STUDY ON WHEAT FARMER'S PERCEPTION AND ADAPTATION MEASURES UNDER CLIMATE CHANGE AND VULNERABILITY CONTEXT OF BARDIYA DISTRICT

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APPROVAL SHEET

This research report entitled **"Study on Wheat Farmer's Perception and Adaptation Measures Under Climate Change and Vulnerability Context of Bardiya District"** prepared and submitted by **Mr. Sandeep Chapagain,** in the fulfillment of the requirements of the Undergraduate Practicum Assessment for the Bachelor of Science in Agriculture, is hereby accepted.

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DEDICATED TO
MY BELOVED PARENTS

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ACRONYMS AND ABBREVIATIONS

AIACC	Assessment of Impacts and Adaptation to Climate Change
ANOVA	Analysis of Variance
@	At the Rate
CBS	Central Bureau of Statistics
CC	Climate Change
CO2	Carbon dioxide
^{0}C	Degree Celsius
DFID	Department for International Development (UK)
DHM	Department of Hydrology and Meteorology
Fig	Figure
FYM	Farm Yard Manure
GDP	Gross Domestic Product
GHG	Green Houses Gas
GoN	Government of Nepal
Ha	Hectare
HDI	Human Development Index
HH	Household
INGO	International Non-governmental Organization
IPCC	Intergovernmental Panel on Climate Change
Mm	Millimeter
MOAD	Ministry of Agriculture Development
MoEST	Ministry of Environment, Science and Technology
MoPE	Ministry of Population and Environment
NAPA	National Adaptation Program of Action to Climate Change
NGO	Non-governmental Organization
%	Percentage
Temp	Temperature
SAFBIN	Small Scale Farming in Rain-fed Area in Bangladesh, India and Nepal
UNEP	United Nations Environmental Program
UNFCCC	United Nations Framework Convention on Climate Change
VDC	Village Development Committee
WMO	World Meteorological Organization

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ABSTRACT

This study was carried out in Motipur and Kalika VDCs of Bardiya district aiming to analyse the wheat farmer's perception and adaptation measures under climate change and vulnerability context. Structured questionnaire for household survey of 80 households and semi-structured questionnaire for conducting five FGD and KIS were developed and administered in Caritas-SAFBIN supported households as well as not supported household. Perception analysis, trend analysis, and regression analysis were undertaken by using SPSS version 16 for the tabulated data.

Perception analysis on various climatic factors in relationship to wheat cultivation revealed that wheat growers perceived increasing temperature level, fluctuating but decreased winter rainfall (intensity and frequency), increased drought length period, late and short duration monsoon, and increasing pest incidence in last decades than that past. These factors were directly and indirectly associated to hampering physiological stages of wheat and tending yield reduction. These perceptions were triangulated by using secondary data analysis of Bardiya district, which showed: 0.064^{0}C, 0.014^{0}C and 0.039^{0}C increase in maximum temperature, minimum temperature and average annual temperature per year, respectively in past 27-year. Precipitation showed decreasing trend with 3.21mm annual rainfall and 1.89mm winter rainfall associated with erratic pattern. Statistically significant negative correlation (-0.455) was found between productivity of wheat and average rainfall of growing season of wheat. There was no statistically significant correlation with minimum temperature and maximum temperature of the wheat growing season. It indicates that there is no effect in wheat production with an increase or decrease in maximum temperature and minimum temperature. In order to response these climactic changes in the study sites, farmers were: changing sowing date, using improved wheat varieties, applying chemical fertilizer and using pest management practices on wheat.

Key words: Adaptation, drought, perception, response, trend, and vulnerability

CHAPTER 1- INTRODUCTION

1.1 Background

Climate change is an issue of concern for Nepal as over two million Nepalese people depends upon climate sensitive sectors like agriculture and forestry for their livelihood (Garg, Sukla and Kapse 2007). Climate variability is an important aspect of the risks of crop production. Most of the climate change scenarios include more intense and more variable precipitation events. Such changes in precipitation may have significant impacts on agricultural systems. Precipitation changes not just have the direct impacts on plant growth but also an important indirect impact resulting from potential changes in soil erosion (Doering et al. 2002). Least developing countries like Nepal are most susceptible to climate change and its impacts due to their limited capacity to cope with hazards associated with the changes in climate (Kates 2000). However, the contribution of agricultural sector to the national economy is challenged by its vulnerability to climate change. Climate change is a phenomenon due to emission of greenhouse gases from fuel combustion, deforestation, urbanization and industrialization resulting variation in solar energy, temperature and precipitation (Upreti 1999).

Wheat is the third major crop after rice and maize in Nepal. The crop contributes 16% in total cereal production in the country after rice (56%) and Maize (24%)(MoAD 2008). Presently, wheat is cultivated in 76, 7499 hectares of land and the production was 1745811 mt in the year 2010/2011 with the average yield 2275 kg/ha (MoAD 2011). The productivity of wheat in Nepal is one of the lowest in South Asia. There are several problems in wheat cultivation in the country. Since wheat is farmed mostly in rain-fed land, lack of timely rainfall and lack of adequate amount of rainfall has been a major concern and it is found to affect wheat yield significantly. The wheat is grown during winter (November/December to March/April) in Terai. During this period about 2 to 5 percent (less than 100 mm, more precisely 30-90 mm) of seasonal rainfall occurs in the Terai. Annual mean temperature is 15^0c to 30^0c during the growing period of wheat in Terai (Nayava., et.al 2008). These winter rains are very irregular and erratic in nature. In Nepal, 70 to 90% of rainfall occurs in the summer monsoon and the rest of the months are almost dry. Distribution of winter rainfall is more in the Western Terai than in the Eastern

Terai. Meteorological data of the past decades also indicate that there is decreasing rainfall trend in winter. That is decrease in total rainfall as well as number of rainy days in winter.
According to IPCC summary report (2007), eleven of the last twelve years (1995-2006) since 1850 rank among the twelve warmest years in the instrumental record of global surface temperature. The increasing temperature, unusual rainfall, extreme climatic events, drought, flooding, increased snow melting rate and sea level rise are threatening the livelihood of human and all other living creatures on the earth. Vulnerability is the degree to which a system is likely to experience harm due to its exposure to hazards (Tunner II 2003).

IPCC (2007) defines vulnerability of a system as “a function of the character, magnitude and the rate of climate variation to which a system is exposed.” In disaster planning, vulnerability is the social, economic and environmental exposure and sensitivity. Rural livelihood is at risk as many natural systems are being affected by regional climate and elevating temperature (IPCC 2007). Predictions on climate change indicates that climate change has its widespread implications on agriculture, water resources, fisheries, forestry, human health, ecosystem as well as social, economic and political systems making climate much complex global issue of social , economic and political dimension (Reilly 2001).

The share of Nepal in total emission is not so high as compared to other developed countries. However, Nepal is likely to be affected highly. So it has to focus in adaptation. Adaptation is all processes through which societies make themselves better able to cope with an uncertain future. Adapting to climate change entails ,making the right measures to reduce the negative effects of climate change (also exploiting the positive ones) by making the appropriate adjustment in natural and human systems to a new or changing environment (Dow and Downing 2006). Adaptive capacity is the ability to understand climate change 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 (ibid). Mitigating the impacts of climate change and variability is not as significant for the countries like Nepal as we lack appropriate sophisticated technologies to cope with those impacts. Thus, for Nepal, to minimize the possible impacts of climate change, adaptation is the only option left. As a least developed country with a very less contribution to GHGs emission, Nepal has to focus more on adaptation approach rather than controlling emission (Smith and Wandela 2006). Appropriate adaptation technologies must be developed making the best use of community's traditional and local knowledge to cope the effects of climate change. Economic diversification can also be an important adaptation strategy for the developing countries to reduce the dependence on climate sensitive resources (UNFCCC 2007). Adaptation to climate change may include many measures. AIACC has given some general recommendations to adapt to climate change as (1)create conditions to enable adaptation, (2)integrate adaptation with development, (3)increase awareness and knowledge, (4)protect natural resources etc. Sustainable organic agriculture can help to reduce the risk of drought, irregular rainfall events with floods, rising temperatures and soil erosion and increase the productivity of agro-ecosystems.

1.2 Statement of problem

Agriculture country Nepal has faced climate change effect since a decade (MoE 2014). There are few studies on climate change perception, impacts, vulnerability and adaptation at the national level. Those include the studies done by Ministry of Environment, Adapt Nepal, PEEDA/Better Nepal, studies done by NAPA, etc. Although few national level study and reports have been published on community vulnerability and impacts of climate change and climate variability, local level studies are very sporadic in spite of the accepted fact that the micro-level community vulnerability and adaptation assessment is more relevant than the mega-scale in a least developed country like Nepal which has a high diversity in natural as well as human system within a very short spatial variations. Thus local level study is to be focused. Climate change is considered to be a problematic issue for many countries impacting various sectors.

As Nepal is an agro-economic country and as its agriculture system is totally dependent on climatic factors, the change in climatic pattern obviously impacts the whole agricultural production and phonology. There is no any study about crop wise perception, impact, adaptation measures and vulnerability context in local levels. Farmers are adopting knowingly or unknowingly by using local traditional knowledge. To adopt disease, pest and weed infestation they don't have new idea and technology. The impacts may also be the loss of certain important indigenous crops, loss in productivity and cultivable land. As Nepal's arable land are almost rain fed, it is sensitive to drought and extreme precipitation too. Also, as a least developed country, our agricultural system is almost traditional as we don't have much access to technical agricultural system. It is the only reason that farmers of Nepal often goes under agricultural losses due to climatic extremes. Thus, in this scenario, adaptation is the best option. Thus local level case studies are vital both for policy formulation and adoption, to stir local people's knowledge on present day's most challenging issue. In this context, study on adaptation has great significance. Climate change has been experienced in Nepal and people have already confronted its effects on agriculture water resources, forest, /biodiversity, buildings and other infrastructure and natural disasters. People have already started adopting various adaptation measures to cope with the effects of climate change and variability on these sectors. Thus, It is important to study whether the adaptation measures undertaken are heading toward positive direction or not. If it has positive impacts, we should learn from their coping strategies and use them as important adaptation measures to cope with the effects of climate change and variability on different sectors and the results can be replicated in different parts of the country. However, studies on those aspects are limited and are not understood well.

1.3. Objectives

The general objective of this study is to know about wheat farmers' perception, adaptation measures under climate change and vulnerability context in Bardiya district. Following are the specific objectives identifying at Caritas-SABIN area:

i) Documenting special differences on climate change vulnerabilities really happening at the project location

ii) Measure community perceptions on climate change before and after project intervention

iii) Mapping climate change adaptation measures taken by the communities along with project level interventions and coordination.

1.4 Scope and limitation of Study

There is very limited understanding about the perception, impacts, adaptation measures of climate change and vulnerability contexts in these rain-fed drought areas of Nepal. In context of Nepal evidence is the major challenge for fighting with impact of climate change diverse microclimatic and geophysical conditions within small areas. So, the best way to measure the impact of climate change would be conduct researches on community and household level studies yield information and adaptation measures and provide basis for development of strategies to fight climate change locally. This research seeks to investigate wheat farmer's perception and impact of climate change in wheat farming and adaptation measures, adopted about perception, local knowledge by the local people in the rain-fed terai area of Nepal.

The research area is purposively selected at rain-fed Terai region. Due to unavailability of researched areas hydro-meteorological data nearest meteorological data from Ranijharuwa nursery data was used to analysis so the data couldn't be considered in weather parameters. VDC label data wasn't sufficient for proper analysis so it was collected from whole district. The study was conducted in two VDCs with limited amount of funds. This study alone cannot generate complete idea about climate change, its impact and adaptation measures in whole Bardia district. It only provides general information about specific region. More intensive researches should be conducted to generalize the whole Terai region of Nepal.

CHAPTER 2: LITERATURE REVIEW

This chapter deals review of the past work done on different economic aspects of production of rice inside and outside of the country that are relevant to this study.

2.1 The global and regional perspective on climate change

UNFCCC (2001) defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere" thus climate change refers to the variation in the earth's global or regional climates over time. Climate change is the consequence of both natural and human systems. Global temperature is increasing by 0.3°C to 0.6°Csince the last 19th century and 0.2°c to 0.3°c over the last 40 years (1960-2000) indicating that the global temperature will increase further in the upcoming days (Xiaodong & Baode 2000). According to IPCC synthesis report (2007), there has been an unprecedented warming trend during the 20th century. The current average global surface temperature of 15°C is increasing nearly by 0.6°C per 100 year which is higher than it was 100-year ago. The most of the increases have been consequences of human activity. Also a further increase of 1.5°C to 6°C is projected for the period up to 2100.

Water resource ranks significantly higher than other sector because this sector is directly related to rising temperatures resulting in faster glacier melts and increased GLOF events, increased intense precipitation events resulting in more floods, landslides and sedimentation, greater unreliability of dry season flows etc (Agrawala et al. 2003). The projected climate change will reduce the stream flow and ground water recharge. It is reported that the developing countries are more susceptible to climate change impacts as they have limited capacity to adapt. IPCC (2007) reported more intense and longer droughts since the 1970s, particularly in the tropics and subtropics. Similarly, the frequency of heavy precipitation events has also increased over most land areas during the same period. (IPCC 2007d) projected longer drought periods may cause more land degradation, lower agricultural yields, crop damage/failure, increased livestock deaths, increase risk of wildfire, more widespread water stresses.

Nepal demonstrates diverse geo-physical and climatic condition within relatively small areas resulting vast biological diversity, therefore, it is an ideal place to study climate change impacts on natural and socio-economic spheres. They have depicted the mean temperature to increase by 1.2°C and 3°C by 2050 and 2100, respectively. It has been observed such as increase in dry period, intense rainfall, flood; landslides, forest fires, glacial retreats and GLOF threats (Shrestha & Wake 2000). The mean surface temperature has increase in the range of 0.3°C to 0.8°C over the past 100 years is Asia including Nepal (IPCC 2006). Shrestha et al. (1999) reported the temperature increase of 0.06°C to 0.12°C per year in most of the middle mountain and Himalayan regions, while the Siwalik and Terai regions shows warming trends of less than 0.03°C/yr from 1971-1994. The scenario of the global climate change in the fragile mountains of Nepal and around is greater and widespread. The general circulation models show the mean annual temperature to increase by an average of 1.2°C by 2030, 1.7°C by 2050 and 3°C by 2100 compared to a pre-2000 baseline. A recent study that used general and regional circulation models project the mean annual temperature to by 1.4°C by 2030, 2.8°C by 2060 and 4.7°C by 2090.The projections show higher temperature increments during winter as compared to the monsoon seasons. Higher increment in temperature is projected over western and central Nepal as compared to eastern Nepal for the years 2030, 2060 and 2090, with projections for western Nepal being greatest. Similar trends are projected for the frequency of hot days and nights for 2060 and 2090 (MOE 2010).

Analysis of trends in daily climatic extremes of temperature and precipitation in Nepal shows a general increasing trend in temperature extremes. The trend is of relatively higher magnitude in mountainous region. Days and nights both are becoming warmer and cool days and cool nights are becoming less frequent. The precipitation extremes show increasing trend in total and heavy precipitation events at most of the stations. (Baidya et.al, 2008) Initial National Communication reports that there is an increasing trend in monsoon precipitation despite a decreasing trend in number of rainy days and increasing trend in more intense precipitation events (MOPE 2004; Chaulagain 2007; Nayava 2004; and Chaulagain 2003). Such an increased trend in intense precipitation events may result in increasing magnitude and frequency of landslide and flood events. Precipitation projections show up to 5-10% increase in eastern Nepal during winter whereas no changes are shown for western Nepal. During the summer months, precipitation is projected to increase for the whole country in the range of 15 to 20 %. Further, the projections indicate an increase in the intensity of rainfall and a decrease in winter precipitation (MOE 2010). The year 2006 and 2009 are reported to be the driest years in terms of rainfall during winter. Based on the readily available data from 35 meteorological stations in Nepal, Although Nepal's contribution to GHG emissions is very less, it is the country where its impacts are very high (Chalise 1994).

2.2 Climate change vulnerability and adaptation

Vulnerability is a term that describes the susceptibility of a group to the impact of hazards. It is the degree to which a system is likely to experiences harm due to its exposure to hazard. It is determined by the capacity of a system to anticipate, cope with, resist and recover from the impact of hazard. In context of climate change, O"Brian et al. (2004) classifies vulnerability as "end-point" and "starting point" interpretation of vulnerability. The end point interpretation mainly focuses on climate change mitigation and compensation policy and technical adaptation. While, starting point interpretation focuses on vulnerability of society to climatic hazards, adaptation policy and sustainable development of societies. Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes.

The least developed countries are among the most vulnerable to extreme weather events and the adverse effects of climate change. Also, these countries have a very least capacity to cope with and adapt to adverse effects of climate change. Projections and predictions indicate that developing countries will have to suffer 75% to 80% of the global climate change related damages (World Bank, 2010). High level of poverty and dense population make the South Asia region more vulnerable to climate change. Crop yields could increase up to 20% in east and Southeast Asia while they could decrease up to 30% in central and south Asia by the mid-21st century. Taken together and considering the influence of rapid population growth and urbanization, the risk of hunger is projected to remain high in several developing (IPCC 2007).

According to IPCC, vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed; its sensitivity; and adaptive capacity (IPCC 2001). Exposure, sensitivity, and adaptive capacity are the three term function of vulnerability. Regmi et al (2008) state that the poor and marginalized people are more vulnerable to impact of climate change as they are heavily depended upon natural resources, lack access to technology, information and infrastructure. Mirza (2003) studied vulnerability of communities to floods in Bangladesh and concluded that vulnerability to extreme climatic hazards increases due to unemployment, high population density, illiteracy, widespread poverty, enormous pressure upon rural land and economy dominated by agriculture. Sensitivity is basically the biophysical effect of climate change; but sensitivity can be altered by socio-economic changes. For example, new crop varieties could be either more or less sensitive to climate change.

The vulnerability of rural communities can be reduced through effective governance over natural resources (Cleaver and Schreiber 1994), as part of the NAPA process, a series of climate change vulnerability assessments at the district level were conducted. The sensitive sectors are agriculture, forestry, water and energy, health, urban and infrastructure, tourism industry and overall livelihoods and economy. The analysis shows that Nepal is highly vulnerable to climate change. The analysis also suggests that more than 1.9 million people are highly vulnerable and millions are increasingly at risk, with climate change likely to increase this number significantly in future. Most of the people living in the mid and far western regions are amongst the most vulnerable, a situation closely correlated with the poverty rates in those areas, the heavy reliance on small scale agriculture is increasingly at risk from more erratic rainfall patterns and their lack of basic services and alternative livelihood options (MOE 2010). The small and medium rain-fed farmers were highly vulnerable to climate change and to a larger extent the small and medium rain-fed farmers adopted coping mechanisms for climate change compared to large farmers.

Adaptive capacity refers to the potential or capability of a system to adjust to climate change, including climate variability and extremes, so as to moderate potential damages, to take advantage of opportunities, or to cope with consequences (Smit and Pilifosova 2001). As the name suggests, adaptive capacity is the capability of a system to adapt to impacts of climate change. Smit et al., 2001, have identified the following seven factors that determine adaptive capacity are: wealth technology, education, institutions, information, infrastructure, and social capital.

The capacity to adapt to climate hazards and stresses depends on a country's wealth, resource and governance (Kates 2000). 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. Adaptation strategy can be of various types viz. shifting natural resources management practices and agricultural practices, building institutions and strengthening communities, raising awareness about climate change and possible ways to adapt, development of new technology and better infrastructure etc. (Hedger et al., 2008). The adaptation measures are aimed at reducing vulnerability of people to climate change and necessary care should be taken that these measures do not have detrimental effect upon the vulnerability (Hedger et al., 2008). The adaptation programs and policies should be designed as such that they will address cross sectoral issues of poverty alleviation, bio-diversity and ecosystem services conservation, reduction of land degradation and soil erosion and increase food security enabling achievement of sustainable development at various scales (FAO 2008). Policies and plans like National Adaptation Plans of Action are regarded as anticipatory adaptation measures (Bohle 2001 and Burton et al. 2003).

2.3 Climate change and Nepalese agriculture

The crop yields have strong association with the amount of rain it receives on right time. Thus crop and livestock production are highly dependent on climate and the Nepalese farms and farming systems are very vulnerable to climate change (MOPE, 2004). The pattern of precipitation has been noticed fluctuated for the past 30 years in Nepal (Shrestha et al 2000). Initial National Communication (INC) of Nepal to the UNFCCC reports that Nepal is already facing water shortages during dry seasons despite the availability of enough annual surface runoff (MOPE, 2004). Local communities from Nawalparasi shared their experiences on change in the climate in the recent years. About 95% people mentioned drought and erratic rainfall patterns as the main indicators of that change. The increase in temperature and availability of irrigation water are negatively related. Research finding shown that, if the temperature would increase by 1^0c the effectiveness of the irrigation is decreased by 10% (Pradhan 2007). Early Maturity of the crops due to increase in temperature may help in destruction of existing cropping pattern. Shifting of climatic zones has been observed in the country. Extinction of local basmati rice varieties, some local wheat, maize and other agricultural crops was also observed. Research study showed that Nepal had the highest level of agricultural productivity in South Asia in the early 1960s, but, its agricultural productivity was the lowest in the Subcontinent by the early 1990s (Tiwari 2002). The destruction of land by floods and landslides, and subsequent declining land productivity, compels people to occupy forest areas, cultivate steeper land and look for alternative means of living (Gurung and Bhandari 2008). Nepal's National Assessment Report for the World Summit on Sustainable Development (2002) recognizes the link between climatic circumstances and land degradation, erosion and landslides: "in a nutshell, 'too much water' and 'too little water' is responsible for land degradation in different land uses in Nepal. Thus, the problem of too little water is going to be intensified due to climate change.

The impacts of climate change on crop yields, which impacts economic well being of the country, are attempted and shown for different crop types (MOPE 2004). Any deviations from the required optimum air temperature and humidity conditions of crops, negative effects will be observed though in some cases, the yields would even increase by 81 to 21% but further change would imply not increased production but reduced nutrient content as shown by some studies (ibid). In terms of agriculture food security, local communities have identified changes in climate as being largely responsible for declining crop and livestock production. Nepal's vulnerable subsistence farming economy is facing risk due to changes in the reliability of stream flow, more intense and erratic monsoon, rainfall and the impacts of flooding. Decline in rainfall from November to April adversely affects the winter and spring crops. Rice yields are particularly sensitive to climatic conditions and these may fall in western region where a larger population of the poor live and this could threaten overall food security (DFID 2009).

Assessments also show that climate change is posing a threat to food security due to loss of local land races and crops (Regmi & Adhikary 2007). Due to uncertainties in climatic behavior, there is always uncertainty in production and it keeps on fluctuating. 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). Increase in temperature result in a reduced growing season and a decline in productivity, particularly in South Asia (Pachauri 1992).

Eastern Terai faced rain deficit in the year 2005/06 by early monsoon and crop production reduced by 12.5% on national basis. Nearly 10% of agri-land were left fallow due to rain deficit but mid western Terai faced heavy rain with floods, which reduced production by 30% in the year (Regmi 2007). Early Maturity of the crops due to increase in temperature may help to have more crops in the same crop cycle (NARC annual report). 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 was also observed. Cold wave in Nepal in 1997/98 had 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 % in potato, toria, sarson, mustard, lentil and chickpea respectively (NARC 2001).

A few efforts have been made to mitigate and adapt climate change impacts in agriculture sector. These include research on flood and drought tolerant varieties of crops, adoption of reduced tillage practices and agro-forestry, promotion of zero energy storage structures, gravity ripe ways, plastic house farming, solar driers, ovens, micro-and drip irrigation, rainwater harvesting ponds; improved water management; crop rotation and diversification; discouraging slash and burn practices; development of early warning system etc. Several farmers are already involved or are taking keen interest on green technology including commercial establishments. Some areas with easy availability of fertilizers and pesticides have also turned back to organic farming which has been popularized by hotels and different environment concerned groups. A few examples are the commercial farming at Thali and Kavresthali and experimental farming at Champi which are adopting organic farming at commercial level (Sharma 2010). Decline in agriculture sectors not only impact food supply but also bring adverse effect on industrial service and health sectors. Improvement of agriculture production can hence be a major input in climate change adaptation measures in Nepal where more than 3 million 21 people are facing hunger and malnourishment. A simplified calculation carried out by an economist indicate that one percent increase in agriculture yield results in the reduction of the population below poverty line by 17 percent (Pyakurel 2009). Organic agriculture could support both GHG emissions reduction as well as the development of resilient farming systems for adaptation (Khanal 2009).

2.4 Climate change and wheat production

Wheat is the first important crop in world and third in Nepal. It occupies 20% of total cereal area and contributes 18.8% of the total cereal production in the country. It is desirable that the minimum and maximum temperature during the wheat growing period should be 3^0C to 32^0C respectively and the mean daily temperature for optimum growth is between 20^0C and 20^0C (Briggle 1980). Assessment made by the Ministry of Agriculture and Co-operatives, WFP, and FAO shows that the production of wheat and barley fell down by 14% and 17%, respectively.

The report also indicated that situations were worst in western Nepal where food production dropped by almost 50% in 2009 and wheat production was adversely affected (WFP 2009). For higher yields, water requirements are 350-500 mm depending on climate and length of growing period in Nepal. It has been mentioned that depending upon the availability of water, irrigation in wheat crop is recommended at the crown root initiation stage (25- 30 days after sowing), at the heading stage and at the grain filling stage (NARC 1997).There should be adequate water during the establishment period. Water deficit during the grain filling period results in reduced grain weight, unlike it rainfall or irrigation destroy both quality and yield during the ripening and drying–off period. Climatic parameters like rain and temperature strongly affect the growth and productivity of wheat.

An experiment conducted in Open Top Chamber at Khumaltar showed increase of wheat yield by 8.63 and 9.74 % even at the increase of the temperature by $6.94^0{}_C$ and the doubling of CO_2. Greenhouse effect due to doubling of CO_2 was observed only by $0.18^0{}_C$ and produced 9.74% higher than ambient plots. Physiological growth stages like panicle initiation, heading, flowering, milking and physiological maturity decreased by 14, 5, 9, 6 and 14 days, respectively due to increase in temperature. Increase in the CO_2 level in the C_3 pathway in rice and wheat increased yield. Wheat sowing in Tarai can be delayed up to the second week of December without significant reduction in yield. Wheat seeds sown beyond these dates resulted yield reduction of 30 to 50 kg/day/ha (NARC 1997). Sowing date of wheat in arid, semi-arid, dry sub-humid, moist sub-humid and humid zones will shift towards cooler months with climate change. The shift in the sowing date towards cooler months can offer an opportunity to offset the likely impacts of climate change. With each advance in sowing date the growing season length decreases compared to the previous sowing, in the baseline as well in the climate change scenarios.

This suggests that alteration in the sowing date might not interfere with other crops grown during the remainder of the year, but might offer an opportunity of some additional time that can be utilized for land preparation or to grow an additional crop. Apart from this, cultivars that can take benefit of shorter durations will be beneficial. Because of high Experiments in India reported by Sinha found that higher temperature reduced radiation associated with increased cloudiness cause spikelet sterility and reduced yield in wheat to such an extent that any increase in dry matter production as a result of co_2 facilitation nullified the advantage of grain productivity. Morey and Sadaphal (1981) reported a decreased of wheat yield by 100kg/ha for a unit of increase of 1^0c maximum temperature 0.5 hour sunshine. Wheat production was increased by 41.5 % in the Terai plain, 24.4 % in the hill and 21.2 % in the mountain under the elevated CO2. The yield however decreased by 1.8% in the Terai but continued to increase by 5.3 % in the hill and 33.3 % in the mountain at 4^0c rise in temperature under irrigated condition. The study conducted in India showed that, in subtropical region there will be small decrease in potential yield by 1.5-5.8% but in tropical zone the decrease will be 17-18% (Agrawal and Kalra 1994). It indicates that rain-fed wheat productivity is likely to suffer more in Terai as compared to the mid-hill's environment in a climate change scenario. The additional rains had favorable impacts on the wheat yield at all levels of temperature rise (Sherchand et al. 2007)

Line sowing with 25 cm rows apart it is found that the introduced wheat variety Bijaya performed slightly better (3 ton per ha) than Gautam (2.8 ton per ha) and locally adaptive wheat variety (2.5 ton per ha). Similarly, Bijaya was found to be taller than other varieties and gave more straw. It rained 4 times (total rainfall 56.6 mm) and there was significant hailstorm during flowering stage in Motipur, Bardiya (Caritas Nepal 2013). Caritas Nepal reported that the farmers improved cultivation practice by sowing in row 25 cm by 25 cm (and line sowing) as against broadcasting. However, they did not use adequate organic fertilizer or any additional chemical fertilizer inputs in these trials in winter of 2012/13. In Nirmalpokhari of Kaski district, the farmers stopped cultivating wheat for some years now because of inadequate winter rainfall (Caritas Nepal 2011). Economic concerns associated with adaptation option, it will be comparatively easy to adopt the alteration in sowing date as it will most probably be at no cost decision (Sultana and Iqbal 2009).

2.5 Climate Change and climatic study of Bardiya

Bardiya, lying in tropical region, is one of the warmest districts in Nepal. District is identified as vulnerable districts as per reported by National Adaptation Program of Action (NAPA) (MoE 2010). The erratic and low rainfall and prolonged dry winters have negative impact on production of wheat crop and hampering food security in Bardiya district. The winter crops like wheat, barley and potato were seriously affected by low and later winter rainfall. There were mainly two meteorological stations for collecting meteorological data of district. District Agriculture Development Office (DADO), main governmental body of Bardiya district in agriculture, was running programs against climate change in agriculture. They had supporting non/climatic adaptation such as varieties demonstration, participatory varietal selection program, study of cropping pattern, home-gardening to conserve local varieties, seed distribution of drought and submerged tolerance rice.

Caritas-SAFBIN project was working in the field of climate change adaptation research. SAFBIN was working in six rain-fed drought areas in Bardiya district by launching its programs in varietal trail on rice Sukkha dhan 1, Sukkha dhan 2 and Sukkha dhan 3 over locally dominant Radha 4 variety. Wheat with different sowing methods and seed distribution of vegetable is also done to promote home garden. They also provided metal bean and locally made dehari for seed storage. Caritas also provided rain gauge, maximum minimum thermometer in project area to record weather data of that area. Caritas Nepal looked into possibility of improving wheat yield by undertaking wheat varietal trials in some of the project locations in Bardiya. The rust resistance varieties like Bijay, Gautam and Aditya were planted in the Bardiya. The locally adaptive resident wheat varieties were used as control in the locations. Caritas Nepal presents here the initial findings of the participatory action research (small holder farmer group led research) undertaken on performance evaluation of different wheat varieties in Motipur and Beluwa VDC of Bardiya district in winter 2012. So the farmers of SAFBIN group had more idea about climate change and adaptation practices to fight its problem.

CHAPTER 3: RESEARCH METHODOLOGY

This chapter deals methods of conducting current research in the study location from starting to proposal preparation, data collection, data analysis and reporting.

3.1 Selection of study area

The research was conducted in Motipur and Kalika VDCs of Bardiya district. Bardia lies at 28º 17"- 28º39” N and 81º 3" - 81º 41" E. Total area covered by this district is 2,025km^2. District headquarter is Gulariya and it is surrounded by East-Banke, West-Kailali, North-Surkhet and South-UP India and 138m the lowest and 1279 the highest regions of this district. It constitutes 31 VDC and 1 municipality. Motipur and Kalika lies on rain-fed region of Bardiya district. These VDCs were purposively selected as Caritas-SAFBIN project intervention areas.

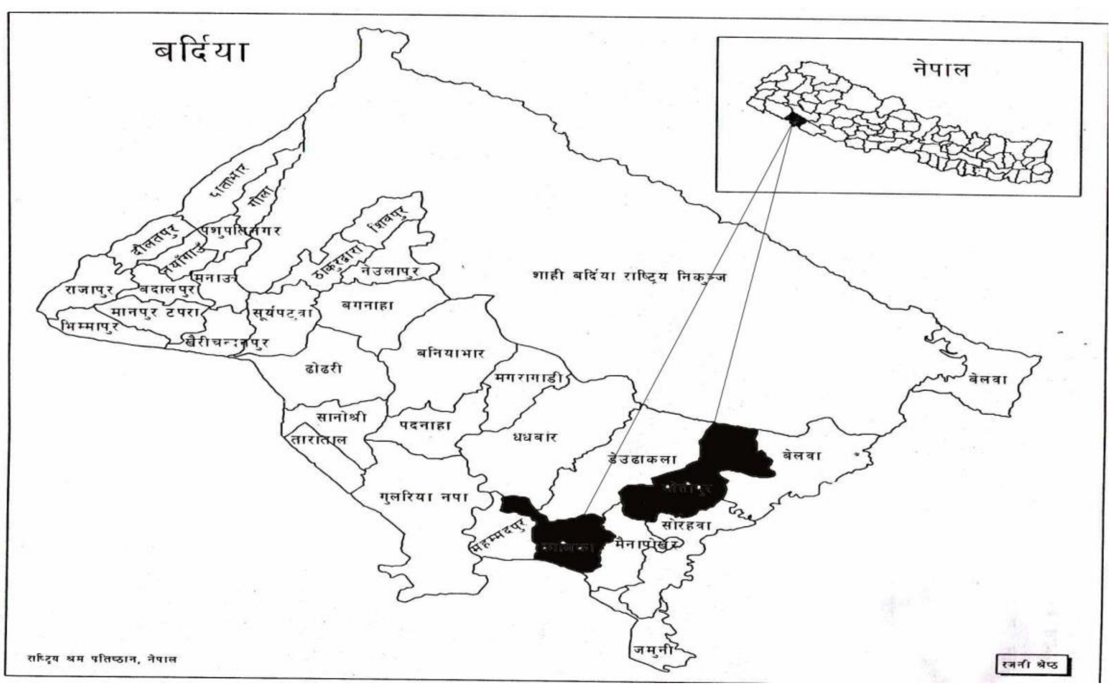


Fig: - 1 Map of study area source:www.ztopics.com/bardiya district

3.2 Sample size and sampling procedure

Pre-field visit to selected VDC was conducted and a respondent's profile was prepared. 50 farmers were selected from Motipur and 30 farmers selected from Kalika VDC in which 50% of farmers were selected from Caritas-SAFBIN group and remaining 50% outside SAFBIN group. Farmers were selected after key informants survey and a pre-field visit. Moreover age over 30 years and indigenous people were given the first priority in sampling. Altogether 80 farmers were selected for study on wheat farmer's perception, impact, adoption measures under climate change and vulnerability context in these areas.

3.3 Interview schedule design

Semi structured questionnaire (see appendix 1) was prepared for data collection through household survey, focus group discussion and key informant survey. Pre-testing of the questionnaire was done by interviewing five respondents near the study area and some necessary adjustments were made.

3.4. Data Collection

3.4.1 Primary data collection

For primary data collection both open and closed question type was used to collect the data.

A) **Household survey:** During the household survey, 80 respondents were interviewed in survey from two VDCs in which 50 respondents from Motipur and 30 respondents from Kalika. Among the respondents 58.8% of the respondents were female and 41.2% were male. Major portion of respondents were female. Study area was under caritas SAFBIN project area where majority of the group members were female. If categorize respondents into three age groups: 71% were 30-60 years old followed by 19% of 60 years above and 9% below 30 years .

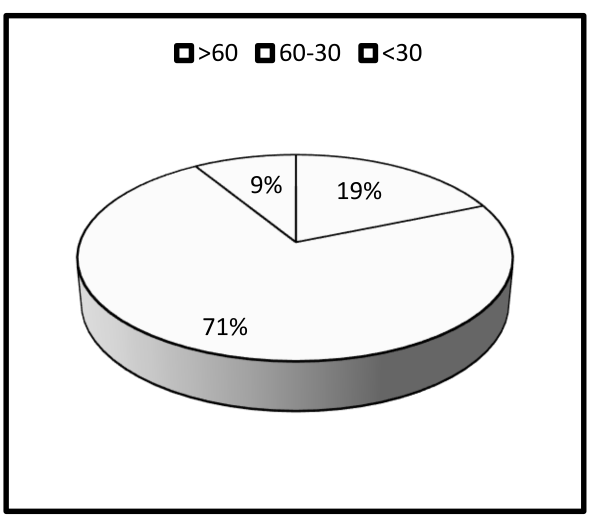


Fig2:- Age of respondents Source: Own drawing field survey (2014)

B) **Key informant survey:** Under this survey, key person who know the knowledge of the area and the changing climatic condition were taken. Leader farmers, Agro-vet shop, DADO officer, Head of Caritas-SAFBIN program Bardiya, RARC Khajura Officer were selected for KIS. Altogether five KIS were taken. (see appendix 2)

C) **Focus group discussion:** Discussion was conducted with the farmers to know the past and present condition of climate, change in the agriculture. Altogether 5 focus group discussions were conducted including more than 15 farmers in each group. (see appendix

3.4.2 Secondary data collection

Secondary information was collected from Central Bureau of Statistics, District Agriculture Development Office and Department of Hydrology and Meteorology, CARITAS-SAFBIN project, RARC Khajura. Some additional information was obtained from associated organizations and professionals.

3.5 Data tabulation and analysis

The information collected from the field was first coded and entered into the computer. Coding of data was based on Statistical Package for Social Science (SPSS) and Microsoft -Excel program need. Mostly, likert scale was formulated making the codes for various responses collected from the respondents. For example, farmers response of: feel of temperature rise: 1= increasing, 2= decreasing, 3= do not change and 4= do not know.

As soon as data tabulation finishes, excel data sheet was imported to SPSS for analyzing by using both descriptive statistics: frequency counting, average, mean, standard deviation, percentage etc. and inferential statistical tools. The descriptive statistics were used to describe the respondents' socio-economic characters such as sex, age, land holding etc. Overall analysis was carried out by using Statistical Package for Social Science (SPSS) and Microsoft -Excel program. After secondary data collection analysis was done by using correlation and regression. Regression analysis was used for prediction and forecasting. Monthly temperature and monthly rainfall data of nearby station for the periods of 27 years (1985-2012 AD) for Bardiya district was collected from Department of Hydrology and Meteorology were taken as independent variables. Duration of wheat growing season was considered from November to April and average of temperature and rainfall data of that period was taken into account. Wheat yield of the same period was assumed as annual yield of the Bardiya district. Thus, wheat yield was considered as dependent variable and its independent variables were climatic (temperature) and non-climatic (area of cultivation).

The linear trend between the time series data (y) at time (t) is given in the equation below:

Predictions of the yield changes with climatic variables, from regression model based on historical climatic and yield data for specific crops are relatively accurate

$\Delta Y = \beta_0 + \beta_1 \Delta R + \beta_2 \Delta T_{max} + \beta_3 \Delta T_{min}$---------------------- (1)

Where, ΔY is change in yield of wheat $_i$ th year, β_0 is the constant term. $\beta_{1,}$ $\beta_{2,}$ and β_3 are coefficient of respective climate variables rainfall (R), maximum temperature & minimum temperature, respectively. Multiple regression model of the above question can be written as:

$Y_t = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + ... + u_i$ ----------------- (2)

Where, y_t = yield of wheat at year t, Xi = independent variables: temperature (X_1), X_2 (rainfall), X_3 (area of cultivation), t = time (year). "α" and "β" are the constants and slope coefficients estimated by the principle of ordinary least square (OLS) estimator (Gujrati, Porter and Gunasekar 2013).

Testing level of significance: It was applied for hypothesis testing by using t-test, f-test, R-squared test, and probability *(p)*-value. The null hypothesis (H_0) of no change in any effect of individual coefficients (by t-test), no "goodness of fit" of the model (by using f-test and R^2) were tested at n-1 degree of freedom (df). If calculated value of t and f exceed 0.05 (tabulated value of t or f at 5% level of significance and n-1 d.f.), we say that the difference between mean of sample and mean of parent population is significant at 5% level, if it exceeds $t_{0.01}$ the difference is said to be significant at 1% level. Chi-square (X^2) test was tested to measure the normality of the model. Also, measuring relationship of various responses was also tested by using X^2 test. If X^2=0, observed and theoretical frequencies agree exactly. The larger the value of X^2 the greater is the discrepancy between observed and expected frequencies. If the calculated value exceeds the tabulated value 5% level only then we infer a significant difference between the observed and expected frequencies. If the calculated value exceeds the tabulated value at 1% level we infer a highly significant departure.

Trend analysis was used to explain average annual production, average annual maximum temperature, average annual minimum temperature and average annual rainfall.

All analysed data were presented under result and discussion section. Their summary and final report will be prepared and submitted at concerned offices.

CHAPTER 4: RESULT AND DISCUSSION

4.1 Socioeconomic status of respondents

Land area of the respondents was divided into three parts. There was large variation in landholding Fifty percent of the respondent had land area between 10-20 *Katta* followed by more than 20 *kattha* thirty percent and twenty percent below 10 *kattha*. The average landholding was 18.98 *kattha*. Similarly respondents with wheat land below 10*kattha* were 78.8% followed by with eighteen percent with 10-20 *kattha* and 2.5% above 20 *kattha*. Average wheat cultivating land was 8.16 *kattha* and average wheat production 6.05 quintal. The major crops grown are paddy, wheat, lentil, chickpea, maize and vegetables. Rice and maize are rainy season crop while wheat, lentil, chickpea were grown in the winter season.

Table1: Total land holding and wheat land holding

Area (*kattha*)	**Respondent%**	
	Total landholding	Wheat land holding
1-10	20	78.8
11-20	50	18.8
>21	30	2.5

Source: Field survey (2014)

It is observed that fifty two respondents were in food sufficiency level while sixteen respondents were in 6-9 month food sufficiency. Similarly eight respondents were in 3-6 month food security and four respondents were only less than 3 month food sufficiency**.**

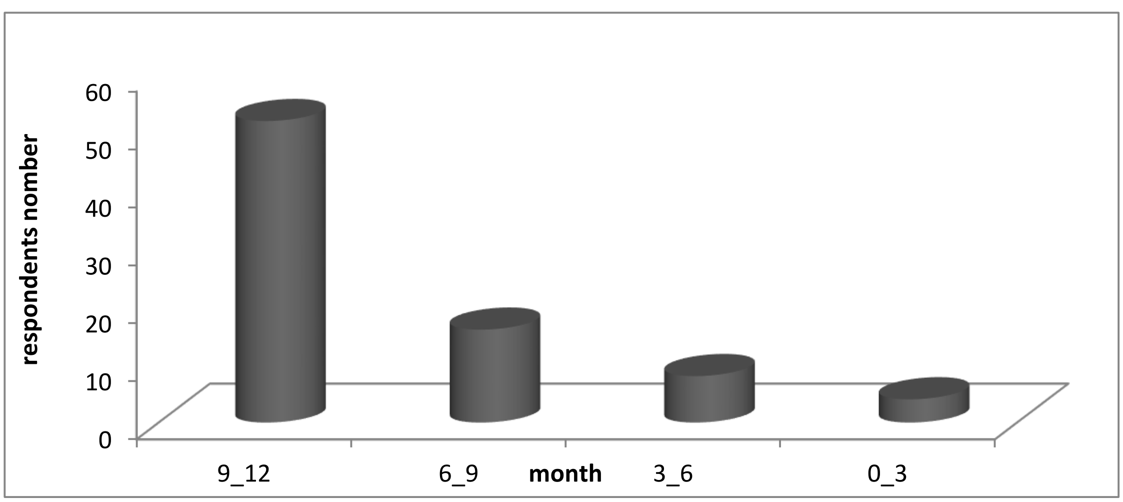


Fig 3: food sufficiency status of respondent Source: Own drawing (2014)

4.2 Climate change perception analysis

4 2.1 Cause of climate change and perception on and weather condition over decade

Table 2 depicts perception of farmers on weather condition. 97.5% of the respondents felt climate change and 2.5% didn't felt climate change. 53.8% of the respondents said climate change was due to human activities naturally (25%) and 21.2% didn't know the cause of climate change. All of respondents experienced in increasing temperature level, decreasing in winter rain intensity, winter rain severity and frequency. Decreasing flood frequency was experienced by 88.5%, increasing 3.8% and 7.5% not change. 58.8% experienced increasing drought length severity, decreasing 28.8% and 12.5% no change. Similarly 90% experienced drought frequency, 5% decreasing and 5% experienced not change. Increasing hailstone severity was experienced by only 18.8% respondents, 40% decreasing, 33.8% not change and 7.5% didn't know. Similarly 81.2% of the respondents experienced in increasing frost and severity, decreasing 10% and 8% experienced not change. All the respondents experienced later monsoon and short duration and experienced the climate change effect and failure of crop in last decades.

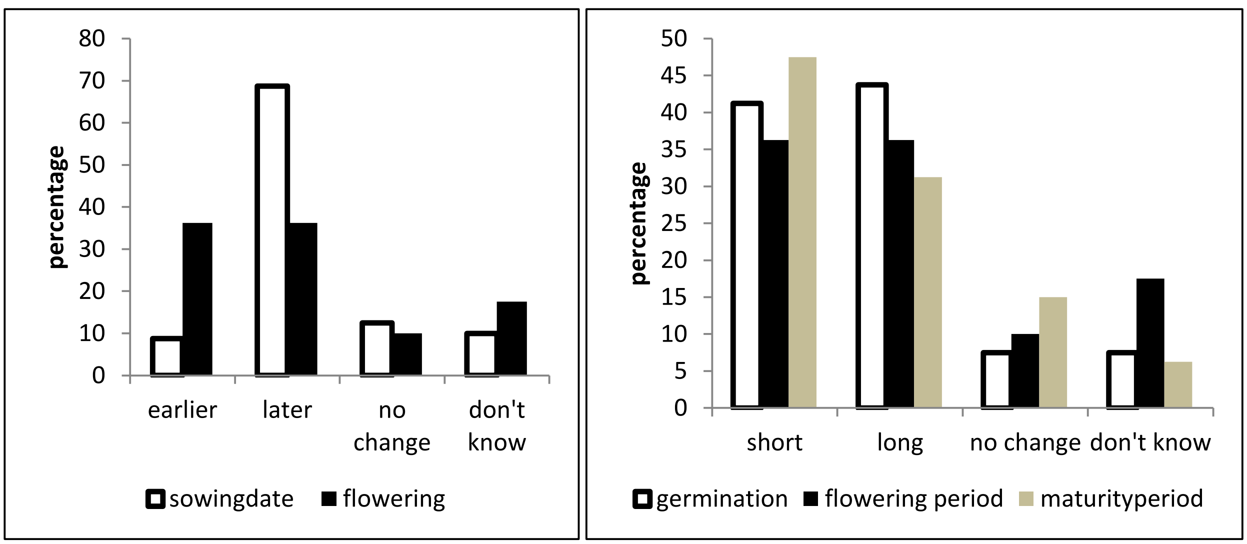
Table2: Perception on weather condition over decade

Weather parameter	Increasing	Decreasing	No change	don't know
Temperature	80 (100%)			
Winter rainfall intensity		80(100%)		
winter rainfall frequency		80(100%)		
Landslide flooding severity	3(3.8%)	70(87.5%)	7(8.8%)	
Landslide flooding frequency	3(3.8%)	71(88.5%)	6(7.5%)	
Drought length severity	47(58.8%)	23(28.8%)	10(12.5%)	
Drought frequency	72(90%)	4(5%)	4(5%)	
Hailstone severity	15(18.8)	32(40%)	27(33%)	66(7.5%)
Frost dew severity	65(81.2%)	8(10%)	7(8%)	

Source: Field survey (2014)

4.2.2 Effect of climate change perception on wheat stages

Perception of respondents on seed sowing because of rainfall pattern is depicted in figure 4. 68.8% of the respondents did late seed sowing, 8.8% earlier, 12.5% no change and 10% of respondents don't know about change in sowing. 36.2% of respondents felt flowering in earlier, 36.2%, later, 10% no change and 17.5% don't know about change in flowering time. Similarly 41.2% of the respondent felt the germination of seed in short time, long (43.8%), 7.5% felt no change and 7.5% didn't know about germination time. 25% respondents experienced flowering in short time, 17.5% in long time, 17.5% no change and 40% didn't know flowering period. 31.2% of the respondents experienced maturity period in long time, short time 47.5%, 15% no change and 6.2% didn't felt change in maturity period. The result shows that 63.8% of respondent observed decrease in wheat yield ,18.8% experienced on yield increasing and 17.4% experienced no change in production during decade but the farmer's who are adopting new improved varieties observed increase in yield in recent years. All the respondents had the knowledge about crown root initiation and irrigation requirement at this time. They experienced that unavailability of irrigation in CRI stage is one of the main reason for reduction of wheat yield.



Source: Own drawings from field survey (2014)

Fig 4: Climate change perception on different wheat stages

4.2.3 Perception on disease, pest and weed infestation

Table 3 depicts perception of farmers on disease, pest and weed infestation. Seventy percent of the respondent experienced disease problem on wheat. They were facing loose smut as the main disease whereas 30% didn't experienced disease problem. Forty percent of the farmers answered more weed infestation and 60% didn't feel. Similarly, insect pest problem was experienced by

85% of the farmers. They experienced disease and pest problem in panicle initiation and grain filling stages of wheat subsequently reduction in production**.**

Table 3: Perception on disease, pest and weed problem

Problem	Yes (%)	No (%)
Disease severity	70	30
Weed infestation	40	60
Insect pest infestation	85	15

Source: Field survey (2014)

4.2.4 Perception on reason for loss in wheat production

Figure 5 depicts perception on reasons for loss in wheat production where all the farmers experienced that drought during wheat sowing and growing time is the main reason of loss in wheat yield. Similarly, 86% farmers experienced due to delayed seed sowing time, 50% soil fertility, 55% due to disease pest infestation, 30% weed infestation, 60% use of local varieties and 70% experienced loss is due to use of less amount of chemical fertilizer and FYM.

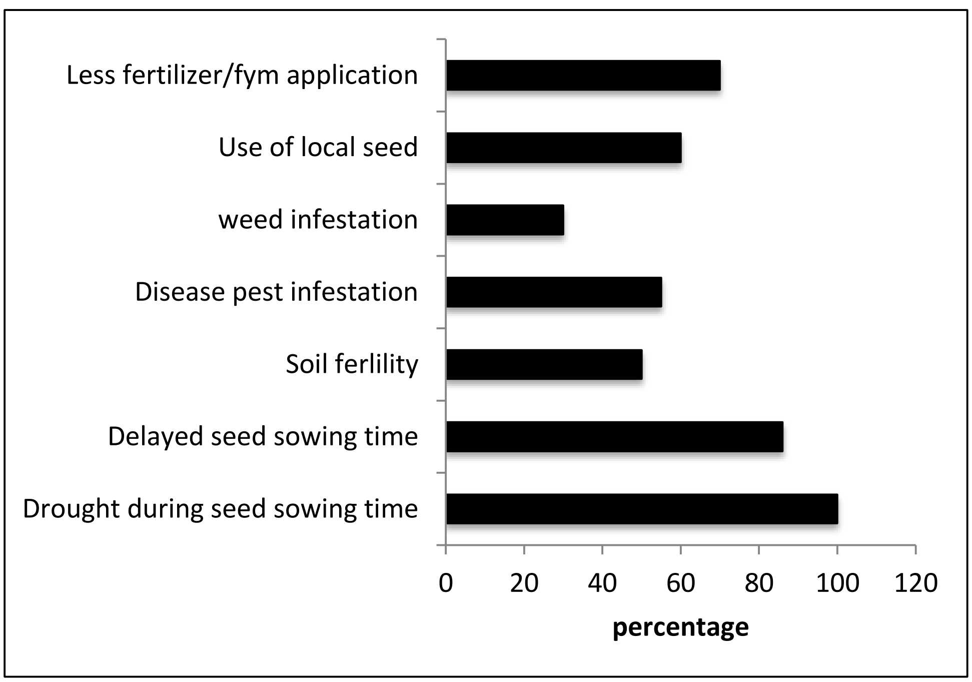


Fig 5: Bar graph showing perception on reason for loss in wheat production

Source: Own drawing from field survey (2014)

4.3 Timeline of climate change hazards in study sites

Sharing from Focus Group Discussion (FGD) revealed and identified major hazard occurred in Motipur (see in table 4) and Kalika (see in table 5) within 10-year associated to wheat farming.

Table.4: Hazard timeline in Motipur VDC

Date (BS)	Disaster	Effects
2065	Drought	Loss up to 25% in wheat and other winter crops
2066	Drought	Decrease the yield of wheat crop by 10-15%
2067	Drought	Decrease the yield of wheat crop by 10-15%
2069	Drought	Loss in wheat crop up to 20%
2070	Hailstone	Loss in wheat yield by 50%

Source: FGD (2014)

Table.5: Hazard trend of Kalika VDC, Bardiya

Year	Disaster	Effects
2061	Hailstone	about 20-25% yield loss in wheat, pea and chickpea
2066	Drought	Yield loss of wheat
2067	Drought	Decrease the yield of wheat crop by 10-15%
2068	Hailstone	Decrease the yield of wheat crop by 50-60%%
2070	Heavy winter rainfall	Partial loss in wheat yield

Source: FGD (2014)

4.4 Caritas intervented and non intervented group in response to climate change perception

Difference in the Caritas intervented group members and non intervented group were clearly demarcated in survey area. Farmers of Caritas group were active to respond the answer, they had knowledge about climate change and adaptation practices to fight against climate change hazards and effects. It was the impact of research programme conducted by Caritas-SAFBIN. Caritas has performed different variety trail at the farmer's field with the farmer’s participation. Farmers of SAFBIN group had better knowledge in seed and grain storage technique to prevent from storage loses. With the view to cope with increase drought in the different area in Bardiya district, varietal trial of wheat varieties Bijay and Gautam were conducted in line sowing. After the adaptation of these new varieties and sowing technique Caritas farmers experienced improving food sufficiency. Caritas SAFBIN group farmers experienced on increasing wheat yield in recent years it is due to cultivating new improve varieties provided by CARITAS before that they used to cultivate local varieties. Same group members had IPM knowledge but not practiced in wheat farming**.**

4.5 Social-economic relationship on wheat yield

4.5.1 Relation between gender, age, khet land and wheat land on wheat production

On the liner regression analysis using SPSS of independent variables age, gender, *khet* and wheat land on dependent variable wheat production. Coefficients of gender and age were not significant but area of coverage *(khet land* and area of wheat) had positive significant relationship at 5% level (see table 6). The value of R^2 (0.639) means only 64% variability was explained by the model over total variation. The analysis of variance (ANOVA) table showed that f-statistics was significant (f= 33.2) meaning that model identified by the regression was best fitted "goodness of fit".

Table 6: Coefficient of regression analysis

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
Constant	-3.595	1.802		-1.994	.050*
Gender	-.365	.574	-.045	-.635	.528
Age	.692	.553	.090	1.252	.215
Khet land	1.172	.450	.218	2.604	.011*
Wheat land	5.329	.686	.647	7.768	.000**

Source: Own analysis (2014)

4.5.2 Correlation between wheat productivity and climatic parameters

Twenty-seven years (1985-2012) maximum temperature, minimum temperature and precipitation data for growing seasons and annual productivity wheat was correlated using Pearson's correlation. In Bardiya growing season of wheat is November-April. Statistically significant negative correlation (-0.455) was found between productivity of wheat and average rainfall of growing season of wheat. It indicates that there is decrease in wheat production with an increase in rainfall but there was no statistically significant correlation with minimum temperature and maximum temperature of the wheat growing season. It indicates that there is no effect in wheat production with an increase or decrease in maximum temperature and minimum temperature. (N=27, p=0.05) (See appendix: 4).

4.6 Trend Analysis

4.6.1 Minimum and maximum temperature trend

On the trend analysis of the temperature of Bardiya district minimum temperature and maximum temperature of the Rani jaruwa nursery station was taken from the DHM. The average annual minimum temperature and average annual maximum temperature was obtained using average of all months using SPSS. Mean maximum temperature obtained is 33℃ where as mean minimum temperature obtained is 23℃. The highly significant relation was obtained between time with maximum temperature and average temperature while no significant relation was obtained with the minimum temperature.

There is also increasing trend of maximum temperature, minimum temperature and average annual temperature while no significant relation was obtained with the minimum temperature. Analysis found the increasing trend was of maximum temperature (0.064), minimum temperature (0.014) and average temperature (0.299) of the Bardiya district.

Table 7: Temperature trend analysis

Temperature	Yearly		
	t max	t min	t avg
Mean (℃)	32.98	22.52	27.75
Standard Deviation	0.843588	0.539106	0.59128369
Maximum temperature (℃)	34.6	24.3	29.7
Minimum temperature (℃)	31.8	21.8	26.95
correlation with time	0.630	0.214	0.547

trend (℃ / year)	0.064	0.014	0.299

Source: DHM(2014)

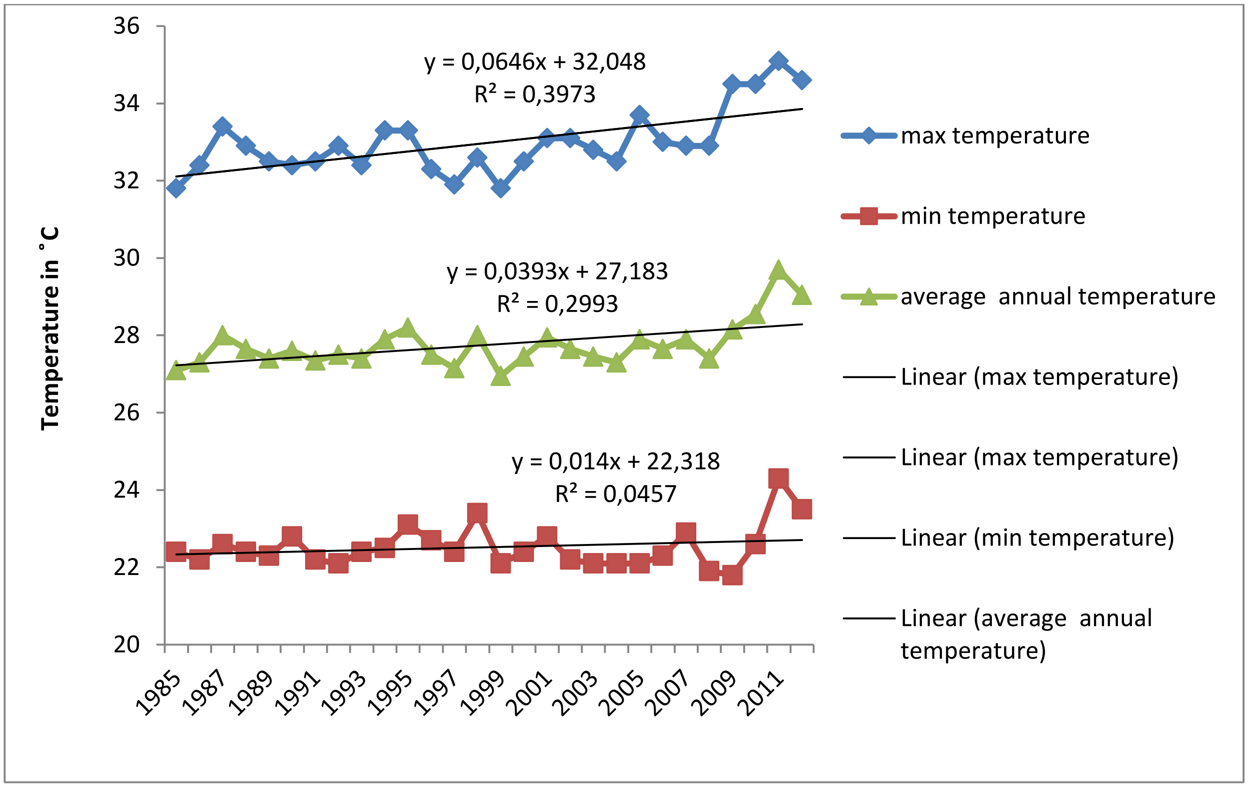


Figure 6: Temperature trend of Bardiya district

Source: Own analysis from DHM (2014)

4.7.2 Rainfall trend

Table 7 depicts different kinds of rainfall patterns nearby the study sites (Ranijaruwa nursery rainfall station of DHM). From this analysis we found that the maximum rainfall was noted to fall in the main monsoon that was 1785 mm while lowest maximum rainfall noted was 155 mm of the winter rainfall. Post-monsoon and winter-monsoon noted to have zero rainfall in the various years. There was highly significant correlation was found between time and main monsoon while no significant correlation was found with others and highest mean was 1105 mm of main monsoon rainfall and the least mean was 38 mm of the post-monsoon rainfall but annual rainfall was 1297 mm. High deviation in the monsoon and annual rainfall was found 317.57 mm and 337 mm, respectively. The lowest deviation was 45.61 mm which was found in the winter monsoon. Trend of the pre monsoon (-3.21), main monsoon (3.21), winter monsoon (-1.89) and annual rainfall (-8.03) was found the decreasing while increasing trend was found in the post monsoon rainfall (1.041). This evidence in decrease in rainfall was also perceived by the farmers as explained in table 2. The evidence in decrease in rainfall trend was also concluded by the various NAPA report.

Table: 8 Rainfall trend analysis

	pre monsoon	main monsoon	post monsoon	winter monsoon	annual rainfall
mean (mm)	90.9	1104.88	38.34	62.7	1296.84
Standard deviation	73.6965	317.5747	57.35573	45.61823	337.3511
maximum rainfall	367.5	1785	261.5	154.8	1909.6
minimum rainfall	7	603.4	0	0	777
correlation with time	-0.427	-0.08	0.144	-0.33	-0.189
Trend (mm/year)	-3.2143	-3.2143	1.0417	-1.8984	-8.0315

Source: DHM(2014)

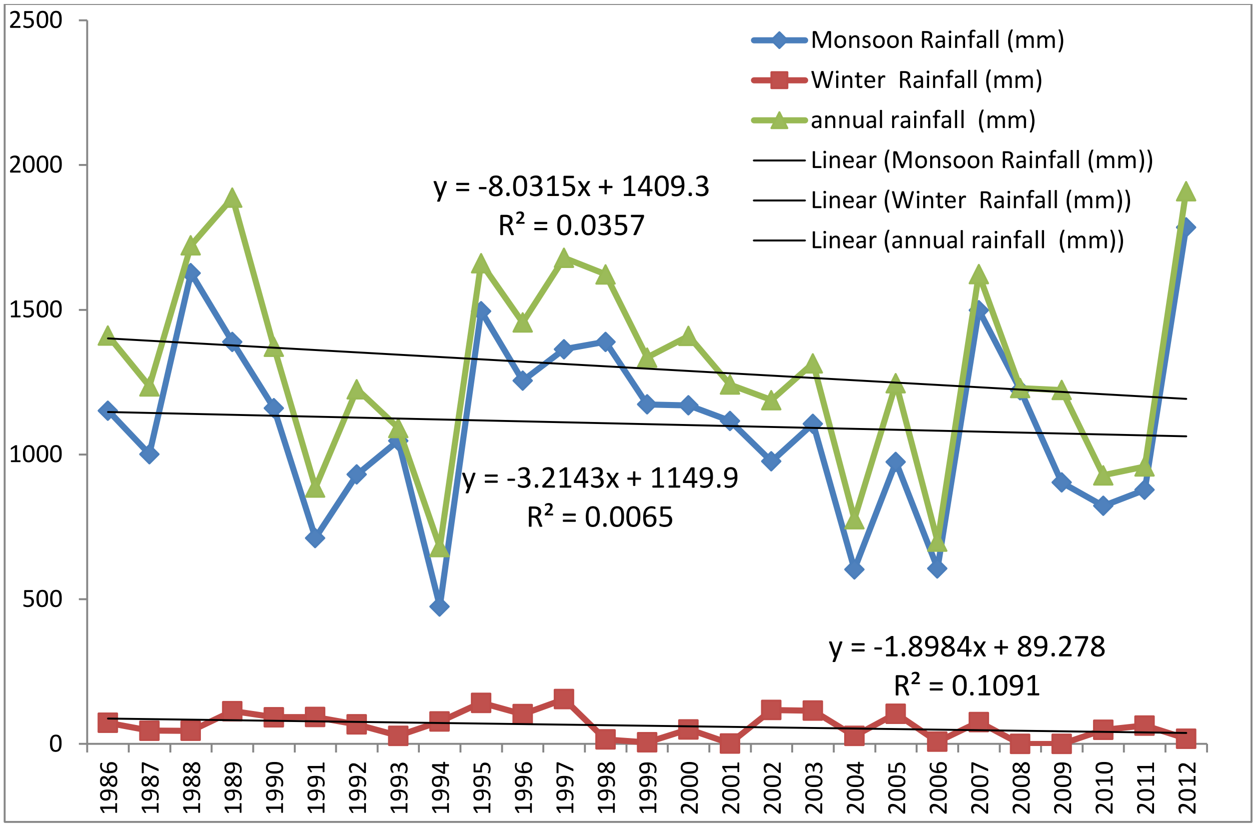


Figure7: Rainfall trend of the Bardiya district

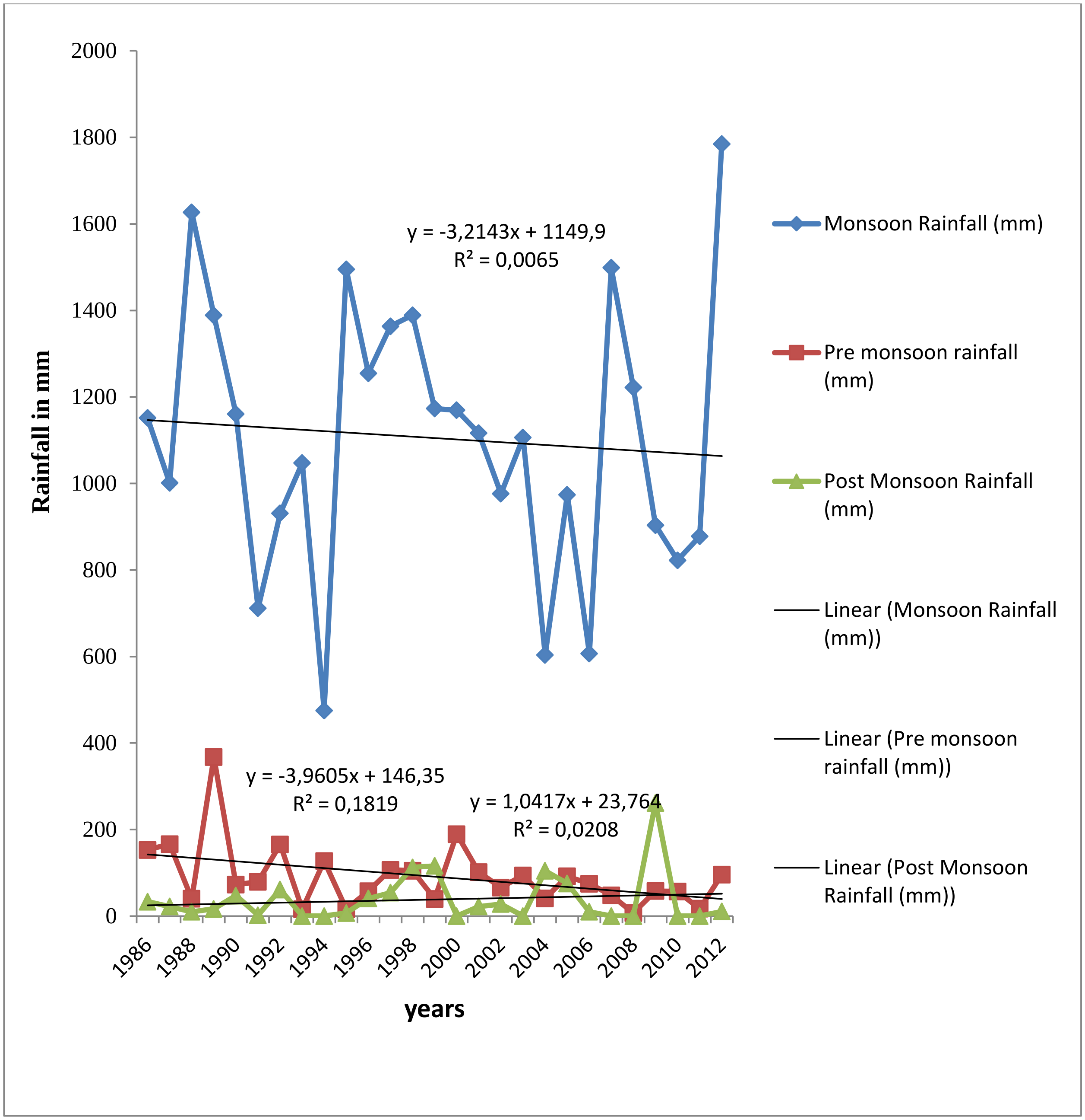


Figure 8: Monsoon rainfall trend of the Bardiya district

4.8 Climate change adaptation practices of the respondents

4.8.1 Adaptation activities over climatic hazards by wheat growing farmer

In adoption practices 65 respondents adopt drought problem by sowing seed after winter rainfall. 43 respondents use improved seed whereas 37 don't use improve varieties (Bijay and Gautam).

Farmers don’t know the name of previous varieties of wheat because they use local seed and named local Seto and Local Rato. Some farmer in Kalika VDC bought seed from India so they didn’t identify variety name but the farmers of SAFBIN who were cultivating new improved varieties Bijay and Gautam. At present, farmers were cultivating NL257, Gautam, Bhrikuti, Aaditya and Bijay as new varieties. Similarly 58 respondents used more chemical fertilizer and all the respondents used more FYM/compost and for adoption in loss of productivity. No any respondent adopted any kind of moisture conserving technique, seed sowing method and IPM practices.

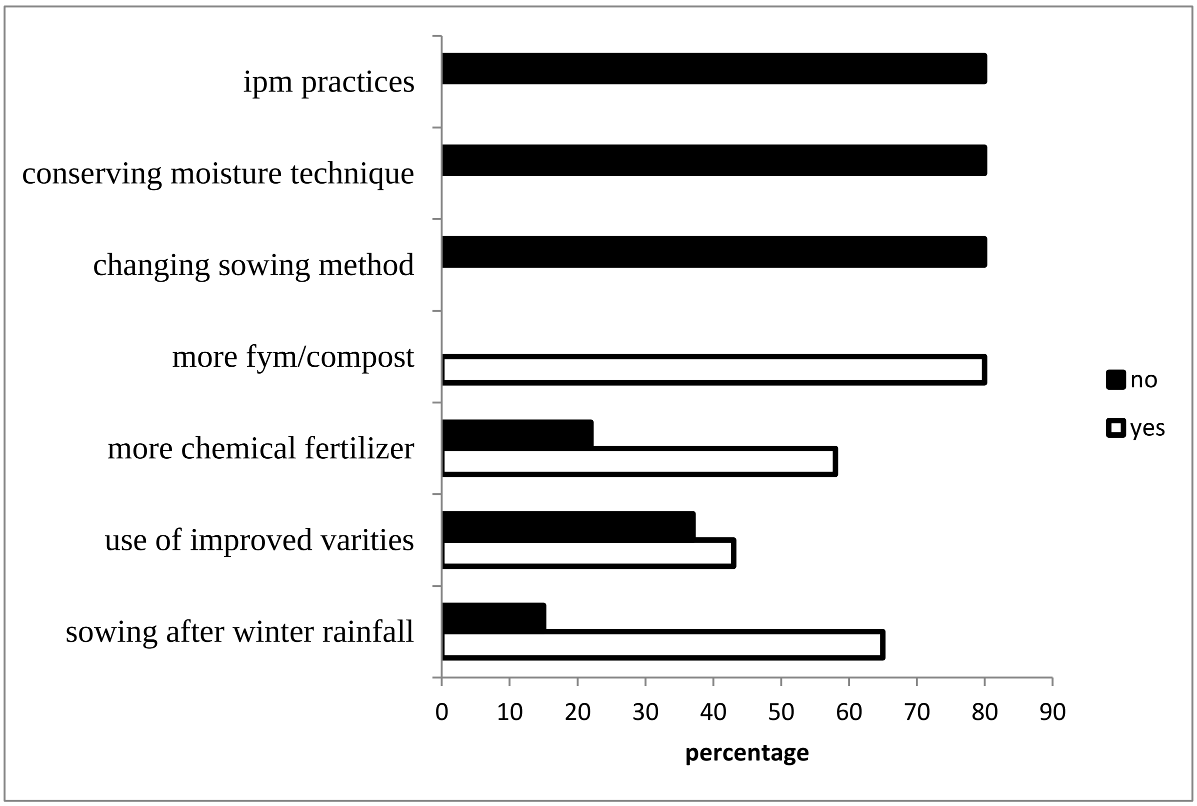


Fig9: adaptation activities adopting by farmers

Source: Own drawing from field survey (2014)

Farmers experienced on loss of productivity, disease, insect pest attack, drought, weed infestation and losses by store grain pest as effects. Table 9 depicts adaptation practices over the effect of climate change by wheat farmers where by changing sowing time adoption of climate smart varieties Gautam, Bijaya and Aditya, use of more chemical fertilizer, fym/compost to adapt loss in productivity. Similarly for disease, pest attack by removing attack part as possible, loose smut is the major problem in disease. For weed problem hand weeding and they didn't adapt any modern and technical practice for moisture conservation. Only rich and elite farmers were using motor pumping. For loss in store grain pest proper drying and mixed with neem as their adaptation practices. DADO and Caritas Nepal launched awareness programmes about climate change and climate change adaptation activities.

Table 9: Adaptation practices over the effect of climate change by wheat farmers

Types of problems	Adaptation activities
Loss in productivity	Changing sowing time Adoption of climate smart varieties(Bijay, Gautam) Use of more chemical fertilizer, FYM/compost
Disease, insect pest attack	Remove attack part if possible agrovet consult
No moisture (or long drought)	motor pumping (only rich farmers) sowing after rainfall
Weed infestation	Hand weeding
Losses by store grain pest	proper drying and mixed with neem

Source: FGD at Motipur and Kalika(2014)

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1 Summary

Wheat is major staple crop in world and third in Nepal. Although the large portions of people are involved with agriculture, agriculture productivity is lowest among the South Asian countries with increasing population growth and decline in agricultural production land.

A study was carried out in two VDCs of Bardiya district with the objectives of a) documenting special differences on climate change vulnerabilities really happening at the project location b) measure community perceptions on climate change before and after project intervention c) mapping climate change adaptation measures taken by the communities along with project level interventions and coordination d) estimating adaption costs caused by the climate change effect.

Altogether eighty HH survey (fifty HH from Motipur VDC and thirty HH survey from Kalika VDC) was chosen and interview schedule was conducted with the help of pre-tested structured questionnaire. Five FGDs with the involvement of 75 participants and 5 KIS were also conducted to collect other data and information by using semi-structured questionnaires. Data on climatic parameters and wheat production of Baridya district were collected from DHM, CBS and MOAD, respectively. The collected primary and secondary data were entered into Microsoft excel worksheet as well as SPSS worksheet. Then, perception analysis, trend analysis and regression analysis were undertaken by using SPSS version 16.

Regarding to perception analysis, on climate change, different types of questions were asked to the respondents. 54 % of the respondents perceived climate change was induced by human activities. Almost all respondents experienced increasing temperature level particularly in wheat planting season, decreasing winter rain intensity, winter rain severity and frequency. Decreasing flood frequency was also experienced by 89%, 59% experienced increasing drought length severity, 90% experienced increasing drought frequency, experience of increasing hailstone severity by 19%, and 81% of the respondents experienced in increasing frost severity. All the respondents experienced later monsoon rainfall, short duration, and experienced the climate change effect on wheat in last decades.

In a same line, perception of respondents on wheat crop production calendar change was also assessed. 69% of the respondents experienced late seed sowing because of no rainfall in winter or no preserved soil moisture. Other morphological growth like: earlier flowering of wheat by 36% respondent, longer duration of germination of seed (by 44%) shorter time of maturity wheat maturity period (by 48%).

The result shows that 63.8% of respondent observed decrease in wheat yield. The reasons of low wheat production were winter drought and use of local varieties. On the study, farmers reported continued losses ranging from 10-40% in the production due to drought or delay in winter rainfall. However, since Caritas-SAFBIN launched, farmers experienced increase in wheat productivity because of adaptation of Bijay and Gautam as new varieties with line sowing method.

Study also analyzed secondary data analysis of last twenty seven years of Bardiya district. Mean annual temperature, maximum temperature and minimum temperature was slightly increasing by 0.039^0C, 0.064^0C and 0.014^0C, respectively while rainfall trend was decreasing by 8.031mm. Pre-monsoon rainfall, main monsoon rainfall and winter monsoon rainfall were decreasing in trend by 3.96 mm, 3.2mm and 1.89mm. But post monsoon rainfall was increasing by 1.89mm.

Coefficients of gender and age were not significant but area of coverage *(khet land* and area of wheat land) had positive significant relationship and statistically significant negative correlation (-0.455) was found between productivity of wheat and average rainfall of growing season of wheat. It indicates that there is decrease in wheat production with an increase in rainfall.

Mostly wheat farming after winter rainfall was practiced in the study site, where there were no facilities of irrigation and moisture conserving techniques. Farmers were fully dependent on natural rainfall, which increases the level of uncertainty. Thus these areas were prone to drought. Adaptation with the changing climatic condition in the research site seem to be poor not modern.

5.2 Conclusions

- It is evident from the study that respondents of the study VDCs felt impact of climate change on wheat crop. Cultivating wheat from November- April had post-monsoon, pre-monsoon, frost, hailstorm, dew and temperature effect.

- Although, poor relationship of temperature effect on wheat yield, continue drought in wheat growing season upto 4-5 years and poor winter rainfall but limited option for irrigation brought poor coverage and poor grain productivity of the wheat in the study area.
- Some farmers suggested cultivation of local wheat cultivar are climate smarter but others said hybrid or improved (Gautam and Aditya) ones. Existing supports on wheat crop related adaptation programme were insufficient in lieu of that farmers have no idea on climate smart or non-smart adaptation. Caritas-SAFBIN supported farmers were a bit opportune to adapt and have more knowledge about the climate change but true fact is "poor adaptation practices on wheat is seen because of poor awareness; or diffusion on climate-smart technologies".

5.3 Recommendations

- Study suggests Caritas-SAFBIN Management Team to replicate the findings of this research in the working districts of similar climate, crop, and clients.
- Motipur and Kalika VDC, being rain-fed so irrigation investments are required to help farmers to adapt the long and unpredictable drought-smart wheat technologies. In order to supplement current level of adaptation supports to the respondents, study recommends more coverage and more adaptation activities. Examples would be supporting groundwater extraction technologies, rapid support of rainwater harvesting technological diffusions along with climate change mitigation programs in a coordinated way.
- As study was completed by taking few VDC’s samples, limited key informant interview, and FGD, the researchers suggests Caritas-SAFBIN to check the current results and findings by conducting advanced research in large sampling frame. Research priority would be including many socio-economic and climatic variables and mapping their relationship on final decision of climate change adaptation. For wheat cultivation frost, dew, minimum temperature, winter rainfall, post-rainfall and pre-monsoon rainfall variables are suggested to taken into research accounts. Further research is the important to document the impacts, vulnerability and adaptation of the study area that might help in policy making and prioritizing adaptation process**.**

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APPENDICES

Appendix 1: Structured questionnaire for household survey

Interviewer: Date:____________________ ___

1. General information

Name:____________________________ Sex: M / F Age: _____yrs

Address:_______________________

Area Of Land:_____________ total *kattha* _____________ Bari land _________________ *Khet*

Area of wheat cultivated land_____ *kattha* production____________ variety name:_______________

Food Sufficiency: a) 0-3 month b) 3-6 month c)6-9 month d)9-12 month

Major Agricultural Commodities_______________________________________

2. Farmer's Perception on Climate change:

2.1 Have you felt about climate change?
Yes / No

2.2 Do you know the cause of climate change?

A. it is Natural

B. it is caused by pollution emitted by people and industry leading to change in climate

C. Don't Know

2.3 Have you experienced any change or deviation in weather parameters over the past 10yrs?
Yes/NO

2.4 Have you noticed changes in the following weather conditions?

Weather	Increased	Decreased	No Change	Don't Know
Temperature level				
Winter Rainfall –intensity				
Winter Rainfall-frequency				

Landslide/flooding severity				
Landslide/flooding frequency				
Drought-length Severity				
Drought – Frequency				
Hailstorm-Amount n severity				
Frost/Dew – Amount Severity				

2.5 Have you noticed Changes in timing of Rainfall (Monsoon)? (Tick)

Weather pattern				
Timing of pre monsoon (before June)	Earlier	Later	No change	Don't Know
Duration of pre monsoon	Short	Long	No change	Don't know
Timing of main rainfall(June 1st - august 30)	Earlier	Later	No change	Don't know
Duration of main monsoon	Short	Long	No change	Don't know
Timing of Post-monsoon(1-30 sept)	Earlier	Later	No change	Don't Know
Duration of post monsoon	Short	Long	No change	Don't know
Timing of winter rainfall	Earlier	Later	No change	Don't Know
Duration of winter rainfall	Short	Long	No change	Don't know

3. Effect of Climate changes on wheat

3.1 Have climate changes had any effect on your farming over the last 10yrs?
Yes/No

3.2 Have you experienced failure of wheat in last 10 yrs?
Yes/NO

Reasons for wheat failure: a. Drought b. heavy/continuous winter rainfall c. wind

d. hailstone e. more weed infestation f. others

3.3 Have you experienced changing problems of pest and diseases in the last 10yrs? Yes/No

A. Increase Severity – Yes/NO

b. In which stage there of wheat is affected more?

____

c. Is there occurrence of new pest/disease in last 10 yrs?
Yes/No

If yes mention the new pest and disease name……………………………………………….

3.4 Have you experience problems and emergence of new weeds? Yes/No

If yes, mention the name of weeds………………………………….

3.5 From where do you get seed of wheat?

a) Own b) Governmental agencies _____ c) Agro vet d) From India e) other___________

3.6 Have you noticed any change in wheat performance in last 10 yrs? Yes/No

Effect on crop Performance	Increased	Decreased	No change
Crop Yield			
Crop Biomass Yield			
Grain Size			
Grain quality			
Crop Taste			
Other			

3.7 Have you noticed any change in wheat growth in last 10yrs? Yes/No

Stage			
Seed sowing date	Earlier	Later	Don't know
Days of seed germination	Short	Long	Don't know
Flowering	Earlier	Later	Don't know
Flowering period	Short	Long	Don't know
Maturity period	Short	Long	Don't know

4. Vulnerability Context in wheat farming

4.1 Have you faced a climate related crisis in last 10 yrs? Yes/No

4.2 What type of climatic hazards affected wheat farming?

S.N	Types of effect	Increasing/Long	Decreasing/Short	Reason
a.	Drought period during seed sowing time			
B	Heavy and continuous Winter rainfall			
c.	Delayed in seed sowing period			
D	Damage in germination of seed			

E	Losses of standing crop			
f.	type of insect pest damage			
g.	type of disease pest damage			
H	losses by wind /hailstorm			
I	losses by weed			
J	Losses by store grain pest			
K	% of losses in wheat yield			

5. Climate change/vulnerability context adaptation situation of wheat

5.1 What are the adaptation activities/strategies followed by your household to adapt the climate change impacts?

a. Change in sowing date

b. change in varieties of wheat **:** previous variety………………...new variety………………

c. Diversified farming instead of growing wheat .

d. (I) Application of more chemical fertilizers

(ii) Application of more FYM/compost

(iii) Application of herbicide and pesticide

e. Use hybrids/improved crop varieties**:** Name of variety………………………..

g. change in seed sowing method ( )

h. adopting different IPM practices ( )

5.2 What are the major adaptation practices as per climatic hazards in your household?

S.N	Types of effect/Hazard	Adaptation practices at present context	Suggestions
a.	Loss in wheat land		
b.	Losses in wheat productivity		
C	No moisture /insufficient water		
D	Loss of agricultural assets		
E	Insect pest attack		

F	Disease attack		
G	Losses by winter rainfall		
H	Losses due to hailstorm/snowfall/fog		
I	Losses by Weed infestation		

5.3. Adaptation strategies for conserving moisture:

a) Rainwater harvesting ( )

b) Mulching ( )

c) Minimum tillage/zero tillage ( )

d) Dew harvesting ( )

e) Others ( )

5.4 Are you willing to give up farming and migrate for remittance and wage labor on adoption practices/strategies? Yes/No if yes what are you going to do …… ……………………………………

If farmers are not able to answer adaptation activities please tell him/her following activities

(Change in seed sowing , appropriate varieties of wheat:, diversified farming instead of growing wheat , application of more chemical fertilizers/pesticides to increase the production, use hybrids/improved crop varieties, willing to leave farming/migrate for remittance, moisture conservation techniques).

5.5 What type of Storage Technique are you following__________________

5.6 What types of adaptation activities are you implementing from Caritas-SAFRIN programme in wheat crop?

………………………………… ………………………………..
………………………………..

5.7 How do you feel that adaptation techniques are better performing in your farm? No/yes

If yes,

If no or partial acceptance mention area of improvements

………………………………… ………………………………..

5.8 How do you feel that adaptation support increasing food self-sufficiency of your house? No/yes

If yes, please said number of month food support ……………………………………………

If no or partial acceptance mention area of improvements

Appendix 2(A): Key Informant survey of climate change for Agro vet, Bardiya

1. General information:

Name: ___________________________ Sex: M/F

Age: ___years

Name of Agro Vet: ___________________________

2. Key informant perception on climate change:

2.1 Have you felt about climate change? Yes/No

If yes, what are the causes of climate change?

____

2.2 Have you experienced any change/deviation in whether pattern in this district?

2.3 What type of hazard effect have you seen in this district in wheat farming?

2.4 Are farmers purchasing chemical fertilizer from this Agro Vet?

Yes/No

If yes, what are they?

Is it increasing or decreasing?

2.4 Mention wheat a variety is preferred most by farmer's in this locality?

2.5 From where are you bringing these seed?

2.6 Is there any failure of rice varieties given by you or any other agro vet?

Yes/No

If Yes which varieties?

2.7 What are the major diseases and pest does the farmer report frequently?

2.8 Are farmers purchasing insecticides and pesticides?

Yes/No

If yes, what are they?

Is it increasing or decreasing?

Appendix 2(B): KIS of climate change for leader farmer, Motipur, Bardiya

1. General information:

Name: __________________________ Sex: M/F

Age: ___years

2. Key informant perception on climate change:

2.1 Have you felt about climate change? Yes/No

If yes, what are the causes of climate change?
____

2.2 Have you experienced any change/deviation in weather pattern in this district?
Yes/No

If yes what are they?

2.3 What type of hazard effect have you seen in this district in wheat farming?

2.4 What are the adoption practices/strategies are you following to cope with climate change hazards in wheat farming? *(Loss of productivity, flooding, disease, pest, drought)*

2.5 Are you implementing these practices in your farming?

2.6 Are you getting any support from any organization to cope with climate change hazard in wheat farming?
Yes/No

If yes mention their name and there support programme?

Appendix 2 (C): Key Informant survey of climate change for DADO, Bardiya

1. General information:

Name: ___________________________ Sex: M/F

Age: ___years

Occupation: ___________________________ position: ______________________________

2. Key informant perception on climate change:

2.1 Have you felt about climate change? Yes/No

If yes, what are the cause of climate change?____

2.2 Have you experienced any change/deviation in whether pattern in your district? Yes/NO

2.3 Does DADO have programs related to climate change in your district?

If yes what type of programs? (Also specify for wheat farming)

2.4 What type of hazard effect have you seen in this district in wheat farming?

2.5 What type of adoption activities strategies are given by DADO for wheat farming to adopt climate change impact?

2.6 What type of farmer's are benefited from this programs?

2.7 Are they implementing them in their farming practice?

Appendix 3: Checklist for Focus Group Discussion (FGD)

Name of Group/community Participants: -------------------- Date of FGD taken--------------

Name of participants: -------------------- …………Address:________________________

Area of wheat farming: total *kattha* ------------------

Q.N1. Do your group feels about the climate change in wheat farming in your locality?

a) Extremely felt b) Moderate feel c) Fairly feel d) No feel

Q.N 2) Does your community discuss on climate change related issues? Yes ( ) No ( )

Q.N.3) What are the major hazard happened in your locality within 10 yrs? Construct timeline of economic losses of climate-induce hazard.

Year	Types of hazards Heavy wind/ Erratic rainfall/hail/insect /disease	Loss of land (kattha)		Loss of wheat (Qnt.)	loss of people (No)	Others
		Cultivable	Others			
2061						
2062						
2063						
2064						
2065						
2066						
2067						
2068						
2069						
2070						
2071						

Q.N 4. Please share effect of hazard and respective adaptation strategies of your group

Hazards	Effects	adaptation strategies implemented
Pre-monsoon rainfall		
More winter rainfall		
Erratic monsoon		
Prolonged drought		
Drought		
Land slide / land loss		

5. In your opinion, what kind of adaptation related supports are getting from Caritas-Nepal? (If other organization supporting adaptation activities please mention)

Support strategy/techniques	**Supported by organizations (Caritas Nepal or other one)**	**Suggestions for future support**
Climate change awareness raising training to the group		
Early warning system		
River/stream control		
Integrated nutrient management		
IPM		
Safe-side construction		
Providing climate-supportive crop varieties		
Rehabilitation of infrastructure		
Other farming technique		
Crop insurance		

Appendix: 4 Correlation between Tmax, Tmin,avg.rainfall with productivity

		Tmax	Tmin	Rainfall	Productivity
Tmax	Pearson Correlation	1	.663**	-.259	.240
	Sig. (2-tailed)		.000	.193	.228
	N	27	27	27	27
Tmin	Pearson Correlation	.663**	1	.009	.322
	Sig. (2-tailed)	.000		.965	.102
	N	27	27	27	27
Rainfall	Pearson Correlation	-.259	.009	1	-.455*
	Sig. (2-tailed)	.193	.965		.017
	N	27	27	27	27
Productivity	Pearson Correlation	.240	.322	-.455*	1
	Sig. (2-tailed)	.228	.102	.017	
	N	27	27	27	27

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Analysis of Variance (ANOVA)

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.582	3	.527	3.805	.024[a]
	Residual	3.187	23	.139		
	Total	4.769	26			

a. Predictors: (Constant), Rainfall, Tmin, Tmax

b. Dependent Variable: productivity

Appendix 5: Model Summary showing correlation between age, gender, *Khet land* , wheat land and productivity

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.799[a]	.639	.620	2.456

a. Predictors: (Constant), wheat land, Age, gender, *Khet land*

Analysis of Variance (ANOVA[b])

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	800.651	4	200.163	33.187	.000[a]
	Residual	452.346	75	6.031		
	Total	1252.997	79			

a. Predictors: (Constant), wheat land, Age, gender, *khet land*

b. Dependent Variable: production

Appendix 6: Rainfall of Rani jharuwa nursery Bardiya

Year	Monsoon Rainfall (mm)	Pre monsoon rainfall (mm)	Post Monsoon Rainfall (mm)	Winter Rainfall (mm)	annual rainfall (mm)	annual rainfall (mm)
1986	1151.4	153	33.2	73.4	1411	1411
1987	1001.1	166.2	22.2	45.9	1235.4	1235.4
1988	1626.9	40	10	45.6	1722.5	1722.5
1989	1388.9	367.5	16.7	113.8	1886.9	1886.9
1990	1160.4	72.6	47.4	92.4	1372.8	1372.8
1991	711.5	79.4	2	93	885.9	885.9
1992	930.9	165.8	61.5	67.5	1225.7	1225.7
1993	1047.6	15.9	0	28.3	1091.8	1091.8
1994	475.2	127.2	0	77.8	680.2	680.2
1995	1495.3	16.1	7.2	142.4	1661	1661
1996	1254.7	57.8	40.6	103	1456.1	1456.1
1997	1363.6	106.8	54	154.8	1679.2	1679.2
1998	1389.1	105	112.5	16	1622.6	1622.6
1999	1173.2	39.7	116	5.9	1334.8	1334.8
2000	1169.5	189.5	0	50.5	1409.5	1409.5
2001	1116.2	101.5	22	2	1241.7	1241.7
2002	976.4	66	28	117.5	1187.9	1187.9
2003	1106	94	0	115	1315	1315
2004	603.4	41	104.6	28	777	777
2005	974.1	91.8	75.5	104.6	1246	1246
2006	606.6	75	10	8	699.6	699.6
2007	1498.8	48	0	76	1622.8	1622.8
2008	1222.2	7	0	0	1229.2	1229.2
2009	903.6	58	261.5	0	1223.1	1223.1
2010	822.5	57	0	49	928.5	928.5
2011	877.9	17	0	64	958.9	958.9
2012	1785	95.6	10.5	18.5	1909.6	1909.6
	317.574664	73.6965007	57.3557278	45.6182318		

Appendix 7: Maximum tem, minimum tem, and average rainfall and of wheat growing season and productivity of wheat (1985-2012)

Year	Tmax(^{0}c)	Tmin(^{0}c)	Rainfall(mm)	Productivity(mt/hac)
1985/86	27.51	11.4	15.18	1.50
1986/87	24.6	12.3	15.26	1.50
1987/88	28.95	11.93	21.98	1.50
1988/89	27.61	11	16.73	1.50
1989/90	28.49	14.3	28.98	1.56
1990/91	27.85	12.3	15.83	1.56
1991/92	27.16	11.05	13.85	1.40
1992/93	27.01	11.61	22.58	1.41
1993/94	28.03	11.55	12.96	1.52
1994/95	27.61	11.61	24.86	1.64
1995/96	27.63	12.53	19.16	1.53
1996/97	26.83	11.2	14.96	1.66
1997/98	25.6	12.36	32.31	1.68
1998/99	27.81	12.6	6	1.90
1999/00	27.05	11.5	15.76	2.20
2000/01	27.9	11.25	0.66	2.34
2001/02	27.9	11.25	18.5	1.82
2002/03	27.16	11.36	25.16	2.30
2003/04	27.6	12.71	8.83	2.49
2004/05	27.18	12.66	21.26	2.42
2005/06	28.73	11.55	6.8	2.40
2006/07	26.66	15.53	23	2.60
2007/08	28.63	11.7	0	2.76
2008/09	29.63	12.38	1.16	2.18
2009/10	28.5	12.76	5.33	2.15
2010/11	36.8	18.4	15.66	2.13
2011/12	30.46	17.7	5.91	2.38

Appendix 8: Field Survey Related Photos

Photo 1: Location of Caritas-SAFBIN working area in Bardia

Photos 2 and 3: Household survey in study sites

Photos 4 and 5: Focus group discussion at Kalika VDC, Bardia