challenges such as increased frequency of extreme weather events, changes in precipitation patterns, rising temperatures, and the spread of pests and diseases. These impacts can jeopardize food security, livelihoods, and the sustainability of agricultural systems. However, adaptation practices are crucial in addressing these challenges. Here are the key points:

- Climate change impacts on rural agriculture include reduced crop yields, water scarcity, soil degradation, increased pest and disease pressure, and disruption of ecological systems.
- Adaptation practices in rural agriculture are aimed at minimizing these impacts and ensuring sustainable food production.
- Common adaptation practices include crop diversification, agro-forestry, conservation agriculture, improved water management techniques, enhanced livestock management, access to climate information and advisory services, capacity building and training, and the establishment of insurance and financial mechanisms.
- These adaptation practices help improve resilience, optimize resource use, conserve water, protect soil health, mitigate pests and diseases, and diversify income streams.
- Collaboration among farmers, governments, research institutions, and agricultural extension services is essential for successful implementation of adaptation practices.
- Adaptation practices not only reduce vulnerability to climate change but also contribute to environmental sustainability, biodiversity conservation, and the well-being of rural communities.
- Continuous monitoring, evaluation, and adjustment of adaptation practices are important to ensure their effectiveness and relevance in the context of changing climate conditions.

Overall, adaptation practices in rural agriculture are vital for building resilience, ensuring food security, and mitigating the negative impacts of climate change on agricultural systems and rural communities.

5.2 Conclusion

Climate change is a natural process but human activities accelerating the speed of change. So, there must prime concern on climate change, increased food insecurity and other consequences like increasing temperature, changing rainfall pattern, melting ice of Himalaya, drought, flood etc. Impact of climate change is direct to the agriculture sector. Due to the scarcity of water for irrigation, agricultural production and productivity is decreasing.

In conclusion, adaptation practices in rural agriculture play a crucial role in mitigating the impacts of climate change and ensuring sustainable food production. As the climate continues to change, it is imperative to implement effective strategies that enhance resilience, conserve resources, and promote long-term agricultural viability. By diversifying crop selection, improving water management, implementing conservation agriculture, enhancing soil health, adopting agroforestry, integrating livestock and crop farming, promoting climate-smart technologies, strengthening early warning systems, providing access to finance and insurance, and fostering capacity building and knowledge sharing, rural communities can adapt to the challenges posed by climate change. These adaptation practices empower farmers to make informed decisions, reduce vulnerability, optimize resource use, and safeguard their livelihoods in the face of a changing climate. The collaboration of farmers, governments, research institutions, and agricultural extension services is crucial for the successful implementation of these practices. Through collective efforts and continuous adaptation, rural agriculture can thrive and contribute to food security, environmental sustainability, and the well-being of rural communities in a changing climate.

5.3 Recommendations

Successful adaptation depends upon technological advances, institutional arrangements, availability of financing and information exchange. So, following

recommendations are made to the local and national level organizations for the successful adaptation to agriculture.

Here are some recommendations for adaptation practices in rural agriculture to address the impacts of climate change:

1. Diversify crop selection: Farmers should diversify their crop choices by selecting climate-resilient varieties and introducing new crops suitable for changing conditions. This helps reduce the vulnerability of agriculture to specific climate-related risks and ensures stable food production.
2. Improve water management: Implement water-saving techniques such as drip irrigation, rainwater harvesting, and efficient water storage to optimize water use and cope with changing precipitation patterns and water scarcity.
3. Implement conservation agriculture: Promote conservation agriculture practices such as minimal tillage, mulching, and cover cropping to enhance soil health, reduce erosion, improve water retention, and increase resilience to climate impacts.
4. Enhance soil health and fertility: Implement sustainable soil management practices, including organic amendments, crop rotation, and integrated nutrient management, to maintain soil fertility, enhance nutrient cycling, and improve soil structure and water-holding capacity.
5. Integrate livestock and crop farming: Encourage integrated farming systems that combine crop production with livestock rearing. Properly managed integration can enhance nutrient cycling, improve soil fertility, and provide diversified income sources for farmers.
6. Promote climate-smart technologies: Support the adoption of climate-smart agricultural technologies such as precision agriculture, weather forecasting tools, and remote sensing to optimize resource use, reduce inputs, and enhance productivity.
7. Access to finance and insurance: Facilitate access to financial services, including credit and insurance schemes, to help farmers manage climate-related risks and invest in adaptive practices and technologies.

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Annex –I

Questionnaires

This Questionnaire has been designed to explore the informative for purely academic purpose. This is to enable the researcher Mohan Kumar Khapangi. This thesis on the topic Impact of Climate Change and Adaptation Practice in Agriculture: A Study of Phalelung Rural Municipality Ward No.5, Panchthar, Nepal in pursuance of Master of Arts in Rural Development.

Name: Address:
Occupation: Age:

Questionnaires

1. How many family members do you have in your family?
   Female ……. Person Male …… Person Total ……. Person
   0-15 Years …… Person 15-60 Years …… Person More than 60 ……. Person
2. Please mention Literacy status of your family
   Unable to read/write ……. Person Literate ……. Person
   Up to Class 5 …… Person Up to Class 8 ……. Person
   S.L.C or equivalent …… Person Intermediate and above ….. Person
3. What is your family's main occupation?
   Agriculture/Livestock Employment Other ……

4. What kind of change you have felt in raining pattern in comparison with past years?
   a. Less b. More c. Same
5. What may be the cause in reduction of rain?
   a. Increase in deforestation
   b. Increase in population
   c. Other …….
6. What kind of change in monsoon season?
   a. Increase/Decrease in winter
   b. Increase/Decrease in monsoon season
   c. Increase/Decrease in both seasons
7. What kind of effects has been occurred due to excessive/less rainfall?
   a. Increase/Decrease in winter

b. Increase/Decrease in monsoon

c. Increase/Decrease in both seasons

8. What Kind of effects have been observed from less rainfall?

a. Rise on production b. less production of crops

c. No changed d. Effects on Cultivation/no cultivation

e. Other …….

9. What kind of effects has been occurred from irregular rainfall pattern?

a. Effects on cultivation

b. Drown of harvested crops

C. Waste harvested crops d. Irregularities in production

e. Other ……

10. What Kind of Problems have been observed from less rainfall?

a. Effects on cultivation b. less production

c. Dry up of water resource d. Effects on Livestock

e. Other …….

11. What Kind of effects have been observed due to excessive rainfall?

a. Flood

b. Landslide

c. Drowned

d. Other

12. Who are more affected from dry up of water resources?

Class/Effected	Male	Female	Child
Rich			
Medium Class			
Poor			

13. How much time has been added from dry up of water resources?

a. Half an hour b. More than half hour c. More than one hour

14. What kind of change in temperature in comparison to last year's?

a. Increase in temperature b. Decrease in temperature

c. same as previous

15. What effects have been observed from increasing temperature?

a. Increase in population of Mosquitoes, Flies

b. Diseases have been appeared in human being

c. Other ……

d. Other

16. What kind of species of crops have been abandoned cropping now a days in comparison to past?

a. ..... b. ..... c. .....

c. .....

17. What sort of change has been observed due to climate change on cash and foodcrops?

……

18. What kind of affects you are facing on livestock after reduction of production of crops and grasses?

a. Reduce in number livestock b. Increase in livestock previous	c. same as

19. Have you changed farming process due to change in climate? (Example crop rotation, mix cropping, reforestation instead of old farming system)

a. Changed b. No change

20. What type of farming techniques are adopted to cope with climate change effect?

a…… b…… c……

d……

21. What is the effect of such change on income?

a. Increased b. Decreased c. No change

22. What kinds of diseases have been appeared on agriculture with increasing temperature?

……

23. What species of plants have disappeared recently?

a……. b…….

c……. d…….

Thank You!

ANNEX - II

Research Related Photos

Photo 1: The Study Area Phalelung RM-5, Panchthar

Photo 2: Meeting with Representative of Local Government

Photo 3 : Collecting Data from Female Respondent

Photo 4 : Collecting Data from Male Respondent

Photo 5 : Group Discussion in Study Area

Photo 6 : Late Maturation in Barley Crops

Photo 7 : Unidentified Diseases in Cardamom

Photo 8 : Tunnel Farming System Adopted by Farmers

फालेलुङ गाउँपालिका

५ नं. वडा कार्यालय

प्राङबुङ, पाँचथर

पत्र संख्या : २०७९/०८०
चलानी नं. : ९६८

कोशी प्रदेश, नेपाल
मिति : २०८०/०३/१७

विषय : सिफ [redacted] बारे।

यो जो सँग सम्बन्धित छ,

प्रस्तुत विषयमा पाँचथर जिल्ला फालेलुङ गाउँपालिका वडा नं. ५ स्थित यस कार्यालयमा **श्री मोहन कुमार खपाङ्गीले** दिएको माग निवेदन अनुसार निज निवेदकले यस वडामा **"Impact of climate change and adaptation practices in agriculture "** विषयमा शोधपत्र (थेसिस) को प्रयोजनका लागि स्थलगत रुपमा टोल वस्तीमा गई स्थानीयबासीहरु सँग छलफल, अन्तरवार्ता एंवम अवलोकन गरी यो शोधपत्र (थेसिस) तयार गरेको व्यहोरा यसै सिफारिस साथ अनुरोध छ।

भरत कुमार खपाङ्गी मगर
वडा अध्यक्ष

भरत कुमार खपाङ्गी (मगर)
वडा अध्यक्ष