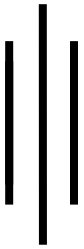
Impact of Climate Change on Agriculture:
A Case Study of Chalnakhel VDC, Kathmandu District, Nepal



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In

Rural Development

Submitted by

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DECLARATION

I hereby declare that the thesis entitled “Impact of Climate Change on Agriculture" submitted to Central Department of Rural Development, Tribhuvan University is entirely my original work prepared under the guidance and supervision of my 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 submitted anywhere else for the award of any degree or foe any other purpose.

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Recommendation Letter

The thesis entitled ***Impact of Climate Change on Agriculture:A Case Study of Chalnakhel VDC***

of Kathmandu District has been completed by **Miss PramilaMaharjan** under my guidance and supervision in the partial fulfillment of requirement for the Degree of Master of Arts in Rural Development. I hereby forward this thesis to the evaluation committee for final evaluation and approval.

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Approval Letter

This is to certify that the thesis entitled ***Impact of Climate Change on Agriculture (A case study of Chalnakhel VDC, Kathmandu District)*** submitted by **Miss PramilaMaharjan** to the Central Department of Rural Development in partial fulfillment of the requirement for the degree of Master of Arts in Rural Development has been evaluated and approved by the evaluation committee.

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PramilaMaharjan

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9, September, 2016

ABSTRACT

The climate change generally refer change in rainfall and temperature pattern which affects several sectors including agriculture and water resources. This study attempts to find the impact of climate change on agricultural sector of Chanlakhel VDC, Kathmandu, Nepal. The study includes the analysis of pattern and trend of rainfall and temperature based on hydrological and meteorological data (1985 to 2014) of study area, pests and disease problem on study area because of cc, and impact of cc on agriculture sector (both crop farming and livestock husbandry) of study area.

Precipitation and temperature are the main parameters of climate change. The changing pattern of rainfall and temperature can impact on agricultural sector of any place either positively or negatively. From 30 years analysis of rainfall, there observed fluctuate and slight change in rainfall pattern per year. The heaviest annual mean rainfall was 137.758mm recorded in year 2011. The minimum annual mean rainfall was 68.267mm recorded in year 1992. That means 69.491mm rainfall difference in annual rainfall of 2011 and 1992. Mean rainfall of monsoon is not same there is also difference in rainfall. Maximum mean rainfall of monsoon was 371.967mm recorded in year 2011 and minimum mean rainfall of monsoon was 171mm recorded in year 2005. Similarly maximum mean winter rainfall was80.2mm recorded in year 2007 and minimum mean winter rainfall was 0.5mm in the year 1985 and no winter rainfall in the year 1999, 2006, 2008 and 2009. From data analysis of temperature, the warmest year was 1999 where maximum mean temperature was 25.808 degree celsiuswas recorded on that year and minimum annual mean temperature was 18.95 degree celsius recorded on the year 1997. And that analysis show temperature is slightly increasing.

Hence agricultural production of the study area decreasing because of climate change. Increasing temperature, changing pattern of rainfall are the indicator of climate change, which affect agricultural sector negatively. Hence climate change introduced several consequences which result have been facing by human beings. Climate change also affect livestock husbandry negatively. So pattern of livestock has been also changed. There is decreasing in number of livestock due to reduced fodder resources and pasture area.

Key Words: Climate Change, Disease, Pests, Agricultural Production, Temperature, Precipitation.

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ABBREVATIONS

ADB: Asian Development Bank.

AEPC: Alternative Energy Promotion Centre

APP: Agriculture Perspective Plan.

BSL: Basic Linked System

CBS: Central Bureau of Statistics.

CC: Climate Change

CCC: Climate Change Council

CDM: Clean Development Mechanism

CH4: Methane

CO2: Carbon dioxide.

DCs: Developed Countries

DHM: Department of Hydrology and Metrology.

DSCWM: Department of Soil Conservation and Watershed Management

FAO: Food and Agriculture Organization

FDG: Focus Group Discussion

GCMs: General Circulation Model.

GDP: Gross Domestic Product.

GHGs: Green House Gases.

GIS: Geographical Information System

GJ: Giga Joule.

GLOF: Glacial Lake Outbrust Flood.

GoN: Government of Nepal

HH: Household

HHS: House Hold Survey

ICIMOD: International Centre for Integrated Mountain Development

IPCC: Intergovernmental Panel on Climate Change

IPM: Integrated Pest Management

IRRI: International Rice Research Institute

KII: Key Informant Interview

LAPA: Local Adaptation Programme of Action

LDCs: Least Developed Countries

LIA: Little Ice Age

MI: Mountain Initiative

MoA: Ministry of Agriculture.

MoAD: Ministry of Agriculture and Development

MoE: Ministry of Environment

MoEST: Ministry of Environment Science and Technology

MoF: Ministry of Forest

MoFSC: Ministry of Forest and Soil Conservation

MoHA: Ministry of Home Affairs

MoPE: Ministry of Population and Environment

MWP: Medieval Warm Period

NAPA: National Adaptation Programme of Action

NARC: Nepal Agriculture Research Council

NEPAP: National Environmental Policy and Action Plan

NPC: National Planning Commission

PPM: Per Part Million

UNDP: United Nation Develop Programme

UNEP: United Nation Environment Programme

UNFCCC: United Nation's Framework Convention on Climate Change

VDC: Village Development Committee

WFP: World Food Program

WMO: World Meteorological Organization

CHAPTER I
INTRODUCTION

1.1. Background of the Study

Global warming and climate change are great concern of today as it affect not only living being but also affect the whole ecosystem of the world. So it also affect agriculture sector directly asit is mostly dependent on nature. Climatechangeisnowrecognizedasoneof themostseriouschallenge,facingthe wholeworld and all the living beings.Thereisnowclearscientificevidencethatthehigh concentration of greenhousegases (GHGs)intheatmosphereis causingglobalwarming.Itis believedthatmostglobalwarmingwecannowobserve isattributableto emissionsof GHGsthat resultfromhumanactivities,inparticularlandusechangessuchasdeforestation,andthe burning of fossilfuels(coal,oil andgas).Increasingnumbersof scientificcommunitiesobservingthe globalclimateshow acollectivepictureof achanging climateandawarmingworld.Climate change is principally increase in temperature caused mainly by the combustion of fossil fuels to yield energy. With the rapid industrialization powered by fossil fuels, developed countries are the mainly responsible for the global warming. Researches show that developing countries are more vulnerable to climate change and are expected to suffer more from the adverse climatic impacts than the developed countries (IPCC, 2001a).Climate change is variation in climate over long period of time regardless of cause (Intergovernmental Panel on Climate Change, 2007). Theglobal averagesurface(landandocean)temperaturehasincreasedandwarmingaveragedfor2011to2030com paredto 1980 to1999is between0.64 degree celsius (ºC) and0.69 degree celsius (ºC), with arange of only0.05degree celsius (Intergovernmental Panel on Climate Change, 2007) andis expectedtocontinue,withincreaseprojectedtobeinthe rangeof1.4to5.8degree celsiusby 2100 incomparisonto1990 (IPCC, 2003).Due tothechangeinclimate, crop production is affectedinadditiontothethreatstofoodsecurityasanimpactofclimatechange (Miraglia,*etal.*,2009).Temperatureandprecipitationstrongly influencephysicalandchemicalreactionsonparentmaterial.Climatealsodeterminesavegetation coverwhichin turn influencessoil development.

In recent time, many studies have confirmed that there is the large variability in climate. The degree of variability can be described by the difference between long- term statistics of meteorological elements calculated for different periods. In this sense, the measure of climatic variability is the same as the measure of climate change. Climatic variability is often used to denote deviations of climate statistics over a given period of time (such as a specific month, season or year) from the long term climate statistics relating to corresponding calendar period. In this sense, climate variability is measured by those deviations, which are usually termed anomalies.The increasing temperature and unusual rainfall, drought, flooding, high rate of snow melting and sea level rise are threats for the sustainability of living organisms. Human activities have been identified as main contributors of global as well as regional climate change (Inter GovernmentalPanel on Climate Change, 2006). Temperature is a good indicator of climate change. Precipitation may be of equal or greater importance in terms of monitoring global change (Shrestha & Wake, 2000). The global and national data clearly show that the numbers of natural disaster events are increasing in recent years. Socio-economic and environmental losses caused by these natural disasters are also increasing. The increasing trend of all type of natural disasters noticeably reveals that highest portion of natural disasters is contributed by climate related disasters compared to other kind of disasters (United Nation International Strategy for Disaster Reduction, 2005).Climate change is a global environment as well as a local development issue (Agbogidi, 2011). It could risk the livelihoods of millions, especially where existing poverty and hunger make it difficult to cope with its impacts. If there is no appropriate and timely responses, climate change is likely to constrain economic development and poverty reduction efforts in agricultural countries(Sasson, 2012). In those countries where food insecurity is high, climate change is expected to drastically change farming activities. Farmers have already made efforts to adjust to climate variations through modifying the sowing periods or changing grazing lands.

In a humid climate like that of Nepal, there will be changes in the spatial and temporal distribution of temperature and precipitation due to climate change, which in turn will increase both the intensity and frequency of extreme events like droughts and floods (Mahtab, 1992). Increases in temperature result in a reduced growing season and a decline in productivity, particularly in South Asia (Pauchuri, 1992). A warming climate would increase water demand on the one hand and would decrease river flows on the other. Reduced river flows will affect the

hydropower generation, irrigation system, inland water transport and aquatic ecosystems. Similarly, reduced water availability may create conflicts between users within and among nations. Vulnerability is the degree to which a system is likely to experience harm due to its exposure to hazards. It is determined by the capacity of a system to anticipate, cope with, resist and recover from the impact of hazard. Exposure to natural hazards of the community is increasing day by day, making it more vulnerable with increasing global change and frequent extreme events. We are globally interconnected and climate change is considered to be problematic issue for many countries impacting various sectors and areas. Widespread implications of climate change indicate that climate change is a complex,serious and burning issue of today. We can assume that dramatic changes are still to be come and they will result in huge lost at community level to regional level. Along with the mitigation approach to climate change and associated risk, mainly for the developing countries, it is coping mechanism developed within the community that helps in risk reduction due to climate change.

According to (IPCC, 2007) report "Global atmospheric concentration of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years". Although Nepal is responsible for only about 0.025 percent of total annual greenhouse gas emissions of the world (Karki, 2007).It is experiencing the increasing trends and the associated effects of global warming. The global increase in carbon dioxide concentration is primarily due to combustion of fossil fuel and land use change, while those of methane and nitrous oxide are primarily due to agriculture practices." Human activities are increasingly altering the earth's climate, changing it in such a way which is not good for the sustainability of the living organisms. Increasing human activities that increase concentration of the GHG gases are increasing threat to whole living worldthrough different disasters. Global warming, the quicker warming of the earth enhanced by greenhousegases, has ultimately brought unavoidable consequences as climate change(United Nation Framework's Convention on Climate Change, 2001). Warming of the climate is now increasing and it can be recognize by every living being of the earth. It is now clear that global warming is mostly due to man-made activities like emissions of greenhouse gases mostly CO2. Developing countries like Nepal are more susceptible to the climate change and its impacts due to their limited capacity to cope with hazards associated with changes in climate (Kates, 2000). Nepal has good reasons to be concerned about climate change.

Over two million Nepalese people depend on climate sensitive sectors like agriculture and forestry for their livelihood (Garg, Shukla, &Kapshe, 2007).

Climate change may alter rainfall patterns. The incidence of extreme weather events such as droughts, storms, catastrophic rainfall, floods and avalanches are expected to be increase. This can lead to loss of lives and highly reduce agricultural production (IPCC, 1998). Climate-induced natural hazards have very serious human implications because they affect the livelihood security of the majority of the population (Swaminathan, 2002). Climate change increases the vulnerability of poor people, affects their health and livelihoods and undermines growth opportunities crucial for poverty reduction (Asian Development Bank, et al. 2003). The snowy mountains are situated in the high altitude area in the north. Climate change-induced floods generated in these mountainous areas have significant negative effects on the society and economy of the mountains as well as the plains far downstream.

For community and people adaptation is the process of social learning too. Adaptive capacity is the ability to understand climate changes and hazards, to evaluate their consequences for vulnerable peoples, place and economies and to moderate potential damages to take advantage of opportunities, or to cope with the consequences (Dow & Downing, 2006). The majority of Nepal's present population depends on agriculture for their subsistence but still about 63 percent of the agricultural lands are deprived of modern irrigation facilities (FAO, 2004a). All the crop water requirements of the non-irrigated lands are fulfilled by rainfall. The increasing variability in precipitation may create difficulties in cultivating these lands and could result in probable food scarcity for the rapidly growing population. Moreover, the agricultural land having irrigation facilities may not have sufficient water in cultivating seasons in the future because of climate change. That may result in water stress in the agricultural sector of Nepal. About, 93 percent peoplework in the agriculture sector as labor force in Nepal (Food and Agriculture Organization, 2004a) which provides about 38 percent of the gross domestic product (Ministry of Forest, 2008). However, agriculture is largely at subsistence level. In the rural hills and mountain areas of Nepal, where as much as 70 percent of the population are poor, local food production sometimes covers just three months of the annual households needs (FAO, 2004c). Changing climate conditions causing soil moisture reduction, thermal and water stress, flood and drought etc. are putting the whole agricultural sector at serious risk (ADB, et al. 2003).

Climate change and agriculture are interrelated processes, both of which take place on a global scale. Global warming is projected to have significant impacts on conditions affecting agriculture, including temperature, precipitation and glacial run-off. These conditions determine the carrying capacity of the biosphere to produce enough food for the human population and livestock husbandry. Rising level of carbon dioxide would have both positive and negative effects,i.e. detrimental and beneficial, on crop yields. The overall effect of climate change on agriculture will depend on the balance of these effects. Assessment of the effects of global climate changes on agriculture might help properly to anticipate and adapt farming to maximize agricultural production. Third Assessment Report (IPCC, 2001) concluded that the poorest countries would be hardest hit, with reductions in crop yields in most tropical and sub-tropical regions due to decreased water availability, and new or changed insect pest incidence. So it is important to research and understand about impact of climate change on agriculture sector.

InContextofNepal,contributiontoglobalemissionof Green House Gases(GHGs)isnegligibleat0.13tonsCO2 per capita,butNepalstillfacestheconsequencesofglobalwarmingbecauseofthegeographicaland climaticconditionsasNepalesemountainsaregeologicallyyoungandfragileandvulnerableeven toinsignificantchangein climaticcondition,highdependenceonnaturalresources andlackof resourcestocopewiththechangingclimate(Dhakal,2003).Scientificstatementsregarding to changingclimateofNepalarepronouncedlyfocusedontemperatureriseatarateof0.06degree Celsius perannum.Suchariseinaveragetemperatureisvariable acrossthecountry(Gautamand Pokhrel,2010),higherin themountainsandHimalaya(0.08degree celsius)ascomparedtolow-lyingterai (0.04 degree celsius), change such as rising temperature, delayed monsoon, increased annual rainfall resulting from increased glacial melting and increased occurrence of intense rainfall (Regmi and Adhikari, 2007) among other has affected many rain fed farmers in Nepal and it is forecasted by the United Nation Framework Convention on Climate Change and Inter Governmental Panel on Climate Change to create even more damage in agricultural production in the coming 20 years (IPCC 2001 and UNFCCC, 2000). Disappearing forests in some areas, invasion of exotic species, outbreak of new diseases sharp andsustained decline in food security and threats to biodiversity are the climate induced risk and hazards have wide range often unanticipated effect on environment including agriculture and food security(World Food

Program, 2009).Changingclimatereflecttheinterplayamongthreefactors:risingtemperatures, changingwaterresources,andincreasingcarbondioxideconcentrations.Impactofclimatechange onagricultureis getting increasing.

Agriculture is very much sensitive to climate variability. Climate variability causes the extreme impacts on agriculture production. Variability of climate not only causes slashing of crop yield but also forces farmers to adapt the new agricultural practices. Decrease in water availability, shortening growing periods due to climate variability reduces the potential yield. The agriculture in Nepal is vulnerable because of two reasons. First, the existing system of food production is highly climate sensitive because of its low level of capital investment and adoption of modern technological options. Second, agriculture is the main source of livelihoods for a majority of the population i.e. 74 percent population depends on agriculture. (CBS, 2011). This will put greater number of people at risk when agriculture is impacted due to climate variability and uncertainty (Dahal, et al., 2010). Climate change impacts on agriculture are very vague that climate change may have increased productivity in some region while it to be decreased in other region. So, it is a complex problem to the world (Pathak, et al., 2003). The impacts of climate change in Nepal, most cultivable land area is rain-fed and therefore productivity is dependent on form, intensity, distribution and timing of precipitation. Agriculture will be adversely affected not only by an increase or decrease in the overall amounts of rainfall but also by shifts in the timing of the monsoon rain. Agriculture Perspective Plan (APP, 1995) stated that the current irrigation facilities may not have sufficient water during dry seasons in the future due to climate change. This change in climate has been shifting the cropping calendar. Summer rainfall accounts for almost 80% of the total annual rainfall over Nepal and is crucial to Nepalese agriculture. Nepal experiences extreme monsoonal rainfall during Shrawan- Bhadra and low during Poush- Fagun (Shrestha, 2007). Increase in temperature and increasing number of events of erratic rainfall directly affect agriculture and food supply through their effects on crops. Insufficient rain and increasing temperature cause drought whereas intense rain in short period reduces ground water recharge by accelerating runoff resulting floods. Both these situations induce negative effects in agriculture.

1.2. Statement of Problem

Nepal is a small land lock country having an area of 1, 47,181 square kilometer, which is situated between two giant countries China in north and India in East, West and South. Main source of economy ofNepal isagriculture sector. About 21 percent land is cultivated for agriculture and it accounts for about 38 percent of the Gross Domestic Product (GDP). The country is vulnerable to disasters including flood, erosion, Glacial Lake Outburst Flood (GLOF) and melting ice in the Mountains, landslides, and droughts.

The raising temperature and emission ofcarbon dioxide (CO2) in some extent is helpful in production of major crops. For example: increase in agriculture production by enhancing photo synthesis process, water use efficiency and soil microbial activities. Decrease in grain filling due to increase in respiration process, fertilizer use efficiencies, desertification, and increase in soil erosion etc. cause malnutrition in the world. Decrease in quality of food such as reduce in protein and decrease in minerals nutrients content in different crops and vegetables that means in overall agricultural produces ,these are the negative effects (Pathak, et al.,2003).

Traditional rainfall of Jestha and Ashad (Mid July) has been shifted in Shrawan and Bhadra in Kathmandu. It has affecting in the paddy production. Nepal has various types of agricultural zones like plains, Hills, mid- hills, high land and Mountains. Changes in agro- zones lead to the change in cropping pattern of zone. Climatic parameters have potential impact to change the ecological distribution of agricultural crops. So the farmers of hilly regions are also affected by climate change but they don't know why their agriculture production pattern is changing? What are the causes of changing agricultural production in existing time? In this scenario, study on the impact of climate change on agricultural production help local farmers to know about climate change. And also help farmers in agricultural practice with the challenge of climate change. Hence it is very important that all the local farmers must know about climate change and its possible impacts whose main occupation is agriculture.

Climate change may alter rainfall and snowfall patterns. The incidence of extreme weather events such as droughts, storms, floods and avalanches is expected to increase (IPCC, 1998). About 29 percent of the total annual deaths of people and 43 percent of the total loss of properties from all different disasters in Nepal are caused by water-induced disasters like floods, landslides and avalanches (Khanal, 2005). Therefore, it is very important to quantify such impacts in order to identify the problem and adaptation options and thereby minimize the

potential damage magnitude of climate change in the production of major cereal crops on a local and regional scale.

Several studies and reports reveals that there is decreasing agricultural production because of climate change. The reason for this decreasing is high temperature, low precipitation, outburst of different diseases and pests in crops and livestock, water stress for irrigation and lack of knowledge and awareness about climate change for eg. What are the causes of climate change, what type of human activities help in climate change etc. As a result it harm agricultural sector in the form of disaster or in form of disease and pests .Also there found less research studies on impact of climate change due to lack of sufficient hydrological and meteorological station. And Chanlakhel is one of agricultural village of Kathmandu. About 80 percent people of this study area depends on agriculture for their livelihood and about 70 percent land covered by agriculture. But total agricultural production rate is not fixed. Also it is near from center of Kathmandu. So we can easily reached for data collection. In this study area, some symptoms of climate change have been recognized by the farmers for e.g. shifting of rainfall, catastrophic rainfall, hot days, drought, and extinction of water resources like ponds, springs etc. of the study area. Due to these problems research must be carried out in this area.

1.3. Objectivesof the study

Thegeneralobjectiveofthestudyisto analyze theimpactsofclimatechangeon agriculture. The specific objectives of the study are:

- To analyze the pattern and trend of rainfall and temperature i.e. climate change in study area based on hydrological and meteorological data.
- To examine the problem of pests and diseases on agriculture sector of the study area because of climate change.
- To evaluate the impact of climate change on agriculture sector(both on farming and livestock husbandry) of the study area.

1.4. Significance of the study

Agriculture can be taken asanindicatorof climate change in thepresentstudy. So,study onimpactofclimatechangeonagriculturalproductioncanbeanalyzedeasily.Thisstudyalsoexploresca

uses for GHGs emission, its impact on agriculture, mitigation method, and adaptation method adopted by farmers of the studyareathatissupportiveelementformaximizeproduction levels.Adaptingagriculturalproduction systemstothechanging climatehas now receivedresearch attention worldwide. Thisstudy isanattempttoanswerwhether agriculturalproduction areaffectedbyclimatic changesinChalnakhel, studyarea. Even agriculture is main source of economy of this study area; this sector is affected directly or indirectly by climate change. So the local level study is more relevant for the country Nepal,having more diversity.

Climate change is considered to be very sensitive, burning issue for many countries impacting various sectors like: infrastructure, forestry, agriculture etc. widespread implications of climate change indicate that climate change is a complex and sensitive issue. Hence local level case studies are very important to analyze climate change issues. Thisstudy areas are famousfor differentagriculturalproductionlike potato, barley, maize, ricebeans, tomato, cucumber, garlic, cabbage, radish, carrot mustard etc. andhence studyareaisthemostimportantplace of agriculture.Thestudyonimpactof climatechangein agricultural production ofthisareahelpstogetclear pictureof decrease inagriculturalproduction duetoclimatechange. Beside these few other significance of the present study could be summarized in below.

- The study on this subject is rare so this study will be significant to the student to know about impact of climate change on agriculture and it will also help student in preparing thesis as it provide quick picture about impact of climate change on agriculture.
- It will serve as a future reference for researchers on the subject of impact of climate change on agriculture.
- It will be significant to know awareness level of farmers about impact of climate change on agriculture, their perception and what type of adaptation technology they are using.
- It will be more significant for recommending to plan and policy makers to formulate appropriate plans on climate change, agriculture, adaptation technology etc.

1.5. Limitation of Study

This is micro level study of impact of climate change on agriculture evenclimate change is considered as global impact not a local. This study based on household survey and personal

interviewwith the people of the village households of Chalnakhel VDC, ward no. 5. Limitation of this study are listed below.

- In this study temperature and rainfall indicate climate change variables.
- Time series limited to thirty years (1985-2014).This study was based on farmers (both male and female) of the study area because it is a case study.
- Due to limited sample size and sample area the present study might not be generalized into other places and other time.
- The conclusion drawn from this study are mere indicative rather than conclusive. So conclusion is not generalized for the whole.
- Considering the limited time and resources, only 60 households are taken for household survey.

1.6 Organization of Study

The whole study is divided into five different chapter. First chapter include introduction, background of the study, statement of the problem, objectives of the study, rational of the study, limitation of the study and organization. Second chapter elaborates literature review includes available literatures about climate change and its impact on agriculture. Chapter three is research methodology includes, research design, nature and source of data, data collection techniques and tools. Chapter four include introduction of the study area. Similarly Chapter five include dataanalysis and presentation. And finally last chapter includes summary, conclusion and recommendation.

CHAPTER II

LITERATURE REVIEW

2.1.Climate Change

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 fossil fuel combustion, deforestation, urbanization and industrialization (Upreti, 1999) resulting variations in solar energy, temperature and precipitation.

Climate change refers to change in the state of the climate that can be identify using statistical test by change in the mean or variability of its properties that persists or extends typically during the period of decades or longer (CBS, 2008). Over a long period of time, global climate has been changing and still continue to change its variation occurs as response to climate forcing which includes factors that can cause either a warming or cooling of the atmosphere. Viewing the earth history most of the forcing has been from natural causes these are continental drift variability in solar radiation, change in earth orbits, and volcanic emission. However after Industrial revolution human activities had large impact on global climate system, increasing amount of greenhouse gases (GHGs) in the atmosphere, trapping heat and contributing to global warming. The rate of warming in the Hindu Kush Himalaya region is significantly higher than the global average (ICIMOD, 2009) Humanbeing, flora and fauna with which the earth planet is shared, have limited capacity to adapt to rapid or extreme climate change However consumption of fossil fuel deforestation burning of fire wood by humans has increase amount of carbon dioxide and other greenhouse gases to the atmosphere. That rise in concentration of greenhouse gases may increase global temperature and average temperature of the earth during this century from about 1.4to 5.8 degree celsius (Pandey, 2005 andRoshan, et al., 2010) Thus climate change and global warming have harmful effect on human life. Furthermore all the living being has to face serious problem of thermal comfort with the rising temperature in the coming decades.

Climate change in the polar region will be greater than anywhere in the earth. Arctic temperature has been rise by 5 degree Celsius over the past 100 years. (IPCC, 2007). In context of Nepal emission of carbon dioxide (CO2), methane (CH4) and nitrous oxide(N2O) for the year 1994/95 were estimated as 9747Gj. 984Gj and 31Gj. respectively whereas the total emission of the main GHG gas in 1994 was estimated as 39265Gj in carbon dioxide equivalent (MoE, 2010). In addition these the annual compound growth rate of CO2 equivalent emission from Nepal was only 2 percent per annum which is lower than that of other developing countries. Total no. of glacial lakes recorded in 2009 were 3577 but because of rapid glacial retreating up to 20meter per year resulting in growth of glacial lakes by six folds which may result in GLOF(Glacial Lake Outburst Flood)(MoE, 2010).The country experienced severe drought and other adverse weather conditions in past and current situations. Farmers from mountain and hilly region experienced dry winter which affects their subsistence winter crops during the year 2006/07. In the monsoon period, scarcity of rainfall lead to drought that is serious situation in eastern Terai where production of paddy was reported to be decline by about 30 percent (MoE,2010).

The distinction between climate change and global warming is that the latter refers to an increase in surface temperature whereas the former includes global warming and everything else that increase greenhouse gas levels. Without appropriate responses, climate change is likely to constrain economic development and poverty reduction efforts. In regions where food insecurity is high, climate change is may drastically change farming activities. These regions are mainly located in Africa and South Asia, but China and Latin America may be affected. The agricultural seasons of these regions will be shorter, warmer and drier, creating risk in the life of hundreds of millions of people who are already poor (Sasson, 2012). Farmers have already made efforts to adjust to climate variations through modifying the sowing periods or changing grazing lands.

People generally use the terms weather and climate for the same phenomenon, without realizing these two are different (Dash, 2007:9). The weather at a place is defined by measuring of defining the state of the weather at a place, at a particular time. Climate, on the other hand is an abstract concept. It represents the sum total of all atmospheric phenomenon at a place, over a particular period of time in a year (Dash, 2007:9). Thus climate refers to the average weather conditions observed over the long periods of time for a given area. The climate where you live is called regional climate. It is the average weather in a place over more than 30 years as defined by

World Meteorological Organization (WMO, 2004).Climate change is defined as statistical distribution of weather over periods of time that ranges from decades to millions of years. It is also define as long term shift of climatic situation of the Earth or a particular place or a region or a whole world. So climate change may be limited to a specific region or may occur across the whole earth. So simply speaking climate change is the change appeared in the climate of a place over a period of time. Humans experience weather and climate differing in different time frames and use language in response to weather and climate and both human perceptions and reactions to these phenomena are ultimately shaped by culture. Climate change according to IPCC is change in the state of the climate that can be identified, using statistical tests, by changes in the mean or the variability of its properties and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity. This definition differ from the definition of the UNFCCC, where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods, certain atmospheric parameters such as temperature, pressure, humidity, wind strength and direction, rainfall, snowfall, cloud, sunshine, etc., at a particular time.

It was observed, increase in global average temperatures since the mid-20th century very likely due to the observedincrease in anthropogenic GHGs concentrations (IPCC, 2007). In case of Nepal, the temperature has been increased by 1.8 degree celsius and the average temperature increase was recorded as 0.06 degree celsius during last 32 per year (Malla, 2008). Furthermore, Hills and high hills are more vulnerable to climate change (Acharya, 2012). The rainfall pattern is also experienced as inconsistent, and unusual with higher intensities of rainfall and less number of rainy days (Malla, 2008) creating drought for short period and heavy rainfall drastically destroy several lives of human being and properties. Changes in hydrological cycles and the depletion of water resources were the top challenges facing Nepal in context of climate change.

Global warming and climate change are the great concern of today, since they affect not only on the living beings but also the whole ecosystem of the world. However, its impact on agriculture can be understood directly as agro sector is more dependent on nurture. This concern is equally applicable to Nepal too as early symptoms of climate change were observed e.g. continuously increasing temperature almost in double pace within shorter time horizon compared to global temperature rise. Furthermore, Nepal import rice to other countries in the past few

years as it was exporter in the past. From view of the millennium development goals and agriculture perspective plan (APP, 1996–2015), Nepal always faces food grains deficit in more than 27 districts in the hill and high hill regions. Productivity and quality of food production are also in question in Nepal as both of them are deteriorating. Excessive and improper uses of chemical fertilizer and pesticides have further enhanced health hazards and soil contamination in particular and increasing pollution in general. It is a real threat to the lives in the world that largely affects water resources, agriculture, coastal regions, freshwater inhabitants, vegetation and forests, snow cover and melting and geological processes such as landslide, desertification and floods, drought have long-term effects on food security as well as in human health.

2.2 Cause of Climate Change

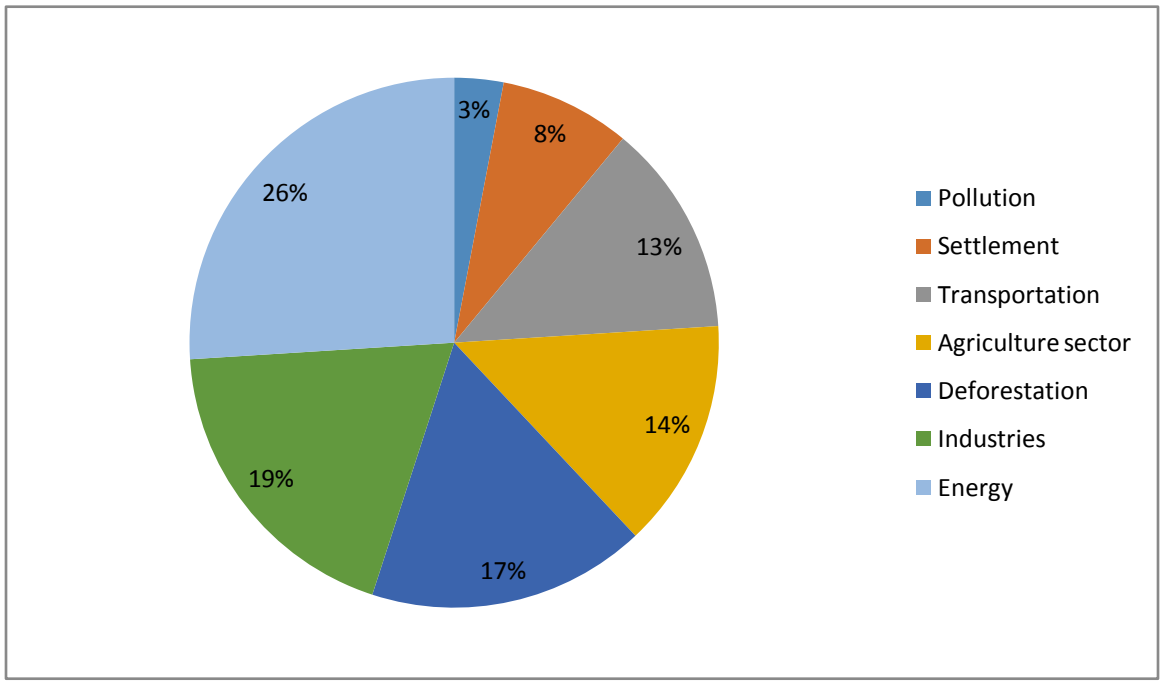
There are two causes of climate change. (a)Natural cause(b) Humaninduced cause(a) Naturalcause: It includes (i) Plate tectonic (ii) variation in solar radiation (iii) Orbital variation (iv) Volcanism (v) Ocean variability.

(b)Human induced cause: It includes human activities which influence the environment very much. So human activity is mainly responsible for rapid increase in global average temperature over the past several decades. Anthropogenic factor includes increase in carbon dioxide level due to emission from fossil fuel combustion including aerosols (particulate matter in atmosphere) cement manufacture. It also includes land use, ozone layer depletion, animal husbandry and deforestation.

Global average temperature has warmed is likely to rise constantly in the future mainly due to increasing concentration of Green House Gas (GHGs) in the atmosphere. In absence of GHGs, the earth surface temperature was raised by 0.740degree celsius and 0.180degree celsius during 20th century and scientists estimated that it could increase as much as 6.40degree celsiusaverages in the 21th century (UNFCC, 2007). Concentration of GHGs in atmosphere determines the temperature on earth. If concentration of GHGs becomes low temperature of earth become less and if concentration of GHGs increased temperature on earth also increase. GHGs forms layer on atmosphere which allows entering of sun light and heat on earth through atmosphere. The earth absorbs some of the heat gained from sun and reflects some fragment of heat on atmosphere. If the GHGs layer is thin the heat passes from atmosphere and the

temperature on earth becomes low, if the GHGs layer is thick, it obstruct the passing process of heat and again reflect the heat to the earth which causes earth surface more warmer and increase the temperature on earth.

GHGs comprise Carbon dioxide (CO2), Methane (CH4), Nitrous Oxide (NO2), (HFCs), Chloroflorocarbon (CFC), SulphurHexafloride (SF6) etc.These gases are emitting naturally, but human induced activities are accelerating the rate of emission of these gases from different activities (Dahal, 2007). Sources of GHGs are shown in the figure 1.



Sources: IPCC, 2007.

The main causes of increasing GHGs are human intervention on environment and excessive use of resources from Nature. Anthropogenic gases or GHGs are causes of increasing global temperature.

2.3. Climatic Elements

Temperature and rainfall are important climatic element. Which help to determine whether the climate is changing in which pattern.

2.3.1. Temperature

Temperature is one of important climatic parameter. Temperature is the degree of hotness or coldness of any object. It play important role in agriculture. Temperature is directly related to the climate change. The global warming is unambiguous and the linear warming trend over the last 50 years is 0.13 degree celsius per decade. Warming is also being observed in Nepal (IPCC, 2007). Based on the records of DHM from 1979, that mean in Nepal temperature is increasing at 0.4 degree celsius per decade (Regmi, Pandit, Pradhan, &Kovats, 2008).

According to DHM, Government of Nepal, average temperature in Nepal is increasing at the rate of nearly 0.06 degree celsius per year between the period of 1977 and 1994. Another temperature analysis from 1976 to 2005 show that the average temperature in Nepal has increased by 0.0597degree celsius per year. According to assessment report (IPCC, 2001b), the global mean surface air temperature has increased by 0.6±0.2 degree celsius in 20th century. Meteorological records showed that global temperature has increased by 0.74 degree celsius during the period of 1906 to 2005. The researches show that the global temperature will rise between 1.5 degree celsius to 4.5 degree celsius in the 21st Century. It also suggested that warming of more than 2.5 degree celsius can reduce global food supplies and contribute to higher food prices. (UNEP & UNFCCC, 2002).

The average temperature of Nepal has increased from 0.060 to 0.098 degree celsius over the last 30 years (Tiwari, 2009). In Nepal average temperature increase was recorded as 0.06degree celsius per year and average temperature recorded in Terai was 0.04degree celsius per yearand in Himalayas was 0.08degree celsius per year. (Shrestha, et al., 1999 and Gautam, and Pokharel, 2010). This indicates that the warming rate of Himalayas (high altitude) is higher than that of lowland. Warming has also been greater in the western half of the country than in eastern half (Malla, 2010). Continuous warming and rise in maximum temperature at the rate of 0.04 to 0.06 degree celsius annually (MoE/NAPA, 2010).

2.3.2. Rainfall

Rainfall is the most variable and least predictable agro climatic parameter. The amount and the distribution of the rainfall determines the cropping season and rainfall during the crop growing season is considered to be more beneficial than off season rain fall. Cropping or farming is very much sensitive to water stress so the rain fall distribution is considered to be

more important than the season total. General increase in the intensity of heavy rainfall in the future, and an overall decrease as many as 15 days in number of rainy days over large part of South Asia(IPCC, 2007). This will cause significant warming particularly at higher elevations, leading to reduction in snow and ice coverage, increased frequency of extreme events like flood, drought, and increased precipitation (MoE/NAPA, 2010).

More erratic pattern (unusual high intensity, less rainy number of days) of rainfall in the country (Baidhya, et al., 2007). Such events increase possibility of climatic extremes like irregular monsoon, droughts and floods. The heavy monsoon has shifted to the end period of monsoon (Malla, 2008). Traditional rainfall of Ashad and Bhadra has been shifted towards Shrawan and Bhadra in Kathmandu affecting paddy production negatively.

Winter drought 2008/9 of Nepal was the worst drought ever that had happened with less than 50 percent rainfall which had badly affected the crop production in Nepal (MoAC/WFP/FAO, 2009). Agriculture of hill and mountain were more affected than terai.According to (Gurung, 2009), "the total amount of precipitation not much differ but are being erratic and irregular time". According to (Practical Action, 2009), "decreasing in the total number of rainy days and increasing in the number of drier day"(MoE, 2010). Days receiving only 100mm rainfall are recorded. Annual variation in precipitation has increased so far(Moench, 2010). Which introduced increased flooding and erosion and affecting agriculture.

2.4. World Climate Change and Global Warming

The climatic reconstructions from various proxy-methods reveal that the late 20th century is the warmest ever period in the past two millennia. Besides, during the past two millennia, Medieval Warm Period (MWP) was another period of unusually warm weather around tenth to fourteen century. This warming period was followed by the Little Ice Age (LIA). It was a cold period that lasted from about 1550 to about 1850 in Europe, North America and Asia. This period was marked by rapid expansion of mountain glaciers. There was three minima, beginning about 1650, about 1770 and 1850, each separated by slight warming intervals. Only after the end of LIA, the meteorological record keeping begun as a regular basis, globally (Thompson, 2006). Research on long-term variations in surface air temperature for the entire as well as for the hemispheres have shown a rising trend during the last few decades (Shrestha, et al., 1999). More

importantly, it has been observed that the temperature changes less in moist regions than in arid regions (Ren, et al., 2006). Climate models referenced by the IPCC,(2007) project that global surface temperatures are likely to increase by 1.1degree celsius to 6.4degree celsius between 1990 and 2100, under various emission scenarios. Although most studies focus on the period up to 2100, warming and sea level rise are expected to continue for more than a millennium even if greenhouse gases levels are stabilized.

While temperature is considered as a good indicator of climate change, precipitation may be of equal or greater important in terms of monitoring global change in low and mid latitude regions because of their vulnerability to both water shortage and quality (Shrestha, et al., 2000). Precipitation usually exhibits much greater spatial variability, such as regional differences are even more variable and complex than those of temperature. Analyses of global precipitation variations reveal marked trends in recent decades. For example, rain and snowfall amounts over the middle and high latitudes rose steadily over the past decades, whereas a pronounced decreasing trend occurred in the sub-tropics (Shrestha, et al., 2000). The same trends have been projected by IPCC,2007 and they predict that precipitation will be decrease by as much as about 20percentin the sub-tropics under the A1B scenario by 2100 AD. (Ren, et al., 2004) suggested that the precipitation decreased in past decades one of the basic characteristics of climate change in the Central Himalayas.

Global temperature is increasing by 0.3 degree celsius to 0.6degree celsius since the last 19th century and by 0.2degree celsius to 0.3degree celsius over the last 40 years (1960- 2000) (Xiaodong,&Baode, 2000) with indication of more increase in the global temperature in coming days making earths sustainability more vulnerable. Scientists predicted through the global climate models that the average global surface temperature increase from 1.4 degree celsius to 5.8 degree celsius due to presumed doubling of CO2 concentration in the atmosphere by the end of the 21st century.Average precipitation also will rise as much 10 to 15 percent because a warmer atmosphere holds more water. (IPCC, 2007). In the northern hemisphere, precipitation has increased by 0.5 percent to 1.0percent per decade whereas the precipitation increase in tropical countries has been 0.2percentto 0.3percent per decade. The trend over the course of the last century has been uneven, but in the period since 1976 the warming trend is roughly three times that of the past 100 years as a whole (WMO, 2004). The increases in average global

temperature (global warming); changes in cloud cover and precipitation particularly over land; melting of ice caps and glaciers and reduced snow cover; and increases in ocean temperatures and ocean acidity – due to seawater absorbing heat and carbon dioxide from the atmosphere (UNFCCC, 2007) clearly indicates the changing trend in climate. Over the last century, atmospheric concentrations of carbon dioxide increased from a pre- industrial value of 278 ppm to 379 ppm in 2005, and the average global temperature rose by 0.74 degree celsius (UNFCCC, 2007) which supports the fact the global increase in the temperature is mainly due to the excess emission of carbon dioxide from human induced sources.Global sea level rose at an average rate of 1.80 (±0.50) mm per year over 1961- 2004, with an estimated contribution of 0.50(±0.18) mm per year from melting glaciers. The projected sea level rise at the end of the 21st century ranges from 0.18 to 0.59 mm per year under the different emission scenarios (IPCC, 2007).

2.5.Global Impacts:

The IPCC report estimates climate change impacts on grain production at the global level and then zeros from the estimated effect on the developed countries (DCs) of North America and Europe as well as on the less developed countries (LDCs) of Asia, Africa, and Latin America.Broad scientific agreement now exists that continued accumulation of heat-trapping "greenhouse" gases in the atmosphere will eventually lead to changes in the global climate,and in the climates of regions around the world. The agreement was expressed in the 1996 report of the Intergovernmental Panel on Climate Change (IPCC), an international body of leading natural and social scientists sponsored by the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO).

The general circulation models (GCMs) that the IPCC used to analyze climate change are in reasonably good agreement that with a doubling of atmospheric CO2 the global average temperature will rise within the range of 1.0 to 3.5 degrees celsius. The models also agree reasonably well that the northern latitudes will warm more than the tropics. With respect to all other regional changes, however, agreement among the models is poor. Because human activities and ecological systems are highly variable among regions, this lack of accord greatly complicates the task of estimating the impacts of the changes on activities of interest to humans(Gates, 1985). Despite this limitation, much useful work has been done on estimating the

potential impacts of different climate change scenarios. Climate change impacts on agriculture are examined on a global scale.)

(Grain is often used as a proxy for all food because it accounts for over half of all food calories consumed in the world.) The sources of the IPCC estimates are the three different GCMs, reflecting four different scenarios for estimating climate change impact on grain production.(Pierre, 1989)

• First scenario: Disregards any adjustment that farmers might make to offset the impacts of climate change on grain production, and disregards the effects on production of an atmosphere richer in CO2. (CO2 is essential to plant growth, and much experimental work shows that higher concentrations of it in the atmosphere in fact stimulate such growth);

• Second scenario: Incorporates the CO2 enriching effect on growth.

• Third scenario: Includes both the CO2 enriching effect and the effect of modest adjustments that farmers could make using currently known practices, for example, shifting to a different variety of the same crop and changing the planting date by less than one month in response to a change in the length of the growing season.

• Fourth scenario: Includes the CO2 effect on growth, the modest adjustments to farming just mentioned, as well as more ambitious adjustments, such as shifting to an entirely different crop, changing the planting date by more than one month, and using more irrigation.

Table 1: Analysis of fourth scenario of IPCC:

Scenario	**World**	**Developed Countries**	**Developed Countries**
No offsetting effects considered	-11 to -20	-4 to -24	-14 to -16
Including CO2 fertilization effect	-1 to -8	-4 to +11	-9 to -11
Including CO2 fertilization and modest farmer adaptation	0 to -5	+2 to +11	-9 to -13
Including CO2 fertilization	2 to +1	+4 to +14	-6 to -7

and more ambitious farmer adaptation			

Source: 1996 IPCC Report.

The IPCC analysis of the fourth scenario are summarized in Table 1. The range in Scenario, Developing Countries (Asia, Africa, and Latin America) each entry reflects differences in the results obtained with the various climate models. Notably, the CO2 fertilization effect substantially reduces yield losses and may even lead to net increases in grain output in developed countries as a whole. Smaller but significant offsets are obtained by allowing for adaptive behavior by farmers. Notwithstanding these adjustments and offsets, however, climatechange is indicated by the IPCC report to reduced grain yields in developing nations, underscoring the greater vulnerability of these countries.

Data on carbon emissions, energy consumption and agriculture related national level variables are obtained for one hundred twenty countries from the World Bank's Green Data Book. Multiple linear regression analysis is revealed that agricultural land, irrigation, forest area, biomass energy, and energy use efficiency negatively affect the carbon dioxide emission. But, fertilizer use and per capita energy use affect it positively. The analysis confirmed that the people in rich countries are more responsible for carbon emission than the people in poor countries. It recommends for cross subsidization for low external input agriculture, particularly for organic farming in poor countries (Panta, 2009).The agricultural damages tend to be greater toward the equator, and hence concentrated in developing countries. Yields and agricultural production potential would fall about 15 to 30 percent in Africa and Latin America and 30 to 40 percent in India. For the United States, the effects would be severe for the south but milder and conceivably even positive for a while for the north. Productivity losses would range between 20 and 30 percent in the southeast, and from 25 to 35 percent in the southwest plains and Mexico(Cline, 2007).

Three primary components results (a) higher temperature substantially reduce economic growth in poor countries (b) higher temperatures appear to reduce growth rates, not just the level of output, and (c) higher temperatures have wide-ranging effects, reducing agricultural output, industrial output, and political stability (Dell, Jones, and Olken, 2011). Production of some crop

sectors (such as wheat), in contrast, is likely to expand due to increased demand from other regions of the world(Zhai, Lin, and Enerelt, 2009).

Using Geographic Information System (GIS) under the Basic Linked System (BLS) modeling framework, the methodology identify crop specific Environmental impacts with varieties of inputs and management conditions. The study finds that climate change has significant impact on agriculture, variability of rain-fed cereal and crop production, changes in agricultural land (both increase and decrease), crop-production pattern and the potential cereal production. The impact (positive as well as negative) and its severity vary region to region. The impact of climate change on gross domestic product(GDP) for the aggregate global level is found to be quite small (between -1.5 percent to 2.6 percent) with developing regions seem to have negative impact to it. For the Asian region, around 4 percent negative impact on GDP was revealed. Nevertheless, developed countries were able to take benefit from the climate change. Developing countries consistently experience reductions in cereal and crops production in all climatic scenarios and production may move to developed regions especially to North America and the former Soviet Union (Fischer, et al., 2002).

The mentioned empirical literatures confirm that climate change has significant impact on agriculture production. The impact, however, can be both positive as well as negative. The developed countries, countries towards the North Pole, including North America, former Soviet Union are seem to be benefited from the climate change due to the increased cereal production, ample resources for factor substitutability and some others. Nevertheless, the negative impact tends to be greater toward the equator, and hence mostly concentrated in developing countries. Developing countries are more vulnerable to climate change especially to the agriculture production lacking adequate resources for the adaptation and substituting the production factors, agriculture based economy, food insecurity and poverty. In this context, the country specific quantitative relationship of climate change (especially that of rainfall and temperature) to the agricultural gross domestic product still deficit in Nepalese context that this paper wants to fill the gap(Bezabih,Chambwera, and Stage, 2010).

2.6. Climatic Scenario of Nepal

Geographically, the climate varies in Nepal from sub-basins in the southern Terai plain to arctic in the Himalaya within a span of less than 200 km. Nepal has relatively wet summers and dry winters (Konz, 2003). The climate of the nation is characterized by monsoon circulation, principally easterly winds during summer and westerly from October to May. The eastern Himalayas receive the brunt of the monsoon, which loses its effect as it moves west along the mountains (Konz, 2003). Consequently, there is a distinct moisture gradient from east to west. (Thomas, and Rai, 2005) reported that temperatures in Nepal are increasing at a high rate, with greatest increases found at higher altitudes. The warming seems to be consistent and continuous after the mid-1970s (Shrestha, et al., 1999; Horstmann, 2004). Analysis of maximum temperature data from 49 stations in Nepal for the period 1971-1994 revealed warming trend after 1977 ranging from 0.06 degree celsius to 0.12degree celsiusper year in most of the middle mountains and the High Himalayan regions while the Siwalik and Terai (southern plains) regions show warming trends less than 0.03degree celsius per year (Shrestha, et al., 1999). Distribution of seasonal and annual temperature trends show high rates of warming in the high-elevation regions of the country (Middle Mountains and Himalaya), while low warming or even cooling trends were found in the southern regions. This is attributed to the sensitivity of mountainous regions to climate changes. The scenario of the global change impacts in the fragile mountains of Nepal and around is greater, the major impacts and threats of global warming are widespread. As a result of global warming, the type, frequency and intensity of extreme events, floods, droughts and heavy precipitation events, are expected to rise even with relatively small average temperature increases. Changes in some types of extreme events have already been observed, for example, increases in the frequency and intensity of heat waves and heavy precipitation events (Meehl, et al., 2005) and such events bring more risk to the people living near to riverside or the marginal community.

Nepal demonstrates diverse geo-physical and climatic conditions within relatively small areas resulting vast biological diversity, therefore, it is an ideal place to study climate change impacts on natural and socioeconomic spheres. In context of Nepal, a few studies have been carried out on vulnerability and risk assessment of natural hazards. However most of them are based on the available information of the past without or in only some extent to climate change and potential future risk of climate change related disasters. Although Nepal is responsible for only about 0.025 percent of total annual greenhouse gas emissions of the world (Karki, 2007). It

is experiencing the increasing trends and the associated effects of global warming. Different reports from (IPCC, 2001), (IPCC, 2006), (IPCC, 2007), (World Bank, 2005), and (DFID, 2006) gives in their reports options and ways to reduce the vulnerability in developing country like Nepal. A number of options can reduce vulnerability in all regions of Nepal to climate change and climate related disasters. Non-structural measures are particularly attractive as they generally involve lower costs than engineering measures and would go a long way towards building capacity for disaster preparedness and water resource management. Such measures include: Developing and implementing land use/zoning policies; maintaining up to date hazard and vulnerability maps; training and capacity building for disaster and water resource management; working withthe community to increase public awareness and develop early warning systems and evacuation plans; afforestation and reforestation programs (for reduction in flooding/landslide risk). In Nepal, in between 1995 to 2002, the totals of 6,854 lives were lost by the landslide and flood disasters (ADB/ ICIMOD, 2006) with billions of dollars economic lossof land and infrastructures. In total more than 5,00,000 people were killed by landslides in the 20th century globally. In first 25 weeks of 2003, there were 2,000 landslides fatalities in 139 large events, 95 percent of which occurred in less developed countries (ADB/ ICIMOD, 2006). Because of its location in the central part of the Himalayas and with its fragile geology, steepslopes, high relief, and intense monsoon climate, Nepal is prone to water induced disasters such as flood and landslides. Over the last twenty years from 1983-2002, flood and landslide caused 6,466 deaths and more than US $200 million was damage. In 1993 alone there were more than 1300 lives lost and over US $ 2 million of property and infrastructure destroyed by an individual event recording the highest 24-hr precipitation of 540mm (ADB/ ICIMOD, 2006). The trend of sea level rise will affect coastal regions throughout the world causing flooding, erosion and salt-water intrusion into aquifer and fresh water habitants. Thus, even those who live far from the mountains will have to face the consequences of melting glaciers (Hall and Fagre, 2003). Snow melting rate of Nepal's Himalayas is increasing, so most of Glacier Lakes are in risk in Nepal. Which may lead to Glacial Lake Outburst Flood (GLOF), According to UNDP/KERP report the SaptaKoshi River flood in Sunsari district affect about 43,000 Nepalese people in 18 August, 2008, was the heavy disaster of that year.

An analysis of about 30 years of observed temperature of Nepal has shown that maximum temperatures in Nepal are increasing at an alarming rate (Shrestha et al., 1999). The

average warming in annual temperature between 1977 and 2000 was 0.06 degree celsius per year. Such warming is found to be more pronounced in the northern high altitude regions of Nepal. Further, warming in the winter is more pronounced compared to other season. Except over western middle mountainous region, increasing trend is dominant over most of the country for maximum temperature. For minimum temperature, the decreasing trend is observed over the western and west of central mountainous regions and the eastern parts of the country. However, increasing trend is dominant over most of the regions. Another analysis of daily temperature data for 36 year from 1971 to 2006 using software also shows that both days and nights are becoming warmer and cool days and cool nights are becoming less frequent (Baidya, et al., 2008).

Nepal is rich in biodiversity and is regarded as a hotspot for some locally and globally important plant and animal species. Study of (MoF, 2008) projected that doubling of atmospheric CO2 concentration will reduce Nepal's forest types and habitats and ecosystems will be destroyed. Climate change will also affect productivity of natural ecosystems, particularly provision of environmental services.

2.6.1. Climate and Agriculture in Nepal

Climate and agriculture in Nepal has a wide variation of climates from subtropical in the south, warm and cool in the hills and cold in the mountains within a horizontal distance of less than 200km (UNEP, 2001; Shankar and Shrestha, 1985; Chalise, 1994). The amount of precipitation varies considerably from place to place because of rugged terrain (Shankar and Shrestha, 1985). The length of the regular and systematic observations of climatological and hydrological data in Nepal is only about 50 years (Mool, et al.,2001) .The longest systematic temperature and precipitation data have been available for Kathmandu since 1921 recorded by Indian Embassy under British rule (Shrestha et.al. 1999). The existing climatological and hydrological stations are generally located at the lower elevations. The high mountain areas with very low population density and negligible economic activities are mostly left without any hydrological and meteorological stations. The meteorological observations in high mountain areas were only initiated in 1987 after the establishment of Snow and Glacier Hydrology Section in the department of Hydrology and Meteorology of Nepal (Mool, et al., 2001).

Nepal is highly vulnerable to climate change. It suggested that more than 1.9 million people are highly climate vulnerable and 10 million are increasingly in risk, with climate change likely to increase this number significantly in the future (MoE, 2010). In terms of agriculture and food security, local communities have identified changes in climate as being largely responsible for declining crop and livestock production. Decline in rainfall from November to April adversely affects the winter and spring crops (DFID, 2009). Rice yields are particularly sensitive to climatic conditions and these may fall in the western region where a larger section of poor population exists and this could threaten overall food security. Food insecurity is also due to loss of some local land races crops (Regmi and Adhikari, 2007). Excessive, catastrophic rainfall, longer drought periods, landslides and floods affect agriculture in that extent that it directly affect the agriculture based industry (Shrestha, et al.,1999).

In a study based on an analysis of temperature trend from 49 stations for the period 1977 to 1994 indicate an annual rate of temperature is raising. Similarly a study conducted by practical action, 2009using data from 45 weather stations for the period of 1976-2005; indicate a consistent and continuous warming in maximum temperature at an annual rate of 0.04 degree celsius. Climate change will have a significant impact on agriculture in many parts of the world (IPCC, 1998). Particularly vulnerable are subsistence farmers in the tropics, who make up a large portion of the rural population and who are weakly coupled to markets (IPCC, 2001b). Agriculture in tropical area is vulnerable to frequent floods, severe droughts, and storm surges that can damage life and properties and severally reduce agricultural production and could threaten food security. Risk levels of climate change often increase exponentially with altitude; therefore, small changes in the mean climate can induce large changes in agricultural risks in mountain areas.

Agriculture is likely to get affected positively and negatively. Negative effects are feared to be larger than the positive effects. Increased temperature during the growing season can reduce yields because crops speed through their physiological development producing less grain. More rapid plant development and modification of water and nutrient budgets in the field (Long, 1991) will make existing farming technology unsuitable. The higher temperatures also increase the process of evapotranspiration and decreases soil moisture availability. Because global warming is likely to increase rainfall, the net impact of higher temperatures on water availability

is a race between higher evapotranspiration and higher precipitation. As the precipitation is not regular, the race will be won by higher evapotranspiration (Cline, 2008). Rain fed agriculture is likely to be affected adversely by the climate change.

In one hand, higher concentration of CO2, carbon fertilization, increases plant photosynthesis and thus increasecrop yields (Rosenzweigand Hillel, 1998, Kimball, 1983). On the other hand, increase in the temperature and changes in precipitation pattern have the potential to affect crop yields either positively or negatively (Reilly, et al., 2001). (Chang, 2002) estimates crop yield response models and finds the negative effects associated with some climate changes. Physical effects of temperature rise on crop yield are feared more damaging in tropical and subtropical countries than in the temperate countries. Initial National Communication of Nepal to the UNFCCC notes that there will be growing negative impacts on ecosystems and people's livelihoods with predicted increase in temperatures and change in rainfall patterns in the future (MoPE, 2004). Agricultural sector of Nepal is highly dependent on the weather, particularly on rainfall. Reduce in agricultural productivity due to climate change may create serious consequence as compared to population growth. Most of the population is directly dependent on a few crops, such as rice, maize and wheat. It was predicted that decrease in precipitation from November to April would adversely affect the winter and spring crops, threatening food security. Higher temperatures, increased evapotranspiration, and decreased winter precipitation may bring about more droughts in Nepal (Alam and Regmi, 2004).

Increased water evaporation and evapotranspiration may also mean that crops will require more water through irrigation. In the mid-hill and high mountain regions, increasing temperature has led to the expansion of agro-ecological belts into higher altitudes and increased length of growing period for some crop species. Conversely, high hill animal herders have reported decline in fodder and forage production that has aggravated the prevalence of livestock parasites. In the mid-hills, decreasing soil moisture availability (due to change in rainfall and temperature) resulted in early maturation of crops, crop failures invasion of new diseases and pests in fields and reduced agricultural productivity. Along with it, decreasing run-off water to fed natural streams (used for irrigation) and reduced in re-charging of natural ponds, reservoirs and lakes have been reported. In the Terai region similar issues were noted, particularly reduced recharge

rate of ground water that has resulted in a reduction of discharge of water in shallow and even deep tube- wells for irrigation for crops.

Agriculture sector is very sensitive to climate change. There exists intricate relationship between climate, crop and the animal husbandry and their long term implication. However, the relationship between the climate and agriculture and their long-term implication have been little studied and researched in Nepal. Nepalese agriculture is highly dependent on weather, so climate change has serious impact on agricultural sector. Glacier retreats combined with higher temperature, increased evapotranspiration, lower soil moisture levels and decreased winter precipitation may bring about droughts in Nepal from November to April. Success of crop production is entirely linked with the weather condition and their relationship has a direct effect on the growth and development of a crop, since the physiological function of the crop is governed by the climatic parameters. Crops production depends on air temperature and humidity.

Rice, maize, wheat, millet and barley are the major food crops grown in Nepal. The rice crops require abundant water for transplanting and mostly depend on monsoon. If the pre-monsoon rain fails, it will delay transplanting and ultimately reduces the rice yield. Maize has a broader ecological adaptation than rice with change of temperature and precipitation. Hence, maize of the same variety can be grown over large altitudinal variations.

2.6.2. Climate Change and Nepalese Agriculture

Climate change having a disproportionate effect on the lives of people in poverty in developing countries. For developing countries like Nepal, climate change is not just an environmental phenomenon but also an economic, social and political issue. Nepal is among one that lies in the most vulnerable countries on earth with regard to climate change. Nepalese economy being greatly dependent on agriculture, it is very sensitive to climatic variability. Agriculture is the main source of income and livelihood of Nepalese people.Nepalese agriculture is very much dependent on rainfall, and any significant change in air temperature can result in change in climatic conditions, like rainfall and weather conditions,
resulting in shift in agriculture pattern. Climate change has the potential to affect agriculture through change in temperature, rainfall, CO2 concentration and the interaction of these elements. Geo-scientists have an estimation that a temperature rise of 4° Ccould result in lossof 70% of snow and glacier areas due to melting of snow and ice. (Chhetri, 2010). Such changes are likely

to contribute to the faster development of glacier lakes and lead to increased potential for Glacier Lake Outburst Flood (GLOF) as hazards. Similarly, glacier retreats have also been recorded which would lead to contracted flow of water during drier seasons. Therefore, because of climate change and the rising temperatures, Nepal could face drier phases during dry seasons with wetter monsoon with chances of flooding and landslides during rainy seasons with subsequent impacts on agriculture and livelihoods (Alan and Regmi, 2005). The recorded extreme weather events between 2006-2009 including droughts and floods have significantly affected the food production in Nepal (WFP, 2009). Reduced precipitation and moisture availability coupled with increased temperature also affect the grasslands, fodder and forage production and productivity and may result in decrease in livestock production and productivity. There also occurs loss of top fertile soil due to soil erosion, landslides and floods bringing about reduction in agricultural production. Production risks include direct physical plant damage by flooding and water-logging, as well as related problems such as increased pest and pathogen outbreaks, enhanced soil erosion, and threatened groundwater quality. At the same time, agriculture has been shown to produce significant effects on climate change, primarily through the production and release of greenhouse gases such as carbon dioxide, methane, and nitrous oxide, but also by altering the land cover, which can change its ability to absorb or reflect heat and light. Deforestation, desertification and fossil fuel burning are the major contributor to high carbon dioxide level in atmosphere. Agriculture is one of the most affected sector from impacts of climate change and also is a major contributor to increasing methane and nitrous oxide concentration in the earth's atmosphere. One third of all carbon dioxide emission come from changes in land use (forest clearing, shifting cultivation and intensification of agriculture). Approximately two thirds of methane and most of nitrous oxide emissions originate from agriculture sector. (Kotschi and Müller-Sämann, 2004).

Agriculture and climate change are interrelated processes and they take place on a global scale. Changing climate and weather patterns are predicted to have severe negative impacts on food production, food security and natural resources in developing countries. This is because agriculture is the main economic activity and it is the only source of livelihood for most people living in rural areas or agricultural countries (Sasson, 2012 andAgbogidi, 2011).

2.6.3. Evidences of Climate Change on Nepalese Agriculture:

i. Eastern Terai faced rain deficit in the year 2005/06 by early monsoon and crop productionreduced by 12.5% on national basis. Nearly 10% of agricultural land was left fallow due to raindeficit (drought) but mid-westernTerai faced heavy rain with floods, which reduced production by 30% in the year (Regmi, 2007).

ii. Early Maturity of the crops due to increase in temperature may help to have more crops in the same crop cycle (NARC 1998).

iii. Shifting of climatic zones has been observed in the country. Extinction of natural vegetation: local basmati rice varieties, some local wheat, maize and other agricultural crops were also observed

iv. Cold wave in Nepal in 1997/98 has negative impacts on agricultural productivity and showed reduction in the production of crops by 27.8, 36.5, 11.2, 30, 37.6 and 38 percent in potatotori, serso, rayo, lentil and chickpea respectively (NARC, 1987/88 and 1997/98).

2.7. Impactof Climate Change on Agriculture

Climate change could affect farming practices, as well as pest control and the varieties of crops and animals that could be raised in particular climactic areas. These could, in turn, affect the availability and price of agriculture products. Although the long-term effects of climate change are still largely unknown, scientists can observe short-term effects of climate change on crops and animals. In addition, scientists can prognosticate about the changes that are likely to occur in agriculture if global climate change causes changes in temperatures and rainfall. Increased intensity and frequency of storms, drought and flooding, altered hydrological cycles and precipitation variance have implications for future food availability. The potential impacts on rain fed agriculture as irrigation systems are lack in most of agricultural fields. The developing world already suffering from chronic food problems. Climate change introduced significant challenges. While overall food production may not be threatened, those least able to cope will likely bear additional adverse impacts (WRI, 2005). The estimate for Africa is that 25–42 percent of species habitats could be lost, affecting both food and non-food crops. Habitat change is already underway in some areas, leading to species range shifts, changes in plant diversity, which includes indigenous foods and plant-based medicines (McClean, Colin, et al., 2005). In developing countries, 11 percent of arable land could be affected by climate change, including a reduction of cereal production in up to 65 countries, about 16 percent of agricultural

gross domestic product (FAO, 2005). Crop productivity is projected to increase slightly at mid- to high latitudes for local mean temperature increases of up to 1-3 degree celsius depending on the crop, and then decrease beyond that in some regions (IPCC, 2004).

Climate change has direct effects on livestock productivity as well as indirectly through changes on the availability of fodder and pastures. Climate determines the type of livestock most adapted to different agro-ecological zones and therefor the animals that are able to sustain rural communities. Climate change is expected to affect livestock at the species level. For example, if the Himalayas turn warmer, the yak could be restricted to higher altitudes where grass and fodder is less available. Communities will seek other species for production, relying on their own knowledge. It is expected that increased air temperatures will cause more stress on livestock. Both humans and livestock are warm-blooded animals, so both are affected by increased heat and humidity. During strong heat, livestock reproduction declines as well as their appetite. Decreased appetite will lengthen the time needed for the livestock to reach their target weight (most animals only eat about half of normal quantities when they are heat-stressed). Stress can also increase the incidence of sickness, decrease rates of reproduction, and increase fighting among animals in confinement. In some areas, night-time temperatures are even more above average than daytime temperatures during heat-waves, which have resulted in increased mortality rates. Despite the warmer winter temperatures, global warming could have a negative overall impact upon livestock.

Since changes are relatively slow, there is need to rely more on continuous observations and experience of farmers and their local knowledge. Climate changes also affect nomadic and transhumant livestock keepers. So new routes and pastures have been found. The negative impact of ruminants on greenhouse gases emissions can be addressed through changes in animal husbandry including ruminant diets and animal stocking ratio to avoid nitrous oxides emissions(IPCC, 2001a). Historical success in coping with climate variability suggests that few of animal husbandry systems could adapt to climate change successfully. Impacts of hotter season are more benifitable than cooler season for animal husbandry. However, adaptation could entail dislocation costs for certain producers. FAO can assist in monitoring both the direct (animal genetic resources) and indirect (availability of fodder and pastures) effect of climate change on livestock, provide early warnings to the various climatic zones and assist countries in

adaptinglivestock policies. In addition, FAO can work with farmers who know by experience which types of animal breeds or varieties can best resist with changing conditions, to mitigate the negative impact of ruminants on greenhouse gas emissions through recommending animal husbandry changes such as ruminant diets and stocking ratios. Insect, parasites and diseases could also become more prolific as global warming progresses. New diseases are also introduced in the Southeast that were once considered as inhabitant of tropical areas. It is experienced that in cases of increased heat stress and humidity, most livestock were not be able to fight with these diseases without the use of costly medicines that means they can't adapt in changing climate.

Agricultural outcomes are determined by complex interactions among people, policies, and nature. Crops and animals are affected by changes in temperature and precipitation, but they are also influenced by human investments such as irrigation systems, transportation infrastructure, and animal shelters. There are uncertaintiesabout where climate change will take place and how farmers will respond; much is still unknown about the effects of climate change on agricultural production, consumption, and human well-being and making it difficult to move forward on policies to combat the effects of climate change (Gerald, 2009).Climate change and global warming are considered as major threats to agriculture sector and food production because it is projected to have major impacts on conditions affecting agriculture such as elevated temperature, carbon dioxide, glacial run-off, (Fraser, 2008) and unpredictable rainfall seasons and susceptibility to invasive species, pest and disease outbreaks thus decreasing crop yields (Agbogidi, 2011).

Rapid climate change produce risks in life of living being like change in food chain which depend on water sources which may recede or disappear, medicines and other resources may be harder to obtain as the plants they are derived from may reduce or disappear (Shah, 2012). Global warming may make water more available or scarce, change rainfall patterns resulting in shorter growing seasons, especially for subsistence farmers who depend on rainfedagriculture (World Bank, 2008).

Global warming may result in higher temperatures and humidity in some countries. As a result of high temperatures, the amount of arable land in high-latitude region may increase through reduction of amount of frozen land(Sasson, 2012). In addition, high temperatures lead to poor vernalization and reduced yield in many cereal crops. High temperatures and relative

humidity conditions favour multiplication and spread of fungal diseases so there may increase pressure from insects and weeds (Cline, 2007). Rice is the second important crop in the world with production of about 525 million tons from about 148 million hectors. It is cultivated within an altitude of 300-2300 meter above sea level. In south Asia, rice production has to be doubled by the year 2020 (IRRI, 2000).According to study of NARC at Khumaltar, increased CO2 and temperature result increase of rice yield by 17.07 and 26.58 percent. Greenhouse effect due to excessive emission of carbon dioxide was observed (Malla, 2008).

2.7.1. Impact of Climate Change on Nepalese Agriculture

Nepal's economy depends on agriculture. Total area of Nepal is 147,181 km, divided in mountains (35 percent), hills (42 percent) and terai (23 percent). A total of 30, 91,000ha area is used for agriculture, and Nepalese agriculture contribute more than one third of GDP, that means it accounts for 38.15 percent of the gross domestic product (GDP).Also growth as well as yield is primarily determined by climatic condition of the country or region. Major constraints of plant growth and yield arerainfall and temperature.

The rising temperature and emission of CO to some extent is helpful in production of major crops. For example, increase in agricultural production by enhancing photosynthetic processes, water use efficiency, shortening physiological period and soil microbial activities. Decrease in grain filling period due to increase in respiration process, fertilizer use efficiencies, shift in agricultural zone, increase in insect pest population, desertification,increase in soil erosion, evapo-transpiration and cause malnutrition in a world overflowing with food due to reducing protein and decrease in mineral nutrients content in different crops are negative effects. The impacts on agriculture are the decrease of productive land in some region and increase in other region. So, it is a complex problem to the world (Pathak, et al., 2003a). Rising CO2 promotes plant growth and if the CO2 gas doubles, yields will increase by 40 percent. Some positive findings with increased CO2 Concentration.

Around 39 percent of the land resource of Nepal is covered by the forests. Agriculture comes second in terms of use of land as it covers around 27 percent. Because of the growing demands of food of rapidly increasing population, land productivity is not so satisfactory and limited opportunities in non-farm activities. In the agricultural sector demand of water for irrigation has been increased greatly. The irrigated area expanded from 0.439 million hectares in

1984 to 0.88 million hectares in 1998. According to studies and researches done by the Department of Hydrology and Meteorology, the average temperature in Nepal is increasing at the rate of approximately 0.06 degrees celsius per year. Nevertheless, the temperature in the Himalayas is increasing at a faster rate and this can have serious impacts on glacial lakes of the country. Although definitive trends in aggregate precipitation have not been determined, there are evidences of more intense precipitation events.

Livestock is a major component of agriculture. It includes poultry, dairy production and raring animals such as cattle, buffaloes, sheep, goats and pigs. It is the major contributor of methane mainly from ruminant animals. It is estimated to be around 365.78Kg from 19.4 million animals in Nepal. Meat and milk products are perishable goods, which require more energy to conserve the products. It is highly sensitive to fluctuation of atmospheric temperature. Increase in temperature by 2 degree celsius would decrease the meat and milk quality, hatchability of poultry increase and increases the possibility of disease in the livestock. Thus, climate change introduced new endemic diseases in the human being and also in animals including livestock and agricultural sector (FAO, 2007). On the other hand, increase of atmospheric CO2 will increase the greenery of the land or fodder and pasture for the livestock's. Increase in amount of green fodder helps to boost up meat and milk production. It will ultimately help in improvement of economic status of Nepalese farmers who have business of livestock farm. However, if CO2 is increases rapidly, all the living beings have to suffer from various impacts like diseases and other problems (Malla, 2008).Hence agriculture sector is very much sensitive to climate change. There exists very close relationship between climate, crop and the animal husbandry and their long term implication. However, in Nepal very little studies have been done in past, on the relationship between the climate and agriculture and their long-term implication. But currently there are many organizations which study and research about climate change and agriculture. Nepalese agriculture is highly dependent on weather, so climate change has serious implications on agriculture. Glacier retreats combined with higher temperature, increased evapotranspiration, lower soil moisture levels and decreased winter precipitation may bring about droughts in Nepal from November to April. Success of crop production is entirely linked with the weather condition and their relationship has a direct effect on the growth and development of a crop, since the physiological function of the crop is governed by the climatic parameters. Agricultural production depends on air temperature and humidity. Climate change is likely to alter the

balance between insect, pests, their natural enemies and their hosts. Increase in temperature and CO2 will lead to an increase in population of pests and severity of diseases in presence of host plant. It increases the rate of reproduction of insect and pest. Pest and disease of plain ecosystem may gradually shift to hills and mountains. Some pathogens of important crops from terai zone has adapted in hills and mid-hills (rust and foliar blight) that may affect the agricultural production. Climate change can negatively affect crops and availability of food appropriate quality by increasing production volatility.(Nicholls, 2011a)

Nepal Agricultural Research Council's (NARC) entomology department has researched, howpest populations are changing in relation toclimate change. Many outbreaks of the fungal disease such as potato late blight and ascochyta blight have already been directly related to climate change however, no prediction models have yet developed. (Oxfam International,2011).Additionally, modern and hybrid seed varieties are increasinglyreplacing local traditional varieties as they often provide greater drought resistance or higher yielding varieties. Coldwater fish, herbs, pasture lands, and livestock are expected to be most at risk in Nepal (Nicholls, 2011a). Temperature was increasing by 0.06 degree celsius per year, a rise in temperature from 1975 to 2006 was 1.8degree celsius, and ithas been recorded in Nepal. Problem of frequent drought, severe floods, landslides and mixed type of effects in agricultural sectors have been experienced in the country because of climate change. Research on CO2 enrichment technology at Khumaltar revealed that the yield of rice and wheat increased by 26.6 percent and 18.4 percent due to double CO2, 17.1 percent and 8.6 percent due to increase in temperature respectively. Record of National Agriculture Research Center (NARC) showed positive effect in yield of rice and wheat in all regions, but negative effect in maize especially in Terai (Malla, 2008).

2.7.2. Impact of Climate Change in Agriculture ofMidHilly Region

Hilly region including snow covered mountains are more vulnerable to climate change than plain region in the context of Nepal. Past researches on climate change in hilly and mountains regions have suggested significant warming in higher elevations leading to reduction in snow and ice coverage with increased frequency of extreme events like landslides and droughts. Researches on temperature trend in Nepal have identified increasing trend in annual mean and annual maximum temperature in high altitude more than that of lower altitude (Baidya,

et al., 2008). Even an insignificant change in climatic variables can cause amplified and devastating impacts in these ecologically fragile hills. The impact of climate change can be much greater for indigenous communities living in the more remote and ecologically fragile zones and relying directly on their surrounding environments forsubsistence and livelihood (UNFCCC, 2004). Economy of the hills largely depends on agriculture. Most of the people are illiterate and unaware of changes occurring in their surroundings. Lower level of awareness on disasters and climate change and its adaptation and mitigation options are associated with higher vulnerability (WWF Nepal, 2008). There is overall increase in rainfall during the monsoon season but decrease in precipitation during winter in the mid and high hills. Continuous rainfall in the summer season caused large and small landslides, floods, soil erosion resulting in loss of fertile land, forest and human properties that adversely impact on agricultural sector. In past years, it was observed that winter drought have serious impact on the farming practices. Long winter droughts have made the life of farmers more difficult. The diverse and complex topography of the hills of Nepal makes the study of climate change more difficult. Migration of people to the fertile lands of Terai by leaving their own cultivable land barren and also reduce in fertile agricultural land of migrated places resulted increased food insecurity. Increased temperature, landslides, flood, droughts and high rate of glacial melting etc. have become threats to living being and agricultural sector.

2.8. Climate Change Policies and Initiatives in Nepal

Nepal has taken some initiatives to reduce the GHG emission and mitigate the effects of climate change. Some of them are briefly outlined. Nepal fully commitment to participate and contribute to address the global environmental challenges at Rio de Janeiro in June 1992 through signing of the UNFCCC on June 12, 1992. Nepal ratified the treaty on May 2, 1994, which came into effect from July 31, 1994, and Nepal responded immediately with the establishment of Environment Protection Council (EPC) under the chairmanship of the Prime Minister with the objective of integrating environmental concerns into the development process. The EPC initiated the process of formulating the national policy on environment and approved the "National Environmental Policy and Action Plan (NEPAP)" in 1994. In November 1996, Government of Nepal (GoN) also established Alternative Energy Promotion Centre (AEPC) under the MoEST. The government of Nepal,realizing the importance of tackling environmental issues, created a

separate Ministry of Environment in 2009. In the policy and legislative front also, Nepal initiated several measures. It brought Sustainable Development Agenda for Nepal in 2003 to guide the sustainable development path until 2017. Other several policies, strategies, and laws, which are relevant to the issues of environmental problems and climate change, have been put into force. The major national environmental policies include the National Conservation Strategy, 1988, the Nepal Environment Policy and Action Plan, 1993, the Sustainable Development Agenda 2003. The climate change policies were prepared and implemented but it was not more successful. The Interim Constitution of Nepal, 2006, first time, recognized "right to clean environment" as a fundamental right of the citizens of Nepal. Environment Protection Act, 1996, Environment Protection Regulations, 1997 and Climate Change Action, 2006 are the key environmental legislations. The other legislations include Soil and water conservation Act, 1982, Water Resources Act, 1992, Industrial Enterprises Act, 1992, Vehicle and Transportation Management Act 1992, and Regulation, 1997 (first amendment in 2004); Forest Act, 1992 and Regulations,1995; and Ozone layer Depleting Substance Consumption Regulations, 2001. World climate change conference, UNFNCC was held in Copenhagen, Denmark (Cope15) from 7 December to 18 December 2009. Nepal has also the participatedin that conference. Cope 15, concludes that 12 points declaration for climate change. But that declaration was not more beneficial for developing countries like Nepal.

The government of Nepal (GoN) has initiated several activities to implement mitigation and adaptation measures to combat climate change problems. Climate change policies are the latest addition to Nepal's legislative framework. The policy had come with international signing of treaty and convention. The impeding adverse impact of climate change, the policy is being prepared in the wake of global climate change awareness and need for urgent responses. Nepal participated in the climate change business right from the Convention preparation process in 1991. Nepal signed the UNFCCC on 12, June 1992 during the UN Conference on Environment and Development (Earth Submit) at Rio De Janeiro, Brazil (Upreti, 2009). A signed global treaty has provided the international framework for managing climate change. The treaty has entered into force on 31 July 1994. Later on in 2005 Nepal has accessed and entered in the Kyoto Protocol. Ministry of Environment (MOE) has been assigned to promote and facilitate the activities related to Clean Development Mechanism (CDM) in the spirit of the Article 12 of the Kyoto Protocol (Kotru, 2009). In line with the national and international commitments,

government of Nepal (GoN) accomplished various CC initiatives including Sustainable Development Agenda, Millennium Development Goals, National Capacity Needs Self-Assessment (NCSA), National Adaptation Program of Action (NAPA), Local Adaptation Plan of Action (LAPA), Readiness Preparedness Plan (REDD RPP), Pilot Program for Climate Resilience (PPCR) and Climate Change Policy-2011. Similarly, Nepal has a lead role for Mountain Initiative (MI) in 2010 as a global initiative aimed to cover the common interest of the most of mountainous countries. The initiatives are expected to work together to better understand the chances occurred in mountains, that means climate change issues and launched adaptation and mitigation program jointly (ICIMOD, 2010). Apart from policy documents prepared and promulgated by the climate change Division of the ministry of environment(MoE), various related departments and ministries have drafted and implemented policies, acts, and regulations associated with climate change issues both mitigation and adaptation. This analysis assesses the four policy documents on climate change (Climate change Policy, NAPA, LAPA, and REDD RPP). Additionally, apart from above policy initiatives government of Nepal(GoN) issued the Three Year Plan Approach Paper (2010-2012) which includes the objectives of promoting green development, making development activities climate-friendly, mitigating the adverse impacts of climate change, and promoting adaptation for the poor and vulnerable communities (NPC, 2011).

2.8.1. Institutional Arrangement for Climate Change Adaptation Practices

Three levels of institutional arrangement have been found in the climate change documents to implement policies and programs i.e. National, District and VDC level (LAPA\MOE, 2011). National level High level Climate Change Council (CCC) chaired by Honorable Prime Minister has constituted for high level coordination and policy formulation in 2009. Similarly, a high- level committee on climate changecoordination focusing Pilot Program for Climate Resilience (PPCR) has been formed in 2011 under the chairpersonship of the minister for MOE, involving secretaries of the relevant sectorial ministries, academicians, experts and civil society members. Additionally, the Multi-stakeholder Climate Change Initiatives Coordination Committee (MCCICC), constituted in 2010 including local governments, non-governmental organizations and development partners, ensures functional coordination to avoid duplication (MoE, 2011). The GoN also established the climate change

Management Division with three Sections (Climate change,Climate change councilsecretariat, and CDM) at the MoE in 2010. In the same year, a REDD Cell was established within the Ministry of Forests and Soil Conservation (MOFSC, 2010). At the national level MoE plays a key role in overall coordination across scales (between adaptation policy and planning and on-the-ground implementation) and across actors (coordinating between different donor support avenues, different CC projects, and activities across ministries under programs of work managed by MoE. MoFSC has taken the lead role in designing and implementing the REDD (REDD+) in Nepal. To prepare the REDD mechanism in Nepal, MoFSC has initiated various programs and activities, including the REDDReadiness Preparedness Plan (RPP), which is a groundwork that will feed into the REDD Strategy (MoFSC, 2010). Likewise, a National Disaster Rescue Committee has been set up under the chairmanship of the Prime Minister which includes most Ministers and Departments. Ministry of Home Affairs acts as secretariat to the committee while other ministry and departments are members to overall coordination and implementation of the disaster management program (MoHA, 2009). Additionally, Department of Water Induced Disaster Management has its own regular program and activities for river training and flood control. The Department of Soil Conservation and Watershed Management (DSCWM) has also initiated the climate adaptation program through its district offices.

District level all CC related policies and programs have identified the district level offices to play key roles to implement the CC adaptation and disaster management programs. Village Development Committee (VDC)/ Municipalities NAPA, LAPA and climate change policies have identified that VDC/Municipalities are the main institutions at the grassrootlevel to plan and implement the climate change adaptation and mitigation practices. The policies are endorsed from the government and there is no any institutional arrangement at the local level to implement the program. Numbers of challenges have been appeared in recent days in implementation of climate change policies and strategies. There is lack of detailed study and scientific evaluation initiatives on impact of climate change on agriculture. However forest sector play important role in minimizing GHGs because green plants absorb GHGsduring photosynthesis process and also minimize climate change events. There are no powerful arrangement for implementing climate change policy and strategy in developing countries (UNEP/WCMC, 2000). So climate change policies, strategies programs etc. have to design as per desire capacity of existing institutions

with appropriate power relation. Even such institutions are failed to implement the programs technically and administratively.

In Nepal issue of climate change is included in Agriculture Perspective Plan 1993 (APP) along with master plan for irrigation and livestock. Similarly in three year interim plan (2007-2010) outlined several policies integrated conservation and development of forest, agriculture and environment sectors and design and implement necessary programs for effective implementation of international declaration that Nepal has ratified (NPC,2007).Nepal has signed several other conventions international treaties,agreement and global affiliations related to conservation of environment and to minimize climate change events and signed UNFCCC on 1992 and United Nation Convention to combat desertification (1994).In this way several policies and strategies related to climate change and agriculture have been included in different plans of Nepal till 2015.

2.8.2.Mitigation of Climate Change

To realize benefits from cc, there is a need for development of massive dissemination strategy of these high yielding and resilient cereal crop varieties to resource challenged farmers. Conversely, the use of greenhouse gas emitting fertilizers, pesticides, etc. should be controlled (Agbogidi, 2011). Also, herbicides which reduce competition from weeds can improve crop productivity and thereby serve to mitigate CO2 gas emissions associated with bringing additional land under cultivation (Lybbert and Sumner, 2010). Afforestation and maintenance of existing natural and artificial forests should be encouraged to minimize adverse effects of climate change. The principle of cut one tree and plant two should be implemented. This is because CO2 gas is used by trees during photosynthesis, thus checking excess CO2 in the atmosphere and also help to reduce the disastrous impact of climate change like landslide, soil erosion(Agbogidi, 2011).

Integrated pest management (IPM) is the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides levels minimum (FAO, 2003). It entails the use of a diverse range of pest resistant crop varieties, crop rotations, intercropping, optimal planting time and weed management.According to (Vermeulen, 2012), climate change adversely affects through intensification of drought conditions or heat waves, heavy rainfall, flooding,

landslides, which result to environmental degradation. A changing climate is associated with increased threats to food safety, post-harvest losses and pressure from invasive species, pests and diseases. Therefore, selective agricultural practices that select major crops and livestock species that adapt and thrive in a wide range of environmental conditions.

In developing countries, technologies required to improve productivity such as higher yielding and sustainable agriculture to exist, but remain too costly for resource-poor farmers to adopt. In addition, farmers may lack adequate knowledge to apply these technologies

2.9. Conclusion of Review

In above literature review different writer, author, persons and organization express their

view and suggestion about climate change. So it is not only problem and issue of only a countrybut it is concern of whole world, as it affect the whole globe. Hence it is most sensitive issue of the world and should give prime concern to solve this issue to save the world.

Above review show two causes of climate change, one is natural and another is human induced cause. In present human activities like deforestation,industrialization, pollution etc. are cause of excessive GHGs (carbon dioxide, methane, nitrous oxide, ozone etc.)emission and these activities are more responsible for climate change. Among GHGs carbon dioxide is very harmful and mostly emitted GHGs in the atmosphere. Hence increasing concentration of carbon dioxide result increase in surface temperature of the Earth which affect plant and organism, environment of the whole earth.

Above review also show that atmospheric carbon dioxide concentration is increasing continuously and temperature of the earth surface is also increasing continuously in comparison to past. Climate change not only affect the temperature but also affect the rainfall pattern. It may result in low rainfall, heavy rainfall, and fragmented rainfall. It may introduce different natural calamities like flood, landslide, soil erosion, drought etc.

Hence both temperature and rainfall negatively affect agricultural production as both of them are closely related with agriculture. It means rainfall and temperature are very important aspect of agriculture sector. As agriculture is not possible without water and temperature. Also excessive

water and temperature is not good for agricultural production. Because high temperature firstly minimize soil moisture and crop become dried, help in spread of diseases and pests. Hence agriculture require optimum temperature. Also excessive rainfall introduce soil erosion, water log in farm and decay of crops. Hence agriculture require optimum water for high yield. Hence crop can't tolerate excessive temperature and water.

Drought as result of climate change may have several consequences in agricultural sector. It may dried up agricultural land, may create stress of fodder and grasses to livestock, dried up of water resources create irrigation problem. Hence temperature and rainfall pattern affect agriculture sector very much and may create food insecurity problem.

Developed countries are more responsible for climate change, as they emits more GHGs from industries. Even less developed countries are less responsible for climate change, they have to face equal problem of climate change. LDCs are more vulnerable to climate change as they have less technology to cope with it. But DCs have more modern technologies through which they can take more benefit even in situation of climate change.

In present there found many organizations related to climate change. They are trying to reduce emission of GHGs through different programs, awareness program also different international organization have introduced different conference, summit, treaties on climate change to reduce emission of greenhouse gases and to save the Earth. Hence all the human beings of the Earth should be aware about climate change, itscauses and possible impacts. As human activities are the main cause of climate change, human being should play important role to reduce emission of greenhouse gases to save the whole Earth. Otherwise there will be drastic change on the Earth because of climate change.

CHAPTER III

METHODOLOGY

The study is primarily based on people perception that means primary data and also onsecondary data like, climatic data recorded over time and data collected from VDC etc. Furthermore, data were collected from different published and unpublished journal, articles, internet etc. as secondary data.

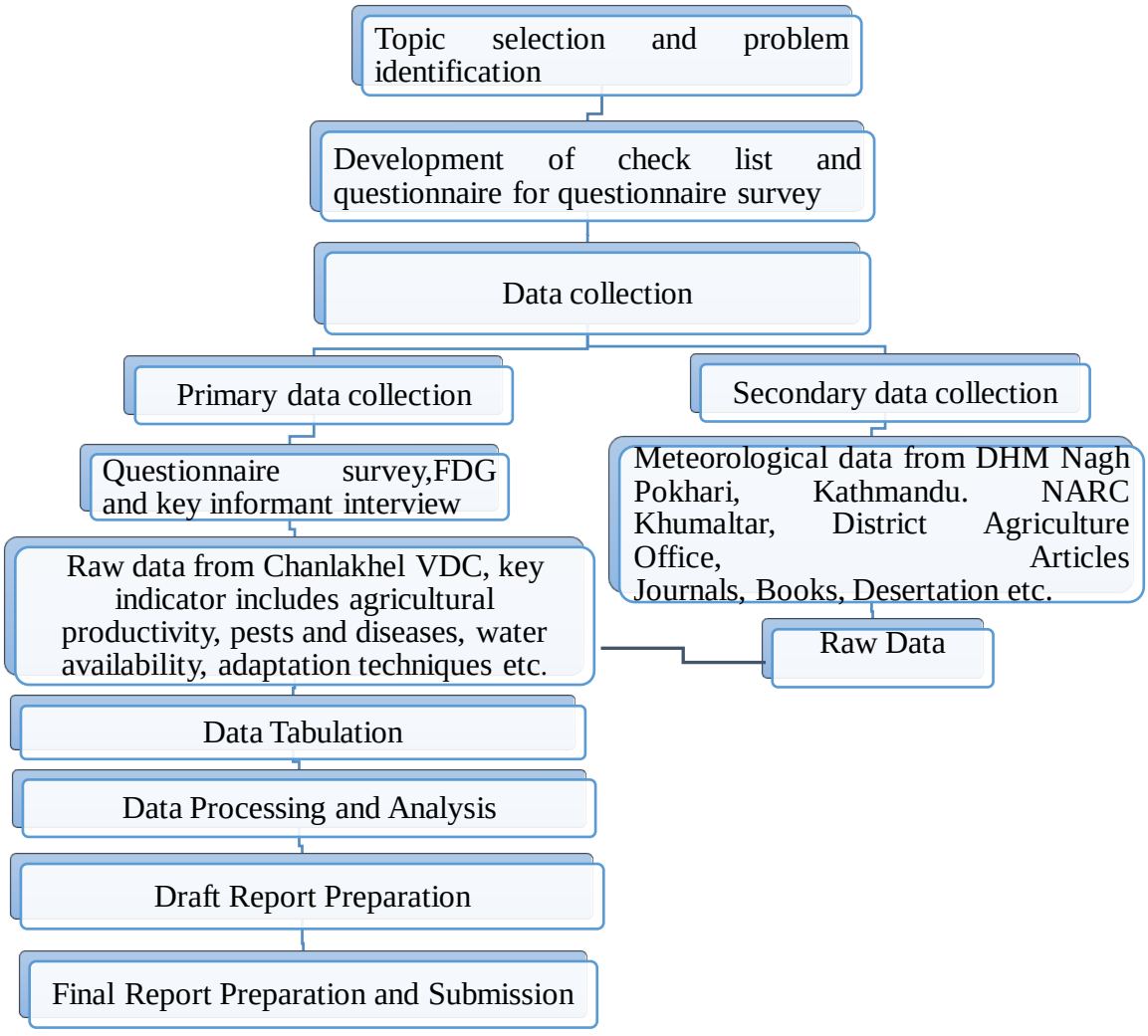
Selected questionnaire survey, Focus Group Discussion and Key Informant Interview and field observation were used to collect field data. KII was also done among key persons. Pre-designed checklist was used during organized FGD and KII in order to ensure that relevant aspects of the research are adequately covered. Sample questionnaire is presented in Annex I. Secondary data were collected from different sources. Rainfall and temperature data were collected from Department of Hydrology and Meteorology. And other data related to agriculture, precipitation, climatic data and livestock of the study area were collected from Chanlakhel VDC. These rainfall, temperature and productivity data were also collected through the people'sperception. The collected information were processed, tabulated, analyzed.

3.1 Research Design

This study is carried out on the basis of both explorative and descriptive research design. This study focus on to investigate the impact of climate change on agriculture both on farming and livestock husbandry. Moreover this study found trend of precipitation and temperature of the study area. In this regard it is exploratory research design. Beside this, the study try to describe many things related to climate change eg. adaptationand mitigation technology adopted by farmers to combat impact of climate change and their role to minimize emission of GHGs into atmosphere etc.

Designing is the initial step of a study in which the research topics and research issues are identified and presented in a systematic manner. The research objectives were set along with the activities and methodology for data collection. To collect perception data some checklist and questionnaires were designed to achieve against each objective through primary data collection. These check lists were used to cross check and extract information from the study area. Secondary data are collected from different published and unpublished journals, articles, books and internet which were tabulated, processed, analyzed according to the study and findings. After review of the literature, research methodology and previous research findings, final report was prepared. Final report is submitted to supervisor and paper is presented.

Figure: Research Design:



3.2 Nature and Sources of Data

This study included both primary and secondary data. Primary data were collected through structured questionnaire, key informant interview with key persons, FGD with aamasamuha, local farmerand field observation. Secondary data were collected from several published and unpublished sources,Department of Hydrology and Meteorology [data of temperature and rainfall of year 1985-2014, longitude (deg/min), Elevation (m):1350, Location Khumaltar], research paper, NARC library,journals, related websites, and VDC of study area.

Both qualitative as well as quantitative information were taken into account. Generally data referring to the following components were collected (a) Demographic (b) Occupational (c)Educational

3.3 Rationale of the Selection of Study Area

Nepal is one of climate change affected country beside hilly region is mostly affected. Chanlakhel VDC is selected for my study because as it is only 9.5 km away from centre of Kathmandu. This was purposive selection and following were reasons for this selection.

- Most of the people in this area are engage in agriculture and livestock husbandry which are affected from climate change.
- There is good size and diversity of settlement which would provide enough number of informant.
- It is easily accessible for data collection.
- Currently farmers are also engage in commercial farming of cash crops
- This study area possess sufficient cultivable land for agriculture.

3.4 Universe and Sample of the Study

Collectionof data from the whole population by using questionnaire (house hold survey) is very difficult and time consuming task. There for small sample from Chanlakhel VDC, ward no. 5 (in present this VDC has been incorporated as ward no. 2 of Dakshinkali municipality) has been taken for the study of impact of climate change on agriculture. The universe of thestudy is total household of the study area that is 201 households. This VDC contain 9 wards but only ward no. 5 was selected as study area. Hence sample size taken for the study was 60 households (30 percent). That means 60 households were sampled out of 201 households.This 60 households were selected random basis for interview. Farmers are the main respondents of this study.

3.5 Data Collection Tools and Techniques

To generate the primary data structured questionnaire, semi or unstructured interview and observation as well as focus group discussion method were applied.

3.5.1 Questionnaire Survey

Structured questionnaire were prepared to generate primary data from the despondence of the study area. Respondent were requested to fill up the questionnaire sheet. Questions were asked to the respondents who were unable to fill up questionnaire and answer were filled up to collect require data. To generate the accurate data from the study sitepeople from different age group and ethnicities were chosen for questionnaire survey in order to collect overall information

about agriculture, difficulty in agricultural sector due to climate change, rainfall pattern, problems of pests and diseases because of climate change, climatic condition in comparison to past years, adaptation method that they have adopted to combat with climate change etc. of the study area. The focus has been given to farmer (both male and female) of that study area.The questionnaire is given in ANNEX- I.

3.5.2 Key Informant Interview

Primary data were also collected from key informant interview using direct interview method. The interview was taken as cross checking for the data obtained from the questionnaire.Toassess the more information from the study area about climate change, key informant interview was applied to those who can provide us more information about climate change. It is interview with key persons to conduct more information about impact of climate change on agriculture. These key persons include local (cash crops) businessman and farmer of the study area MaileeMagar, Ram Nagarkoti, teacher of ChanlakhelMadhayamikVidayalayaandPradhumnaKarki, VDC secretary shree Krishna Bista, social worker SaritaBistaarekey person of the study area and asked them question about impact of climate change on agricultural production of the study area, rainfall pattern, problems on agriculture sector due to climate change, problem of pests and diseases due to climate change, adaptation methods they adopt to minimize its impact etc. Checklist was used for key informant interview.

3.5.3 Focus Group Discussion

Two focus group discussion was carried out, one with local farmers and another with aamasamuha to get information about the past and present climatic condition, its impact on agricultural sector,and stress on water resources for irrigation,problem of disease and pests on agricultural sector due to climate change, adaptation method adopted by farmers to minimize the impact ofclimate change on agricultureetc. Focus group discussion is necessary to understand impact of climate change on agriculture according to the view and experience of farmers of the study area. Checklist was used for this focus group discussion.

3.5.4 Field Observation Method

Field observation was carried out for number of times for additional information. During field visit, observation was made on the drought condition due to lack of rainfall andlack of irrigation facility so most of land found uncultivated, few vegetables are cultivated in some places where poor irrigation facility available even due to high temperature observed pests and disease problem, Because of drought condition there found stress of fodder, grasses for the livestock etc. All these observed informationwasnoted for study. Photographs of the area were taken to illustrate later.

3.6 Method of Data Analysis

Collected data were analysed both from logical and statistical method. Quantitative data were analysed through simple statistical tool like table, graph, pie chart, bar diagram and qualitative data were analysed through descriptive method.

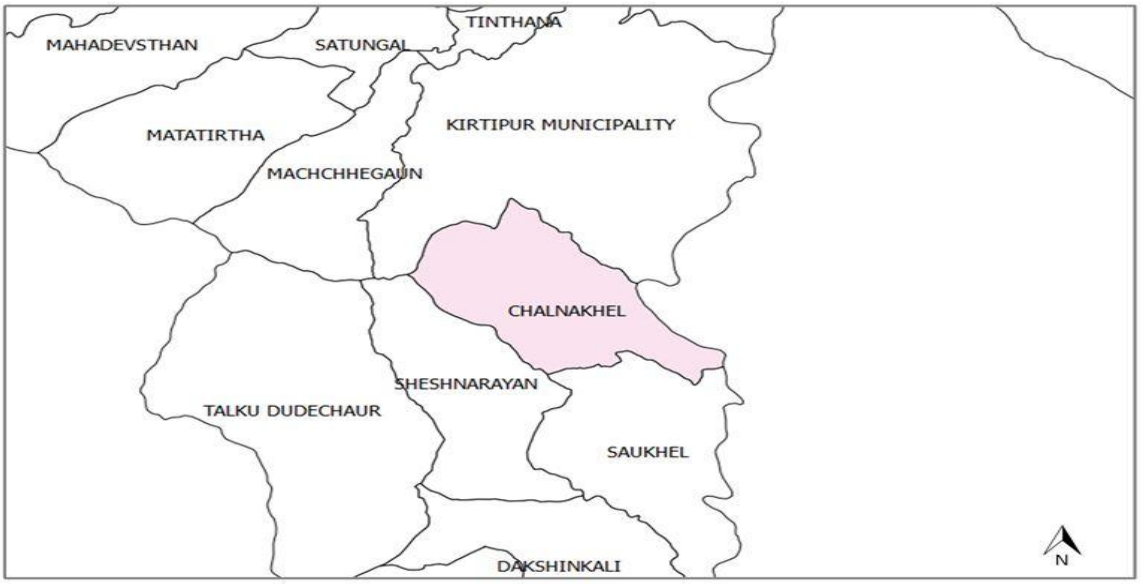
CHAPTER IV

INTRODUCTION OF STUDY AREA

The study area is Chalnakhel is a one of VDC of Kathmandu District, Bagmati Zone of Central Nepal. It is 9.5 km southwest of Kathmandu Valley. It is one of agricultural village of Kathmandu valley. Bagmati river is situated in East of this VDC and in the west there lies Machchhegaun, TalkuDudechaur VDC and in south there lies Kritipur where as in North-west there lies Seti Devi VDC and Sheshnarayan VDC . Total area ofthis Chanlakhel VDC is 5.70 sq. km, where 70 percent land is steep and percent land is plain. It lies in 85°16'12" longitude (length) and 27°38'24" latitude (width) .Total population of study area is 43,650 according to Population Census 2011 of Nepal. The study area is only 5.7km away from centre of Kathmandu, that means it is quite near and we have gone easily there for field data collection and house hold survey. It possess total 9 VDC. Total number of household of Chanlakhel is 1,005. But only ward no. 5 was choosed for detail study. Which include total population of 973 and 201 household. Out of which we take 60 households for our study. Now this VDC have became municipality in 2071 as Dakshinkali municipality. It includes total fifteen wards and total population 25743.So that previous ward no. 5 of Chanlakhel VDC became ward no. 2 of Dakshinkali municipality.

This VDC has sub-tropical type of climate. In summer season maximum temperature recorded of this VDC is 24℃ to 32℃ and in winter season minimum temperature reached 2 degree celsius to 0 degree celsius. Average annual rainfall of this VDC is about 1200 mm. About 80 percent out of total rainfall received by this VDC usually from Ashad to Ashwinbecause of effect of monsoon.

Figure:Map of study area:



4.1.Agriculture of the Study Area

The production of food, crops is the most climate-dependent activity. Changes in climate may impacts crop yields through changes in both temperature and moisture. As climate patterns shift, changes in the distribution of plant diseases and pests may also have adverse effects on agriculture.

About 75 percent people of this VDC depend on agriculture sector .It include paddy farming, vegetable farming, cash crop farming, fruit farming, livestock husbandry etc. Here farmers practice rice as main paddy in plain land called khet, also practice wheat, maize in little sloppy land called bari and fruits like orange,naspatti, lapsi,bhogatte in steepy land called pakho .Similarly cash crop includes different types of vegetables like mustard, soyabean, beans,potato, tomato, chilly, cucumber, pumpkin, spinach, radish, onion, garlic, coriander, cabbage, peas, cauliflower, brinjaletc. are practice in this VDC. And farmers reardifferent types of domestic animals like cow, goat, chickens, duck, pig etc. as one of mean of their livelihood as assistance occupation that help to increase their family income as well as for their subsistence. Income of this VDC from vegetables is about Rs.4,00,000, from paddy is about 6,00,000, from soyabeanis about 10,00,000, from fruits is about 5,00,000 and from livestock is about 10,00,000 according to VDC record.

4.2. Perception of Farmer aboutClimate Change

Local people of this study area observed that rainfall pattern distribution have been changed. It means rainfall doesn't occurred at time, no rainfall when need and heavy rainfall when it doesn't need. Also monsoon doesn't arrive when it is expected as it became more irregular. Also drought frequency is increasing resulting water stress, drying up of available water resources. Small farmers are mostly suffer from it, as they have less land to cultivate and depend on agriculture and they have no skill beside agriculture. To cope with rainfall deficit period some of farmer provide irrigation water in their farm even paying money. While farmer nearby river side provide irrigation water from the river to moist their farm because most of the farmers know irrigation is only way to cope with drought. People consume what they cultivate or farm in their land, e.g. rice, maize, potato, garlic, carrot, cucumber, radish, pumpkin, carrot, spinach, beans, peas, soyabean, mustard, cauliflower, cabbage etc. And buy those things from nearby market, what they can't grow in their farm. Some of farmers are using improved/hybrid seed to get more yield and to adapt in changing climatic condition .Also increasing temperature because of climate change may spread different disease and pests on their farm result in loss of their agricultural production if they don't care by using their local pesticides, consulting agricultural specialist.

Most of farmers keep livestock along with agriculture because fodder for their livestock also come from their agriculture as agricultural residue and also grasses too. So livestock husbandry s also affected by irregular rainfall, drought because it create scarcity of fodder of livestock and it make difficult to feed them. Also increasing temperature because of climate change also spread different communicable and non-communicable diseases on livestock which may loss of livestock. In this situation most of farmer go to vetnary hospital for treatment only few provide treatment to their livestock at home.

CHAPTER V

DATA ANALYSIS AND PRESENTATION

The collected data were analyzed using various methodologies.Data collected from questionnaire survey were analyzed through MS Excel to gather information about impact of climate change on agriculture, temperature and rainfall pattern, problem of pests and disease because of climate change, difficulties in farming due to climate changes, and adaptation method they have adopted to combat with it etc. Meteorological data were analyzed using Microsoft Excel.

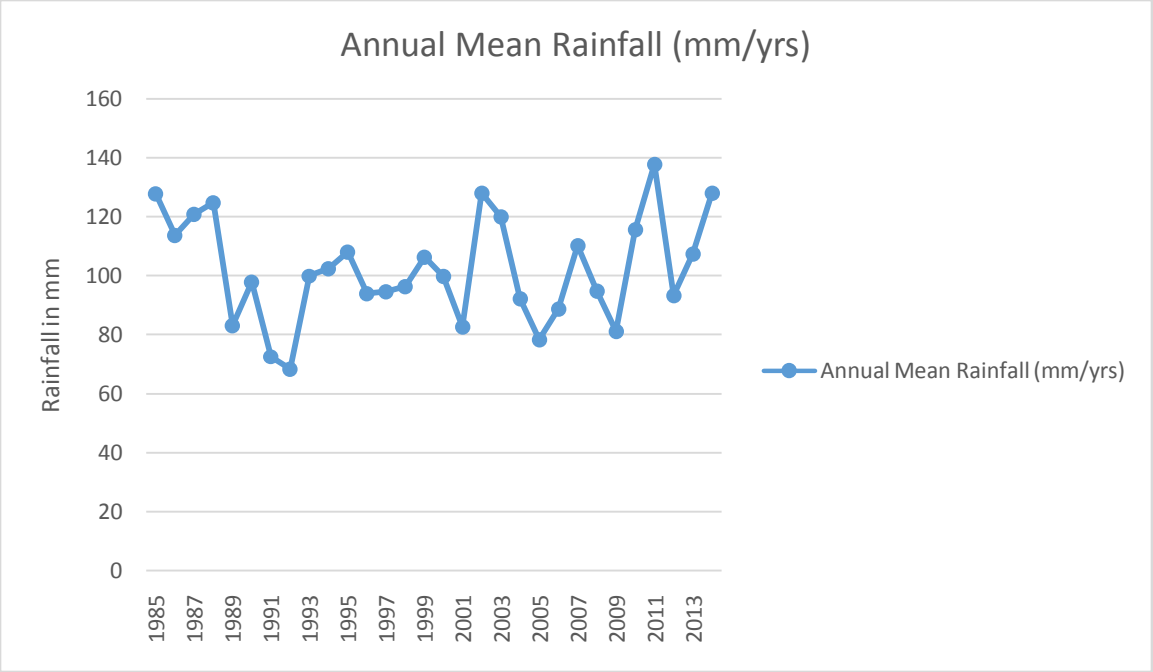
5.1. Rainfall of the Study Area

Rainfall is one of the most important source of water and water is very essentialfor all living organismincluding plants. Rainfall may have different pattern and intensity eg. low rainfall, heavy rainfall, fragmented rainfall. Also rainfall is the main source of water for agriculture in Nepal. Hence rainfall of place affect agriculture of that area very much.

5.1.1.Annual Mean Rainfall

Rainfall isthe most variable and least predictable agro climatic element.The amount and the distribution of the rainfall determines the cropping season and rainfall during the crop growing season is considered to be more beneficial than off season rain fall. Cropping or farming is very much sensitive to water stress so the rain fall distribution is considered to be more important than the season total.The basic agricultural water requirement includes water for soil preparation to start the crop and for its transpiration.

Fig: Annual Mean Rainfall (1985-2014):



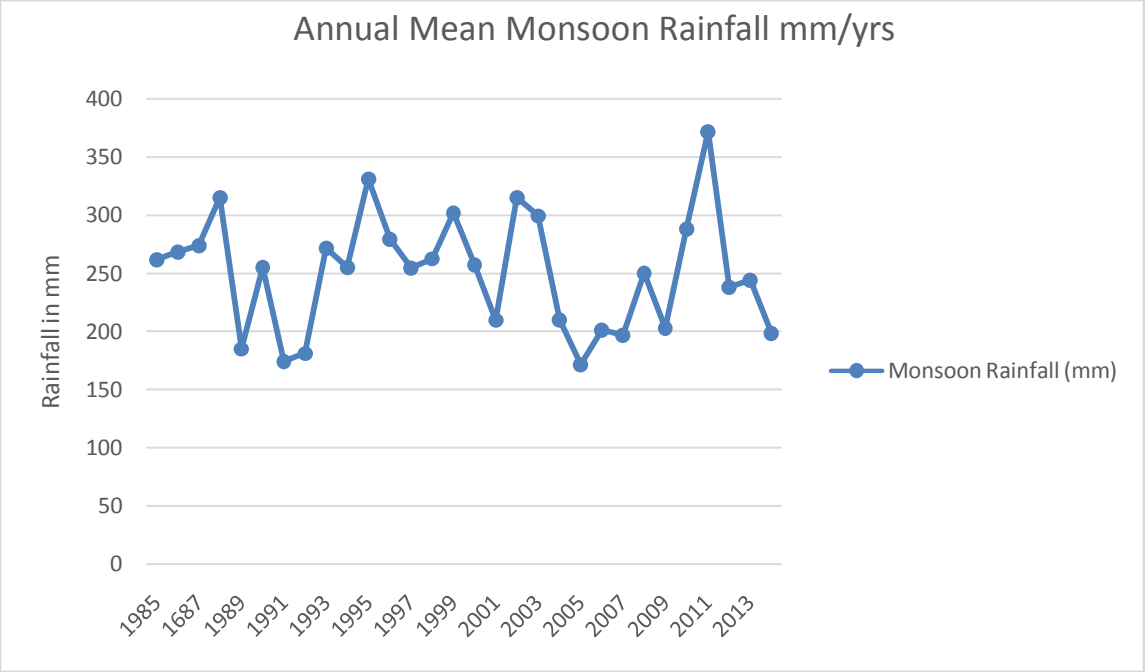
Source: DHM, Naghpokhari, Kathmandu, Nepal.

From above 30 years (1985-2014) data analysis annual average rainfall differ in each year. 137.758mm rainfall was recorded in 2011 which is the maximum rainfall as recorded in Khumaltar as nearest station to Chanlakhel. Minimum rainfall was recorded as 68.267mm in 1992. Annual mean rainfall of 1985 is 127.758 mm nearly equal to2014 that is 128mm. It shows that rain fall in the years 1989, 1991, 2001, 2005, 2009 is decreased these rainfall are 83.025, 72.5, 82.6, 78.358, 81.008mm respectively. So we can conclude that annual rainfall of the study area is not same, changing pattern of rain fall each year i.e. increasing and decreasing pattern.

5.1.2. Annual Mean Monsoon Rainfall

Annual Mean Monsoon Rainfall is mean rainfall of monsoon of the year. It can be obtained from nearby meteorological station. In monsoon rainfall intensity found generally high. So rice plantation heavily lies on monsoon as it require more quantity of water than other crops for high yielding.

Fig: Annual Mean Monsoon Rainfall (1985-2014):



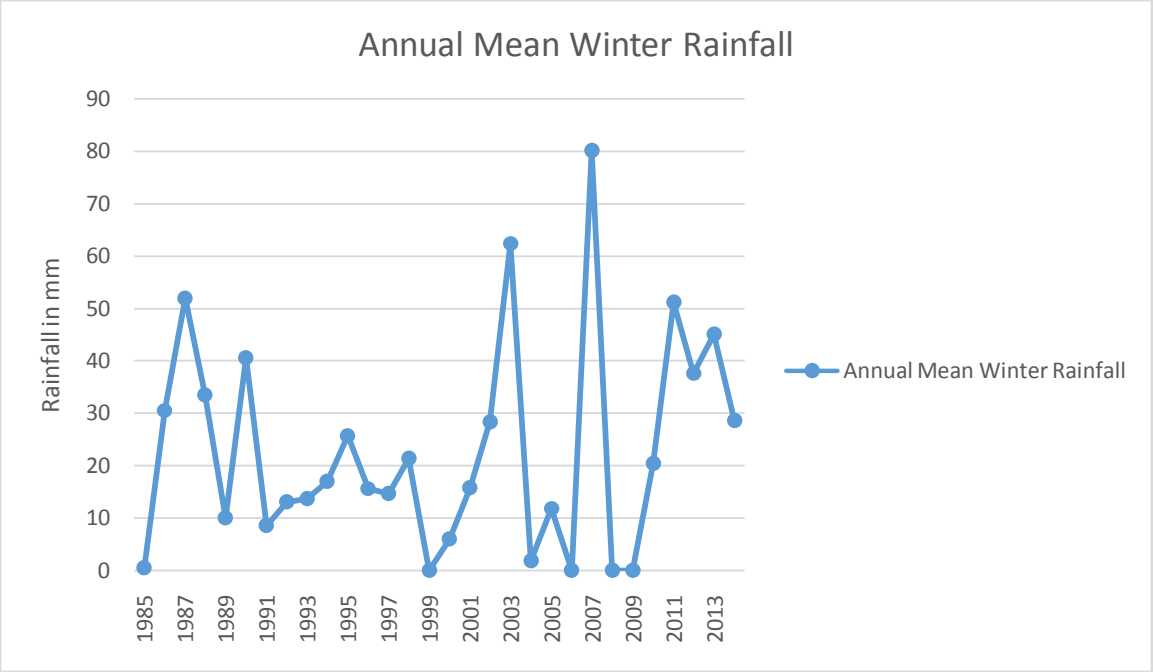
Source: DHM, Naghpokhari, Kathmandu Nepal.

Analysis of mean rainfall of monsoon season shows that maximum rainfall of monsoon was recorded in the year2011 is 371.967mm, and minimum rainfall of monsoon was recorded in the year 2005 is171mm.It show changing pattern of rainfall in eachyear, i.e. few year increase few year decrease. So the monsoon is shifting every year with decreasing annual mean monsoon rainfall. Which affect agriculture sector very much. Asfarmers of Nepal mainly depend on monsoon water for farming. So that shifting of monsoon rainfall means shifting of farming which affect agricultural produces that means reduce in agricultural produces.

5.1.3. Annual Mean Winter Rainfall

Annual mean winter rainfall is mean rainfall of winter of the year. It can be obtain fromnearby meteorological station. Intensity of winter rainfall is usually less even it is very important for agriculture.

Fig: Annual Mean Winter Rainfall (1985-2014):



Source: DHM, Naghpokhari, Kathmandu,Nepal.

Analysis of mean winter rainfall shows that maximum winter rainfall observed in the year 2007 is 80.2mm and minimum rainfall in the year1985 is 0.5mm.In the year 1999, 2006, 2008and 2009 there observed no rainfall but in the year 1987, 1990, 2003, 2011, and 2013 have rainfall slightly more in comparison to other years they are 52mm, 40.6, 62.4, 51.2, 45.1 respectively. It show that very little rainfall observed in most of winter season and zero rainfall in some winter. Winter rainfall also affect the agricultural sector very much.

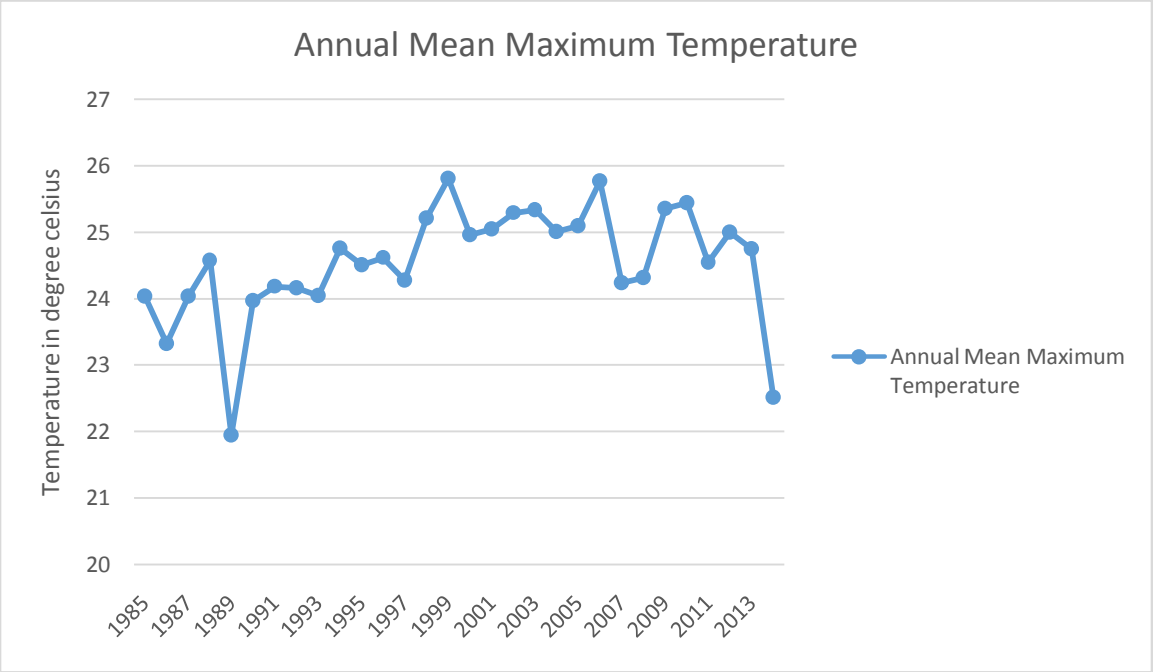
5.2. Temperature of the Study Area

Temperature is one of the important climatic parameter.Temperature is the main indicator of climate change. Maximum temperature and minimum temperature may also impact on agricultural system of any region. It is essential for plant growth. Hence temperature play important role in agricultural production. Temperature does not remain always same, it varies with time period. Both high and low temperature is not suitable for agricultural production. It require optimum temperature for high yield. Some crop require high temperature some require low and some require optimum temperature for high yield of production, as different crop species require different temperature for its growth and fruiting.

5.2.1.Annual Mean Maximum Temperature

Annual mean maximum temperature is mean maximum temperature of the year. Temperature of the study area is not same, there is change in maximum and minimum temperature each year. Analysis of maximum and minimum temperature data are analyzed as recorded from Khumaltar station, which is the nearest hydro-metrological station from study area.

Fig: Annual Mean Maximum Temperature (1985-2014):



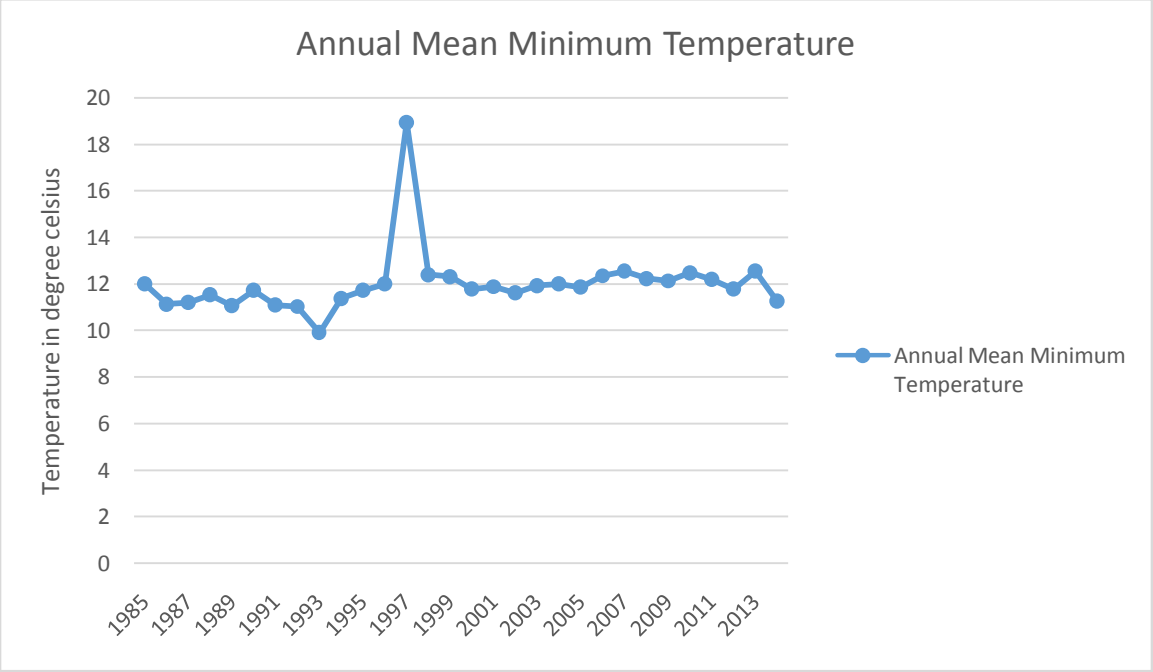
Source: DHM, Naghpokhari, Kathmandu, Nepal.

From above 30 years data (1985-2014) data analysis of maximum temperature, annual mean maximum temperature was25.808°C was recorded in 1999, whereas 25.767°C temperature was recorded in 2006. It shows that maximum temperature is increasing slightly to 2013 but slightly decreased in 2014 ie. 22.508°C.So increasing maximum temperature is not good for agriculture sector because all crops and livestock can't tolerate high temperature but it maybenefitable for some cropspecies.

5.2.2. Annual Mean Minimum Temperature

Annual mean minimum temperature is the mean minimum temperature of the year. It can be obtain from nearby meteorological station.

Fig: Annual Mean Minimum Temperature (1985-2014):



Source: DHM, Naghpokhari, Kathmandu, Nepal.

From the data analysis of 30 years, annual mean minimum temperature recorded in Khumaltar, shows18.95°C temperature was recorded in 1997 as the highest minimum temperature and other minimum temperature of other years found almost similar, not so different. The data show minimum temperature were slightly increased in the year1998, 1999 , 2006, 2007, 2008, 2009, 2010, 2011, 2013, they are 12.392, 12.308, 12.342, 12.55, 12.225, 12.12, 12.475, 12.183, 12.55 respectively.

5.3. Population

Population is the most important aspect of any research. Out of 9 wards of Chalnakhel, 60 household/respondents are taken randomly from same ward i.e. ward no. 5 for the study.

Table2: Population composition of respondent.

Sex	No. of Respondents	% of Respondents
Male	19	32
Female	41	68

Source: Field Survey 2016

Total number of respondents are 60. Male respondent participate were 19 i.e. 32 percent and female respondents participates were 41 i.e. 68 percent. That means female participate more than male. It show that male mostly engage in their daily duty, in agriculture or in service or in business etc. So women left in home.

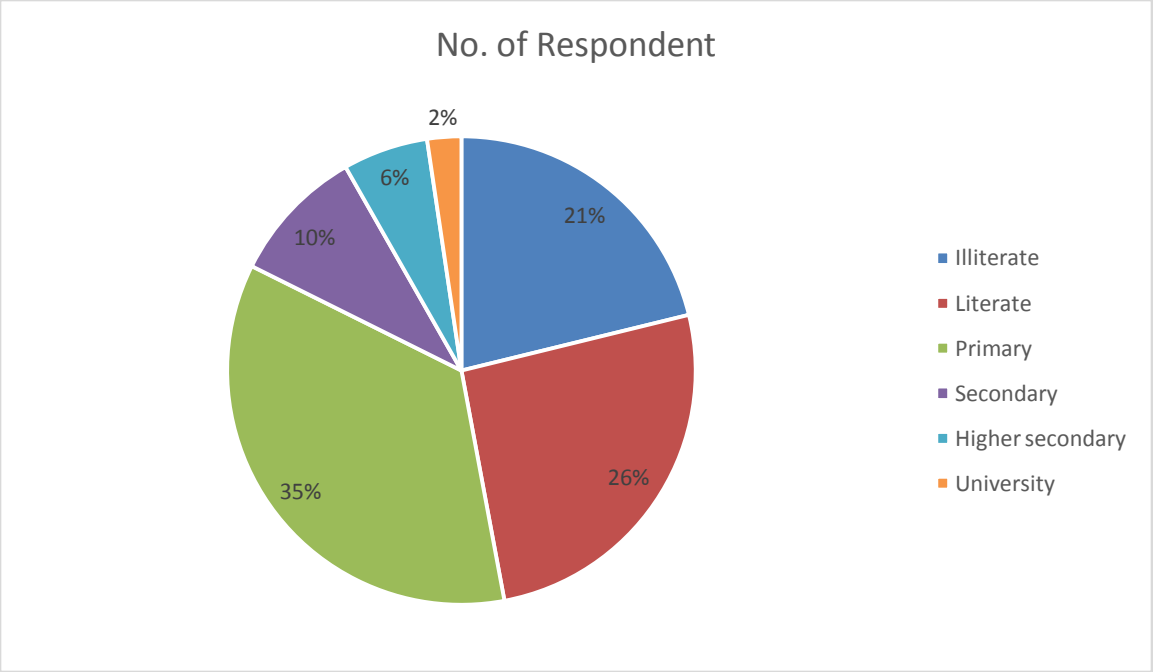
5.4. Education

Table 3: Education level of respondent.

Education level	No. of respondents	% of respondents
Illiterate	18	30
Literate	22	37
Primary	5	8
Secondary	8	13
Higher Secondary	5	8
University	2	3

Source: Field Survey 2016

From above table education level of this VDC is not good. Only 30 percent respondents were illiterate, 37 percent were literate, 8 percent respondents have attained primary level education only, and 13 percent respondents attained secondary level education, 8 percent respondents attained higher secondary level of education, only 3 percent respondent attained university level of education. That means well educated people are less in this study area out of 60 respondents. Even there are developed many schools, community school, primary school, and colleges. There develop different informal education system like praudsikshya through which 37 percent respondents became literate and they became able to write and read their names, sign, write letter etc. It can be also shown in pie chart below.



Source: Field Survey 2016

5.5. Occupation

Primary occupation of most of the respondent are agriculture. Respondents having primary occupationagriculture, 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 4: Occupation of respondent.

Main occupation	**No. of Respondents**	**% of Respondents**	**Assistance occupation**	**No. of Respondents**	**% of Respondents**
Agriculture	60	100	Livestock husbandry	42	70
			Business	6	10
			Service	12	20

Source: Field Survey 2016

Above table show 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 it

is not difficult for them because fodder are 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 10 percentrespondents involved in business and 20 percentrespondents involved in service.

5.6. Rainfall Pattern

As rainfall is one of most important fact for the agriculture and we know agriculture of Nepal is highly dependent on rainfall. Also rainfall is main source of water for agriculture ,in direcct form or deposited form eg pond,reservoir, well etc. If there is sufficient rainfall occured during cropping or planting period there need no irrigation facility. Hence rainfall pattern of the place affect agriculturel production very much.That means crop production depend on rainfall pattern of that place. So there is less irrigation facility.

5.6.1. Rainfall Pattern in Comparision to Past Years

As rainfall pattern do not remain same, it vary with changing time. Some time there may intense rainfall, low rainfall, untimely rainfall and some time rainfall pattern may remain same as usual.

Table 5: Rainfall pattern in comparison to pat year according to respondents.

Current rainfall pattern	**No. of HHs**	**%**
Intense rainfall	3	5
Low rainfall	35	58
Untimely rainfall	7	12
Same	15	25

Source: Field Survey 2016

Above table show rainfall pattern in comparision to past in which only 5 percent respondent have answered intense rainfall,58 percent respondent answered low rainfall,12 percentrespondents answered untimely rainfall and 25 percentrespondents answered rainfall pattern are same as usual.Hence most of respondents observed low rainfall in comparison to past years.

5.6.2. Effects of Irregular Rainfall Pattern in Agriculture

As we know rainfall pattern play key role in agriculture, also irregular rainfall pattern effect

agriculture differently. Irregular rainfall means rainfall doesn't occurred in timely, sometime it occurred before and sometime after. That means it doesn't occurred when required in field and occurred when it doesn't required. It may shift crop calendar of the farmer. Such type of untimely rainfall may affect agricultural field differently such as it may effect on cultivation, may drown ripped crops andalso waste of ripped crops when unnecessary rainfall occurred and may occurred irregularities in production some time less production due to spoil of ripped crops due to unnecessary rainfall.

Table 6: Effects of irregular rainfall pattern in agriculture according to respondents.

Effect of irregular rainfall pattern	**No. of HHs**	**%**
Effects on cultivation	38	63
Drown of ripped crops	1	2
Waste of ripped crops	4	7
Irregularities in production	17	28

Source: Field Survey 2016

From above table 63 percent respondents answered effect on cultivation, 2 percent respondents answered drowned of ripped crops, 7 percentrespondents answered waste of ripped crops and 28 percent respondents answered irregularities in production due to irregular rainfall pattern.

5.6.3. Problem in Agriculture Due to Less Rainfall

As we know water is very important for agriculture because without water on soil crops can't germinate and grow. In context of Nepal rainfall is main source of water for agriculture. Hence less rainfall negatively affect agriculture. Both excessive and less rainfall result reduced in agricultural produces. Less rainfall may create effect on cultivation, less production, dry out of water resources and effect on livestock by reducing its fodder.

Table 7: Problem in agriculture due to less rainfall.

Problem due to less rainfall	No. of HHs	%
Effect on cultivation	29	48
Less production	19	32
Dry up of water resources	5	8
Effect on livestock	7	12

Source: Field Survey 2016

From above table 48 percent respondents answered effect on cultivation, 32 percent respondents answered less production, 8 percent respondents answered dry up of water resources, and 12 percent respondents answered effect on livestock due to less rainfall. Hence most of respondents observed reduced in rainfall.

5.7. Irrigation Facility Availability and Its Condition

As irrigation is most important for agriculture. Irrigation means extra water supply required by crops and vegetables. Some time it is fulfill through rainfall if rainfall optimum and in timely.It is mosly important in that situation when rainfall is less and drought occurred.Without water agriculture is impossible as crops cann't germinate and grow.If water deficit in farm agricultural produces decrease and also reduce in fodder for livestocks which negatively affect livestock husbandry too. So irrigation water is very important for agriculture.

Table 8: Irrigation facility availability and its condition.

Irrigation facility	No. of HHs	%	condition	No. of HHs	%
Yes	23	38	Poor	48	80
No	37	62	Fair	12	20

Source: Field Survey 2016

Above table show availability of irrigation facility and their condition. Only 38 percent respondents have irrigation facility and 62 percent respondents have no irrigation facility. Even having irrigation facility they are in not good condition. 80 percent respondents have poor irrigation facility only 20 percent respondents have fair irrigation facility.

5.8. Condition of Temperature According to Respondent

Temperature is another very important fact for agriculture. Temperature may indicate air

temperature, soil temperature and water temperature and all type of temperature is very important for crop germination and growth. All of these temperature are driven by solar radiation. Soil temperature usually affects the nutrition of the crops and water temperature affects during the germination and seedling stage. Hence agriculture require optimum air, soil and water temperature for germination of seed, growth of plant and fruit bearing periodfor high yielding from agriculture.

5.8.1.Condition of Temperature in Comparison to Past

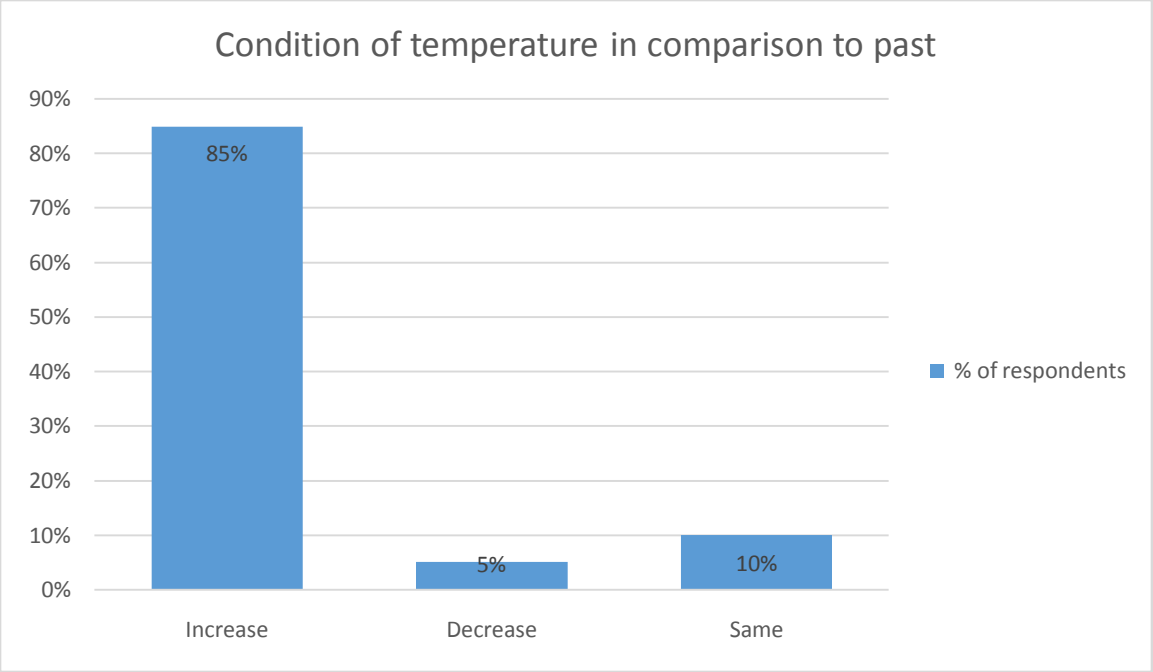
Temperature may not remain same for all time, it means it vary with time. So some year it may be increase where as in some year it may be decrease and may remain same in comparison to past year. Condition of temperature of the place differ with season and year. Hence condition of temperature of the place affect the agricultural production greatly

Table 9: condition of temperature in comparison to past.

Condition of temperature	**No. of HHs**	**%**
Increase	51	85
Decrease	3	5
Same	6	10

Source: Field Survey 2016

From above table 85 percent respondents answered increase in temperature, 5 percent respondents answered decrease in temperature and 10 percent respondents answered same temperature in comparison to past year. Hence most of the respondents observed increased in temperature than past year. It can be also show incolumn chart below,



Source: Field Survey 2016

5.8.2. Effect of Increasing Temperature on Agriculture

Higher air temperature in the ripening period causes the crop to ripen faster, as a result the carbohydrate in the plant steam and leaves cannot translocate properly, thus grain size becomes smaller and the yield becomes less. So crops require optimum air temperature. Crops can't tolerate high air, soil and water temperature. And high temperature produce several problems in agriculture such as shortening the time of reaping of crops, shortening the time of germination of seed, increase the number of pests and disease and other .

Table 10: Effect of increasing temperature on agriculture.

Effect of increasing temperature on farming	**No. of HHs**	**%**
Shortening the time of reaping of crops	26	43
Shortening the time of germination of seeds	11	18
Increase the no. of pests and	21	35

disease		
Others	2	3

Source: Field Survey 2016

From above table 43 percent respondents answered shortening the time of reaping of crops, 18 percent respondents answered shortening the time of germination of seed, 35 percentrespondents answered increase the number of pests and disease, and 3 percent respondents answered other. Hence most of respondents observed rising temperature negatively affect farming.

5.9. Spread of Pests and Diseases inAgriculture in Comparison to Past

Disease and pests destroy crops and vegetables. So it require pesticides to cure it. Pesticides may be local pesticides, which is environment friendly, it means it does not possess side effect to human health and environment. Another is chemical pesticides, which affect environment and human health negatively. If any kinds of pests and diseases are not controlled in time it will destroy whole crops of farm. Temperature is one fact that help in spread of pests and disease, also high temperature help in rapid multiplication in number of these pests and disease.

Table 11: Spread of pests and diseases in agriculture in comparison to past

Spread of new pests and disease	**No. of HHs**	**%**
Yes	49	82
No	11	18

Source: Field Survey 2016

From above table 82 percent respondents answered spread of diseases and pests and 18percentrespondents answered no disease and pests appeared in their farm in comparison to past years. Hence most of respondents observed spread of new pests and disease on their farm than past year. Pests observed in study area by respondents are Lai Kira (Aphid), Khumle Kira, Caterpillar, birds, mouse etc. and disease observed are root, stem and shoot rot, black powder on young fruit (loose smut), appearance of tuber on root of spinach, cauliflower etc. in their farm, necrosis of leaves of vegetables etc. on their field in comparison to last year. It result in reduced in agricultural production. Hence most of respondents observed spread of new pests and disease in comparison to past year.

5.10. Different Disease in Livestock Because of Climate Change

Climate change enhance increase in temperature and increasing temperature help in spread of different diseases in livestock such as diarrhoea, dysentery, cholera , typhoid, khoret, malaria, cold cough, different types of parasites like liver flue, tapeworm etc. If these disease are not cure in time, it result in loss of several livestock.

Table 12: Different diseases in livestock because of climate change.

Disease in livestock	**No. of HHs**	**%**
Yes	57	95
No	3	5

Source: Field Survey 2016

From above table 95 percent respondents answered appearance of different disease in their livestock and only 5 percent respondents answered not appeared of diseases in their livestock because of climate change. Hence most of respondents observed appearance of disease in livestock because of climate change. According to VDC profileonly few farmers provide treatment to their livestock in their home and most of farmers take sick livestock to the vetnary hospital for treatment.

5.11. Change in Yield of Agricultural Production Because of Climate Change

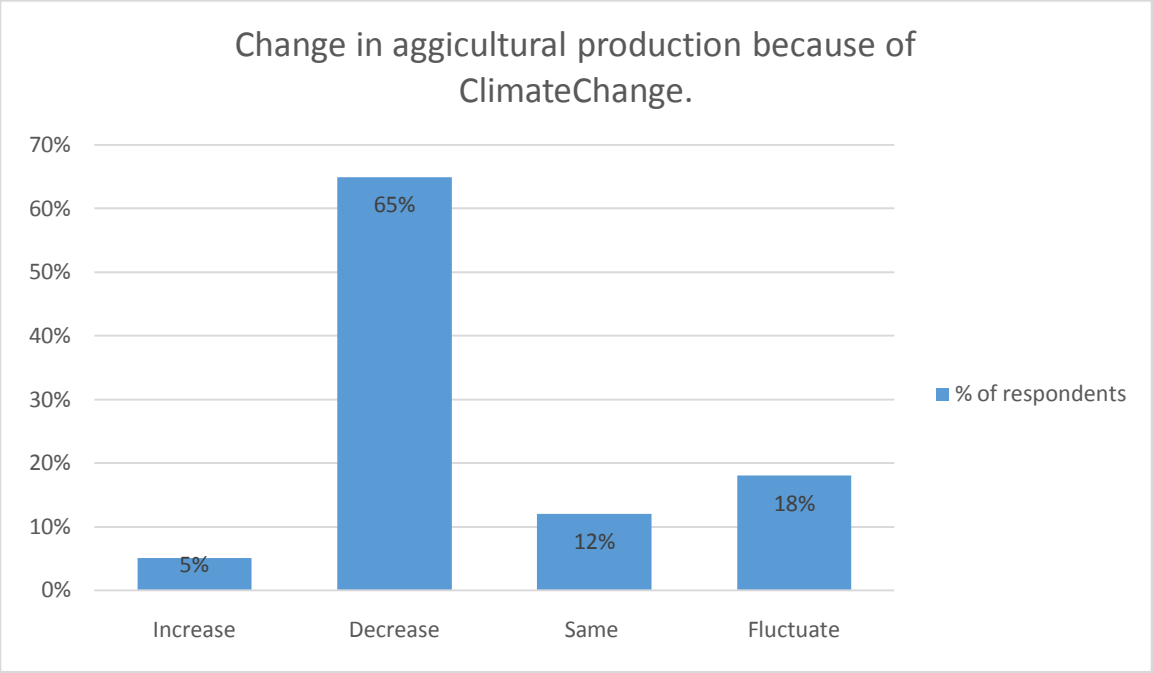
Climate change may result in increase in temperature, reduce in temperature, change in rainfall pattern, catastrophic rainfall, drought etc. All of these facts largely affect agricultural production because climate determine crop yield. So Suitable climate is required for high agricultural production. Climate change may result in increase or decrease in agricultural production may result same or may fluctuate agricultural production.

Table 13: Change in yield of agricultural production because of climate change.

Change in agricultural production due to cc	**No. of HHs**	**%**
Increase	3	5
Decrease	39	65
Same	7	12
Fluctuate	11	18

Source: Field Survey 2016

From above table 5 percent respondents answered increase, 65 percentrespondents answered decreased, 12 percent respondents answered same, and 18 percent respondents answered fluctuate in agriculture production due to climate change. Hence most of respondents observed decrease in agricultural production because of climate change. It can be also show by chart below,



Source: Field Survey 2016

5.12.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 are also other adaptation technique adopted by farmer to minimize impact of climate change. These are providing irrigation water, 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 14: Adaptation technique adopted by local farmers to minimize impact of climate change.

Adaptation techniques	**No. of HHs**	**%**
Reforestation	11	18
Crop rotation	8	13
Mix cropping	12	20
Providing irrigation water	9	15
Use of local pesticides	5	8
Use of organic fertilizer and livestock's manure	15	25

Source: Field Survey 2016

From above table 18 percent respondents involved in reforestation, 13 percent respondents involved in crop rotation,20 percent respondents involved in mix cropping, 15 percent respondents involved in providing irrigation water,8 percent respondents involved in use of local pesticides and 25 percent respondents involved in use of organic and livestock's manure as adaptation technique to minimize impact of climate change.

CHAPTER VI

SUMMARY, CONCLUSION AND RECOMMENDATION

6.1. Summary

Climate change is burning issue of the world. All nations of the world have been affected from this issue. So it also affect the agriculture sector as it depend on nature.Less developed countries are more affected by climate change than developed countries because of low capacity to cope with and adapt in but DCs have developed many advanced technology through which they can take benefit even from such changing climate.

The analysis indicates continuous rising temperate, low intensity of rainfall, drought etc. These allare result of climate change. From rainfall record, rainfall pattern found fluctuated, altered, delayed monsoon, irregular duration of rainfall etc. Winter season rainfall is also delay and slight decreased. Temperature rising pattern is also increasing. Lifecycle of plants, behaviour regarding to flowering, shedding and germination of seed are shortening, maturation time of fruits and crops also indicates the pattern of increasing temperature.

The production and productivity of agricultural product have been decreasing because of less rainfall. There observed lack of irrigation facilitywhich make farmers unable to cultivate in time. Scarcity of grass and fodder from farm and pasture land resulting in decreased number of livestock. Because of the lack of adequate fodder, livestock pattern has been changed. People are replacing those animals which consume large amount of grass by that animal consuming less fodder and other alternative by which they gain comparative benefit. Different diseases have been spread out on livestock. Which decreased benefit from livestock husbandry.

Changing climate create problem in farmer's life, even they are using different local adaptation technique, which are not sufficient. So farmer are facing many problems on their occupation on which they are depending. So people are changing their profession slowly from agriculture and livestock farming to easy sector business, service, labourer and foreign employment. People are

made to change their traditional occupation, because of low productivity, reduction of fodder, grazing land.

6.2. 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. LDCs are more affected from climate change than DCs because they have less adaptation techniques and mitigation capacity to cope with it. LDCs are less responsible for GHGs emission than DCs. Nepal contribute negligible percent of GHGs, that is about 0.025% of global GHG emission. Even that Nepal is more vulnerable to climate change. So Nepalese farmers are experiencing different problems from increasing temperature and changing rainfall pattern, like shifting of crop calendar, scarcity of irrigation water, spread of pests and diseases on agriculture sector, drought, decreased agricultural production etc. Thus decreased agricultural production may create food insecurity problem in the country.

Livestock husbandryis also affected from climate change. People kept only few livestock as grazing area have been reduced and difficulty in availability of grasses, fodder because of drought induced by climate change. Hence livestock pattern has been changed. Those livestock which require more fodder is replaced by other livestock which require less fodder. For eg. cows, buffalos are replaced by goats, pigs, hens, ducks etc. So income from livestock is decreasing too. Hence we can conclude that human activities accelerating climate change and global warming, so human being should try to reduce such activity which accelerate GHGs emission as possible.

6.3. Recommendation

In this study following recommendation have been made on the basis of the findings.so this recommendation may be useful for future researcher, local farmers and policy maker.

i. Awareness program that aware people about climate change, its cause and consequences.

ii.To get improved agricultural production there need to develop improved irrigation facility to combat drought problem.

iii. Need to develop heat resistant, drought resistant varieties and breeds.

iv. Water is most important for agriculture, so rainwater harvest program should be promoted. So that harvested water can be used in the farm when there is water stress.

v. Discourage in use of harmful chemical pesticides, herbicides and encourage to use local pesticides and safe agro-chemical to minimize pests and disease problem.

vi. To reduce uncertainty on livestock husbandry, encourage livestock insurance policy which may helpful for farmer.

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ANNEX I: QUESTIONNAIRE

PERSONAL PROFILE:

General information:

a. Name: b.Address:
c. Age: d. Sex:
e. Education: f.No. of family member:
g. Occupation: Main: Assistance:

1. How much of land do you have?

a.1 to 2ropanib.3 to 5ropani

c. 5 to 10ropanid. More than 10ropani
And of what types,
a. Khet b. Bari c. Both d. Pakho

2. Which types of livestock do you have?

a. Cow b. Goat

c. Buffalo d. Chickens

Why do you kept them for,

a. Subsistence b. Commercial

3. Is there irrigation facility?

a. Yes b. No

If yes, then how is that?

a. Poor b. Fair

c. Good d. Very good

4. Do you feel any changes in climatic condition in comparison to previous years? a. Irregular precipitation pattern b. Rise in temperature c. Both d. None

5. How is the current rainfall pattern in comparison to past years? a. Intense rainfall b. Low rainfall c. Untimely rainfall d. Same

6. How is the present condition of start of monsoon? a. Early (how much)? b. Late (how much)? c.Fluctuate d. Same

7. What is the present condition of duration of monsoon? a. Long (how much)? b. Short (how much)? c. Fluctuate d. Same

8. How is the present condition of winter rainfall? a. Early (how much)? b. Late (how much)?

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

10. What kinds of problems have been observed from less rainfall?
a. Effects on cultivationb. Less production c. Dry up of water resource d. Effects on Livestock

11. What Kind of effects has been observed due to excessive rainfall? a. Flood b. Landslide c. Drowned d. Other

12. What kind of change in temperature in comparison to last year's? a. Increase in temperature b. Decrease in temperature c. Same as previous e. Fluctuate

13. What kind of effects on crops has been observed from increasing temperature? a. Shortening the time of reaping of crops b. Increase the number of insects and diseases
c. Shorten the time of germinating seeds

14. How are the days of winter in comparison to past? a. Hotter b. Warmer
c. Colder d. Same

15. Have you noticed any change in agriculture production pattern? a. Yes b. No

16. If any changes observed in duration fromplanting to harvesting days?
a. Shortened b. Lengthened

c. Same

17. Is there observedspread of any new pest?
a. Yes b. No18.Is there observedspread of new diseases?a. Yes b. No If yes, what are they?

19. Do you feel any change inyield of produces because of climate change?
a. Increased b. Decreased c. Same d. Fluctuate

20. Is quality of agricultural produces changed? a. Yes b. No

21. Is land preparation method
a. Same b. Changed

22. Isquantity of fertilizer a. Increased b. Decreased c. Same

23. What kind of affects you are facing on livestock after reduction of production of fodder and grasses? a. Reduce in number livestock b. Increase in livestock c. Same as previous

24. What kinds of diseases have been appeared on livestock with increasing temperature?
……

25. What are the adaptation techniques you have adopted to minimize the impact of CC?

Annex II

Check Lists for Key Informant Interview (KII):

1. Amount of land he/she has
2. Amount and types of livestock
3. Monsoon shifted or same
4.Amount of rainfall decreasing or increasing
5.Catastrophic rainfall or fragmented rainfall
6.Days are becoming hot or cold
7.Winter are becoming warm than past years
8.Drought observes in farms
9.Problems of irrigation
10.Causes for introduction of endemic diseases and pests
11.Increasing temperature makes livestock hard to adapt
12.Mitigation measure adopted by farmers with changing climatic condition
13.Obstacles to increase agricultural production
14. Any types of changes in farming pattern because 0f cc
15. Agricultural produces increases or decreases due to cc

Latitude (deg/min): 2740

Longitude (deg/min): 8520

Elevation (m): 1350

Rainfall (mm) for KHUMALTAR

Year	Jan	Feb	Mar	Apr	May	Jun	JUL	AUG	SEP	OCT	NOV	DEC
1985	9.0	0.5	4.0	35.4	121.5	136.6	356.3	292.8	327.0	182.5	0.0	67.5
1986	0.0	30.5	19.3	105.5	106.7	266.5	303.4	234.8	203.5	44.7	0.0	49.7
1987	19.4	52.0	28.8	36.7	35.8	108.4	503.2	210.2	149.1	288.6	0.0	17.0
1988	2.0	33.5	73.5	53.5	133.2	266.6	350.0	328.5	120.0	9.0	21.0	106.0
1989	58.5	10.0	4.0	0.0	217.0	61.5	357.0	136.0	149.5	2.8	0.0	0.0
1990	0.0	40.6	61.3	60.8	81.1	103.5	396.9	264.5	111.0	48.8	0.0	5.4
1991	18.2	8.6	39.6	60.6	90.1	153.3	137.4	231.9	107.4	0.6	0.0	22.3

1992	14.6	13.1	0.0	43.0	72.6	163.9	206.0	173.1	86.9	42.8	15.6	2.2
1993	13.6	13.7	33.0	71.6	68.4	207.4	310.3	296.9	149.3	32.8	1.4	0.0
1994	29.2	17.0	13.2	6.1	144.8	301.6	180.9	283.0	244.6	0.0	6.8	0.2
1995	3.6	25.7	37.1	0.1	72.8	456.3	245.0	291.7	76.8	23.0	56.9	7.2
1996	59.5	15.6	7.2	11.1	40.2	343.5	274.8	219.5	106.7	47.8	0.0	0.0
1997	20.0	14.7	14.2	124.4	85.6	205.1	305.7	253.2	9.5	18.3	4.8	79.2
1998	0.0	21.4	67.1	42.6	117.4	193.5	292.1	302.0	50.8	59.8	8.6	0.0
1999	2.4	0.0	0.0	5.4	94.5	224.7	421.2	260.1	153.6	113.2	0.0	0.0
2000	1.0	6.0	23.6	80.9	162.5	222.0	241.1	309.3	147.4	1.8	0.0	0.4
2001	5.0	15.8	11.4	41.4	130.9	164.0	247.5	217.3	131.3	26.6	0.0	0.0
2002	35.5	28.4	73.6	108.2	176.5	108.7	436.2	400.6	153.2	10.4	4.0	0.0
2003	19.8	62.4	52.6	60.2	60.0	196.5	398.6	303.4	237.6	27.5	0.0	21.8
2004	23.7	1.8	DNA	69.9	203.1	115.1	391.8	122.9	108.0	60.2	8.5	0.0
2007	0.0	80.2	46.0	49.8	91.8	149.5	246.1	194.2	409.2	41.2	14.0	0.0
2008	0.0	0.0	40.3	59.6	119.8	184.6	239.4	326.8	161.2	4.4	0.0	0.0
2009	0.0	0.0	25.8	5.0	139.7	40.0	260.9	307.4	113.6	74.9	1.2	3.6
2010	2.4	20.4	5.2	100.8	84.8	315.4	233.2	316.2	249.8	53.0	6.2	0.0
2011	7.0	51.2	7.2	87.4	151.2	410.0	329.4	376.5	210.0	17.0	6.2	0.0
2012	15.6	37.6	11.6	61.7	77.8	139.2	362.2	212.6	199.1	0.2	0.8	0.0
2013	12.4	45.1	32.8	39.8	197.0	242.0	223.0	267.5	134.0	94.4	0.0	0.0
2014	2.5	28.6	44.8	2.6	119.5	93.2	264.7	236.6	112.2	610.3	0.0	21.0
2008	0.0	0.0	40.3	59.6	119.8	184.6	239.4	326.8	161.2	4.4	0.0	0.0
2009	0.0	0.0	25.8	5.0	139.7	40.0	260.9	307.4	113.6	74.9	1.2	3.6
2010	2.4	20.4	5.2	100.8	84.8	315.4	233.2	316.2	249.8	53.0	6.2	0.0
2011	7.0	51.2	7.2	87.4	151.2	410.0	329.4	376.5	210.0	17.0	6.2	0.0
2012	15.6	37.6	11.6	61.7	77.8	139.2	362.2	212.6	199.1	0.2	0.8	0.0
2013	12.4	45.1	32.8	39.8	197.0	242.0	223.0	267.5	134.0	94.4	0.0	0.0
2014	2.5	28.6	44.8	2.6	119.5	93.2	264.7	236.6	112.2	610.3	0.0	21.0

Temperature (°C), Khumaltar:

1985 KHUMALTAR		
MONTH	Tmax(øC)	Tmin(øC)
Jan	17.0	1.3
Feb	19.4	4.3
Mar	26.4	9.8
Apr	28.1	12.4
May	27.1	15.3
Jun	28.2	18.2
Jul	25.9	19.6
Aug	27.8	19.7
Sep	25.6	18.0
Oct	22.9	14.0
Nov	21.1	7.1
Dec	18.9	4.2

1986 KHUMALTAR		
MONTH	Tmax(øC)	Tmin(øC)
Jan	17.6	2.0
Feb	18.4	2.9
Mar	23.0	6.6
Apr	24.8	11.0
May	25.7	13.5
Jun	28.0	18.9
Jul	26.5	20.0
Aug	27.4	19.8
Sep	25.4	17.9
Oct	23.8	12.0
Nov	21.2	7.2
Dec	18.0	1.7

1987 KHUMALTAR		
MONTH	Tmax(øC)	Tmin(øC)
Jan	17.8	0.3
Feb	19.4	4.7
Mar	21.9	7.0
Apr	26.5	10.3
May	28.0	13.3
Jun	28.0	18.8
Jul	26.8	19.9
Aug	26.3	19.4
Sep	26.4	18.8
Oct	24.8	12.4
Nov	22.5	6.5
Dec	20.0	2.9

1988 KHUMALTAR		
MONTH	Tmax(øC)	Tmin(øC)
Jan	18.2	1.4
Feb	20.9	5.0
Mar	22.3	7.1
Apr	27.2	10.6
May	27.4	15.5
Jun	28.0	18.7
Jul	27.2	19.9
Aug	26.8	19.6
Sep	27.2	17.6
Oct	26.0	13.5
Nov	23.2	5.8
Dec	20.5	3.7

1989 KHUMALTAR		
MONTH	Tmax(øC)	Tmin(øC)
Jan	15.8	1.8
Feb	19.1	1.6
Mar	24.2	6.0
Apr	28.8	9.9
May	28.4	15.0
Jun	28.3	18.8
Jul	26.3	19.4
Aug	27.2	19.2
Sep	26.4	18.2
Oct	26.5	15.1
Nov	21.8	6.0
Dec	18.9	1.8

1990 KHUMALTAR		
MONTH	Tmax(øC)	Tmin(øC)
Jan	19.7	2.5
Feb	18.6	4.8
Mar	20.2	6.8
Apr	25.2	9.9
May	26.3	15.1
Jun	28.6	19.8
Jul	26.6	20.3
Aug	27.4	20.1
Sep	26.9	18.8
Oct	24.8	13.2
Nov	23.5	6.9
Dec	19.8	2.5

1991 KHUMALTAR

MONTH	Tmax(øC)	Tmin(øC)
Jan	16.9	1.4
Feb	21.1	2.9
Mar	23.8	7.2
Apr	25.9	9.8
May	28.1	14.6
Jun	27.2	19.0
Jul	27.6	20.4
Aug	26.9	20.0
Sep	26.9	18.4
Oct	25.9	12.5
Nov	21.5	4.9
Dec	18.4	1.9

1992 KHUMALTAR

MONTH	Tmax(øC)	Tmin(øC)
Jan	17.3	3.2
Feb	17.3	2.6
Mar	25.9	6.5
Apr	28.7	10.1
May	26.4	13.8
Jun	28.7	18.0
Jul	27.1	19.5
Aug	26.9	19.7
Sep	26.9	18.0
Oct	24.8	12.8
Nov	21.8	6.1
Dec	18.1	1.9

1993 KHUMALTAR

MONTH	Tmax(øC)	Tmin(øC)
Jan	17.0	2.1
Feb	20.4	4.5
Mar	22.4	5.2
Apr	25.4	10.5
May	27.0	15.2
Jun	27.9	18.9
Jul	27.5	20.3
Aug	26.7	20.3
Sep	26.2	17.9
Oct	25.6	13.5
Nov	22.4	7.7
Dec	20.0	3.0

1994 KHUMALTAR

MONTH	Tmax(øC)	Tmin(øC)
Jan	18.9	1.8
Feb	18.8	2.7
Mar	23.7	8.4
Apr	27.0	9.9
May	28.3	15.2
Jun	28.6	19.8
Jul	28.1	20.4
Aug	28.2	20.1
Sep	27.4	18.6
Oct	26.0	11.7
Nov	22.7	6.3
Dec	19.4	1.6

1995 KHUMALTAR

MONTH	Tmax(øC)	Tmin(øC)
Jan	16.5	0.7
Feb	18.8	3.6
Mar	23.5	6.7
Apr	27.9	9.2
May	30.3	15.8
Jun	27.7	20.4
Jul	27.2	20.3
Aug	27.5	20.0
Sep	27.1	18.7
Oct	26.1	13.2
Nov	22.8	7.9
Dec	18.7	4.1

1996 KHUMALTAR

MONTH	Tmax(øC)	Tmin(øC)
Jan	17.6	1.8
Feb	19.8	4.0
Mar	24.7	9.0
Apr	27.6	9.7
May	29.7	15.0
Jun	27.1	18.9
Jul	27.0	20.3
Aug	27.0	19.8
Sep	26.9	18.5
Oct	25.0	13.6
Nov	23.3	7.7
Dec	20.0	2.4

1997 KHUMALTAR		
MONTH	Tmax(øC)	Tmin(øC)
Jan	16.8	1.3
Feb	18.1	2.4
Mar	24.3	6.9
Apr	23.8	10.6
May	28.1	13.5
Jun	29.6	17.8
Jul	28.5	20.6
Aug	28.5	20.2
Sep	27.2	18.2
Oct	25.4	10.3
Nov	22.7	6.8
Dec	18.3	3.4

1998 KHUMALTAR		
MONTH	Tmax(øC)	Tmin(øC)
Jan	18.2	1.1
Feb	20.3	3.9
Mar	22.2	7.1
Apr	26.6	10.9
May	28.2	16.6
Jun	30.2	19.8
Jul	27.6	20.8
Aug	27.4	20.5
Sep	27.9	19.2
Oct	27.4	16.0
Nov	25.0	9.4
Dec	21.5	3.4

1999 KHUMALTAR		
MONTH	Tmax(øC)	Tmin(øC)
Jan	19.6	0.9
Feb	23.9	5.4
Mar	26.9	6.8
Apr	30.8	12.3
May	28.4	16.9
Jun	28.4	18.9
Jul	27.2	20.3
Aug	27.3	20.1
Sep	27.4	19.2
Oct	25.2	14.5
Nov	23.7	7.9
Dec	20.9	4.5

2000 KHUMALTAR		
MONTH	Tmax(øC)	Tmin(ø
Jan	19.1	1.4
Feb	19.9	2.4
Mar	23.4	6.2
Apr	27.9	11.3
May	28.4	17.0
Jun	27.9	20.1
Jul	27.7	20.5
Aug	27.4	20.3
Sep	26.7	18.3
Oct	26.7	13.0
Nov	23.9	8.5
Dec	20.5	2.2

2001 KHUMALTAR		
MONTH	Tmax(øC)	Tmin(øC)
Jan	18.7	1.2
Feb	21.6	3.8
Mar	23.8	6.6
Apr	27.2	10.2
May	27.1	16.3
Jun	27.9	19.7
Jul	27.9	20.8
Aug	28.2	20.4
Sep	27.0	18.8
Oct	26.7	14.4
Nov	24.5	7.9
Dec	19.9	2.4

2002 KHUMALTAR		
MONTH	Tmax(øC)	Tmin(ø)
Jan	18.5	2.0
Feb	21.3	4.3
Mar	23.8	7.8
Apr	26.7	10.7
May	28.3	15.6
Jun	29.1	18.8
Jul	28.6	20.2
Aug	28.6	19.8
Sep	27.6	17.6
Oct	26.6	12.7
Nov	24.0	6.9
Dec	20.4	3.0

2003 KHUMALTAR MONTH Tmax(øC) Tmin(øC)	2004 KHUMALTAR MONTH Tmax(øC) Tmin(øC)	2005 KHUMALTAR MONTH Tmax(øC) Tmin(øC)
Jan 18.9 0.8	Jan 18.0 2.1	Jan 17.6 3.2
Feb 19.7 4.3	Feb 20.3 4.0	Feb 20.1 4.5
Mar 22.9 7.7	Mar 26.9 8.8	Mar 24.8 8.5
Apr 27.6 11.8	Apr 27.5 12.5	Apr 27.4 10.1
May 29.2 13.7	May 28.5 15.7	May 28.4 13.9
Jun 29.9 18.3	Jun 28.5 18.7	Jun 29.7 18.0
Jul 29.1 20.2	Jul 27.6 19.9	Jul 28.0 20.5
Aug 28.8 20.4	Aug 28.4 20.6	Aug 27.8 20.6
Sep 28.1 19.3	Sep 27.7 19.1	Sep 28.6 19.4
Oct 27.1 14.3	Oct 25.3 12.7	Oct 26.2 13.5
Nov 23.7 8.6	Nov 22.1 6.6	Nov 22.5 7.5
Dec 19.0 3.7	Dec 19.3 3.2	Dec 20.0 2.5

2006KHUMALTAR MONTH Tmax(øC) Tmin(øC)	2007KHUMALTAR MONTH Tmax(øC) Tmin(øC)	2008KHUMALTAR MONTH Tmax(øC) Tmin(øC)
Jan 20.41.0	Jan 18.0 2.0	Jan 17.5 2.5
Feb 23.77.7	Feb 17.95.6	Feb 18.72.6
Mar 25.4 7.7	Mar 22.38.4	Mar 23.68.8
Apr 27.511.3	Apr 27.3 12.9	Apr 27.011.3
May 28.416.3	May 29.016.2	May 27.3 15.0
Jun 29.6 18.9	Jun 28.119.4	Jun 27.819.2
Jul 29.0 20.9	Jul 27.2 20.3	Jul 27.1 20.1
Aug 28.8 20.1	Aug 27.5 20.5	Aug 28.3 20.3
Sep 27.5 18.6	Sep 26.719.1	Sep 27.4 18.6
Oct 26.7 13.3	Oct 25.814.9	Oct 25.613.1
Nov 22.98.4	Nov 22.18.2	Nov 21.99.4
Dec 19.33.9	Dec 18.93.1	Dec 19.65.8

2009 KHUMALTAR		
MONTH	Tmax(øC)	Tmin(øC)
Jan	19.7	2.9
Feb	23.0	4.6
Mar	24.8	7.2
Apr	28.6	12.6
May	28.2	15.4
Jun	29.4	18.7
Jul	28.6	20.6
Aug	27.8	20.4
Sep	27.7	18.4
Oct	25.5	13.8
Nov	22.3	7.3
Dec	18.7	4.4

2010 KHUMALTAR		
MONTH	Tmax(øC)	Tmin(øC)
Jan	19.9	2.5
Feb	20.4	3.8
Mar	26.7	9.7
Apr	29.8	12.5
May	28.7	16.5
Jun	29.8	19.1
Jul	27.9	20.2
Aug	27.5	20.2
Sep	26.4	18.8
Oct	25.8	14.8
Nov	23.1	9.5
Dec	19.3	2.1

2011 KHUMALTAR		
MONTH	Tmax(øC)	Tmin(øC)
Jan	17.3	1.5
Feb	20.6	4.6
Mar	25.1	8.0
Apr	26.4	11.0
May	27.5	16.1
Jun	28.5	19.1
Jul	27.5	20.5
Aug	27.9	20.2
Sep	27.1	19.1
Oct	26.1	13.7
Nov	21.5	8.8
Dec	19.0	3.6

2012 KHUMALTAR		
MONTH	Tmax(øC)	Tmin(øC)
Jan	16.6	1.9
Feb	20.4	4.0
Mar	24.2	7.4
Apr	27.0	11.9
May	29.5	15.1
Jun	30.4	20.2
Jul	27.8	20.6
Aug	28.1	20.3
Sep	27.9	19.1
Oct	25.9	12.0
Nov	22.5	5.6
Dec	19.7	3.1

2013 KHUMALTAR		
MONTH	Tmax(øC)	Tmin(øC)
Jan	18.2	0.9
Feb	20.5	5.5
Mar	25.2	9.4
Apr	27.2	11.7
May	28.1	16.8
Jun	28.0	20.2
Jul	27.7	20.7
Aug	28.0	20.1
Sep	27.8	18.7
Oct	24.9	15.6
Nov	22.4	7.1
Dec	19.0	3.9

2014 KHUMALTAR		
MONTH	Tmax(øC)	Tmin(øC)
Jan	18.5	2.9
Feb	19.9	4.7
Mar	23.4	8.2
Apr	27.6	11.4
May	28.6	15.9
Jun	29.6	20.4
Jul	28.5	21.2
Aug	28.2	20.7
Sep	27.1	19.1
Oct	25.5	13.3
Nov	22.6	9.1
Dec	19.2	4.0