THE EFFECT OF CLIMATE CHANGE ON AGRICULTURAL PRODUCTIVITY IN THE CASE OF KOBO WOREDA, ETHIOPIA

A Thesis Submitted to Faculty of Bussiness and Economics Department of Economics

In Partial Fulfillment of The Requirements Master of Science Degree in Development Economics

By: Adane Mekonen

Faculty of Business and Economics

Department of Economics

JUNE, 2024

WOLDIA, ETHIOPIA

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Submitted by: Adane Mekonen (ID, GSE14013)

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STATEMENT OF DECLARATION

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This is to certify that this thesis entitled 'The Effect of Climate Change on Agricultural Productivity in the Case of Kobo Woreda, Ethiopia' embodies the work carried out by Adane Mekonnen himself/herself under my supervision and that is worthy of consideration for the award of the MSc degree.

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TABLE OF CONTENTS

Contents **Page**

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LISTS OF TABLES

List of tables **Page**

LISTS OF FIGURES

Lists of Figure page

ABSTRACT

Agriculture remains the main activity in the Ethiopian economy being the most susceptible sector to climate change. This study was initiated to analyze the effect of climate change on crop productivity and livestock production, and assess perception and adaptation strategies of farmers in Raya Kobo Woreda.. Climate data (1990-2019) and crop data from 2010-2019 were collected from the National Meteorology Agency of Ethiopia (NMA) and agricultural office of the woreda respectively. Data on farmers' perception of climate change and adaptation strategies used in the study area were collected from 322 household heads using structured questionnaire. Descriptive and Inferential statics were used to check the relationship between climate variables and agricultural production. Meteorological analyses of climate variability results, which demonstrated a statistically significant increase in temperature and decrease in rainfall in the study area. The results of analysis showed rainfall and temperature contribute significant variations in the yield of the selected items in the study area. Livestock Production in Raya kobo Woreda were also appeared inconsistent as shown with coefficient of variation 30%, 24%, 26%, 36% 44% and 22% for oxen, Cows Sheep Goat, camel and chicken respectively. Perception analysis indicated that most of the respondents perceived long-term variability in pattern of rainfall and temperature. The current result revealed that when the annual rainfall diverges from its long run mean, the level of production of all crops and livestock diminished significantly. Extreme temperature had also diminished the productivity of livestock and crop. Thus, it is concluded that extreme temperature and rainfall were an inevitable treat to crop and livestock production in the study area. Thus, to sustain economic growth and reduce those risks, farmers intensify adaptation and mitigation measures such as s oil and water conservation, livelihood diversification environmental rehabilitation, irrigation and water harvesting schemes, planting trees, mixed cropping, using resistant varieties and small irrigation.

Key words*:* Adaptation, Climate change, Crop production , Livestock

CHAPTER ONE

1. INTRODUCTION

1.1. Back ground and Justification

In Ethiopia, agricultures is about 47% of the country's Gross domestic product (GDP) and more than 70million that is people (85% of the Ethiopian population) depend on agriculture directly or indirectly for their livelihoods (Mundi, 2014).Therefore, any effect on agriculture was significantly affect the Ethiopian economy. It is predicted that climate change was lead to recurrent droughts and reducing the amount of land that can be used for agriculture and consequently decreasing crop productivity. Ethiopia is the home to Africa's largest livestock population, and is the world's tenth largest producer of livestock and livestock products (Macdonald and Simon, 2011), which make up about 10% of the country's foreign currency earnings (Pantuliano and Wekesa, 2008).Frequent and extensive droughts in the country have a considerable effects on Ethiopia's livestock. Decreased rainfall shrinks the availability of water resources and reduces the productivity of grassland. The number of animals per household declined on average ‘to three oxen from ten; to seven cows from 35; and to six goats, down from 33'(MacDonald. and Simon, 2011).

Climate change is expected to increase the surface of temperature of the earth and the ocean, raises the sea levels, alter the global distribution of rainfall, affect the direction of ocean currents and major airstreams, and increase the intensity and frequency of extreme weather. It is already causing loss of life, damaging property and affecting livelihoods in all the nations. Population in developing countries‟ is expected to increase by around 2.4 billion by 2050. In these developing countries agriculture is the main source of employment and income to the majority. 20 per cent of the populations are food insecure and 75 per cent of the World populations live in rural areas where agriculture is the main source of their livelihood Lipper, Campell and Thorntonn (2014). Global projections puts it that agricultural production need to be increased by 60 per cent in 2050 to meet high demand of food and this need to come from agricultural production increment. Climate change already interferes with agricultural productivity IPCC (2015), crop production is affect the most in most developing nations with negative effects greater than positive effects.

Climate change has already reduced crop production by 4.7 percent and it is expected to experience a steep decrease if temperatures exceed the critical physiological thresholds. Climatic change is a public good, therefore, requiring comprehensive action to deal with. Causes of climate change are found to be the natural greenhouse effect due to3 high carbon dioxide concentrations in the atmosphere, Wheel and Braun (2013).Accumulation of too much carbon dioxide in atmosphere reduces ozone layer allowing infrared rays of the sun to infiltrate resulting to global warming which subsequently leads to climate change. Climate change is an externality that agricultural production of the world faces such that current decisions made by agents influence future welfare of individuals in the future periods, Sanders and Islam (2007). Externality is a global environmental issue that has a cost to be incurred by everyone and all nations including those that do not contribute to its effect through the decisions made currently which results to changes in state variables such as the atmospheric concentration of greenhouse gases, water availability and specimen richness.

Stern (2009), says that efficient allocation of resources with global externalities require cooperation by independent countries over a long period of time involving various cohorts of decision-making. Failure to address these issues results to devastating effect on the economy of any particular nation. In case of climate change, IPCC said that continues emissions of greenhouse gases (GHGs) would possibly results to global warming over the subsequent years with possibility of large degradation on the world economy (IPCC, 2007). There is consensus that climate change is a serious issue in Sub-Sahara Africa and in fact the greatest problem during the 21st century, together with poverty, Wario (2012). Development projections in Africa proportionately affected by climate change as most countries in Africa are composed of undiversified economic structures, poor infrastructural facilities, weak governance institutions and structures, low human development and more so the countries heavily rely on agriculture to feed most of their population (Akram, 2012).

Agriculture in Ethiopia is heavily dependent on rain and geographical location and topography, plus a low adaptive capacity, make the country highly vulnerable to the adverse impacts of climate change (Zenebe G., *et.al*. 2011). It is believed that agriculture is the most susceptible sector to climate change. This is attributed to the fact that climate change affects the two most important direct agricultural production inputs, precipitation and temperature. Climate change also indirectly affects agriculture by influencing the emergence and distribution of crop pests and livestock diseases, exacerbating the frequency and distribution of adverse weather conditions, reducing water supplies and irrigation; and enhancing severity of soil erosion (McCarthy *et al*. 2001).Climate variability directly affects agricultural production since agriculture is inherently sensitive to climatic conditions and is one of the most vulnerable sectors to the risks and impacts of global climate change. Climate change wasaffect food security by reducing livelihood productivity and opportunities (Chichongue *et.al*, 2015).

Reports strongly agreed that observed variation in climate and weather conditions, such as recurrent droughts, heat waves, shift in onset and cessation, short duration of growing season, erratic and uneven rainfall distribution and long dry spell conditions during the growing season significantly affecting the efforts of sustaining food production in Ethiopia with more severity in rural communities subsists in dry areas (IFAD, 2016). According to the report of food and agriculture organization, increasing population, land degradation, and frequent droughts results frequent food crises in Ethiopia (FAO, 2015). In Ethiopia, climate plays a significant role in explaining variation in crop net income and food security levels. Average precipitation and temperature during the rainy season is positively and significantly associated with food security and crop net income.

Agriculture serves as the main economic stay and means of livelihood to the majority of the Kobo towns' people. It is characterized by traditional mixed farming as it includes both crop production and livestock rearing, dependent mainly on rainfall. The main crops produced through rainfall are cereals (Teff, sorghum and maize) and pulses (chick peas). Furthermore, as of 2003, horticultural crops (onion, tomato, pepper) and fruits such as Mango, Papaya, Banana and Avocado are being produced with the help of modern small scale irrigation (Goitom, 2009).

Erratic rainfall patterns and frequent drought prevalence in the North Wollo Zone are common climatic problems in both time and space (Mohammed *et al*., 2018). There had been gaps or no previous research on this topic in this study area. Hence, Kobo Woreda being most of the population entirely depends on agriculture and livestock production with vast number of animals, fertile land and different crop production; it demands understanding the seasonal patterns of climatic conditions to manage and identify the possible climatic risks of the location in respective of the production season.

1.2. Statements of Problems

Many Regional summits worldwide have dedicated discussion sessions on climate change based on the recognition that the global climate change has an adverse impact on a nation's economy in general, and agricultural production in particular, Intergovernmental Panel on Climate Change (IPCC, 2010). Ethiopia is one of the most vulnerable countries to climate change. The agriculture sector which contributes more than 45% of GDP, 80% to labor force and 85% to foreign exchange earnings is highly susceptible to climate change. More than 95% of crop production which is rainfall dependent has been produced by small holders and subsistent farmers who have less capacity to adaptation of climate change (MoFED, 2006).

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Ethiopia is one of the countries in the Horn of East Africa hit by frequent drought over the last century. This was confirmed by various local and national level studies conducted in the country (Bewket and Conway, 2007; Cheung *et al*., 2008; Viste *et al*., 2013). For instance, the study by Rosell (2011) for three decades (1987-2007), indicated a decline in rainfall and an increase in temperature for the spring season in the central highlands of Ethiopia. Besides, Viste *et al.* (2013) found that the years 1972-1975, 1980-1982, 1984, 1987, 1990-1992, 1999-2000, 2002-2003, and 2008-2011 were the periods of severe drought episodes in Ethiopia. Furthermore, the recent 3-5 decades temperature and rainfall data analysis by Fazzini *et al.* (2015) reported a markedly increasing and decreasing trend for minimum temperature and annual spring season rainfall respectively in the country.

However, there are studies reported the absence of significant variation, particularly in terms of total annual rainfall, as opposed to the farmers' usual perception of total rainfall shortage in most parts of Ethiopia (Seleshi and Zanke, 2004; Kassie *et al*., 2013; Adimassu *et al*., 2014). The main reason for these divergent results in the trend analysis of the annual rainfall of the country is the difference in base periods used for analysis (Agnew and Chappell, 1999; Bewket and Conway, 2007). In general, Ethiopia as a country whose economy is mainly dependent on rain-fed agriculture, the trend of seasonal rainfall is an important factor determining the socioeconomic functioning, particularly food production potential of the country (Mideksa, 2010; Fazzini *et al*., 2015; Fekadu, 2015). Climatic trend information is quite crucial to practice climate-responsive agriculture and to minimize climate-related production risks. Hence, this study was intended to assess the effect of climate change on agricultural productivity on Kobo woreda and to propose evidence-based recommendations for enhancing resilience and sustainability in agricultural systems and devise future policy direction and better management strategies.

1.3. Objectives

1.3.1. General objective

The general objective of the study were to examine the effect of climate change on agricultural productivity on Kobo woreda.

1.3.2. Specific objectives:

The specific objectives of the study were:

To assess the current state of agricultural productivity in Kobo Woreda, Ethiopia, and identify any trends or changes over time.

To investigate the adaptive strategies employed by local farmers and communities to cope with climate-related challenges and maintain agricultural productivity.

To examine the effect of climate change on agricultural productivity in the study area.

1.4. Research question

The study was seek to respond to the following questions:

i) What looks like the current agricultural productivity of Kobo Woreda so far?

ii) What is the effect of climate change on agricultural practices, crop yields and livelihoods in the study area?

iii) What adaptive strategies employed by local farmers and communities to cope with climate-related challenges and maintain agricultural productivity?

1.5. Significance of the study

Changes in climatic conditions have been proved problematic when it comes to development planning. The study assess the effect of climate change and seeks to form both mitigation and adaptation policies which are cost effective and easy to implement into Ethiopian development plans. The study findings would be more important to farmers who are suffering loses as a result of climate change by planting drought resistant crops; keeping livestock that adapt to climatic changes to avoid such loses in future. The study would provide important information regarded by the provision of how to tackle the adverse impact of climate change on agricultural crop productivity and livelihood in the study area. It has also to provide an input for policy makers to modify the policy of climate change as according to the problems at grassroots level in the country. Furthermore, the study would be helpful for researchers, academicians, farmers and students to identify the problem of climate change and sustainable development.

1.6 Scope of the Study

The study was carried out in kobo with metrological data from1990- 2019 to assess changes in climatic conditions in terms of temperature and rainfall which often affect the agricultural production in the country as a whole and also has greater impact on crop production specifically. The arrival of climate change on the policy agenda in Ethiopia is fairly recent. The timeframe from 1990- 2019 is chosen to give appropriate sample size that was used for data analysis during research work. Scope of the study pressured on impact of climate change on crop production in Kobo woreda. The study was limited only to this woreda because of attempted to analyze the agricultural crop production farmers to facilitated accessibility which comes beyond the researcher.

1.7. Organization and Structure of the study

This research paper was organized in five chapters. Accordingly, the first chapter provides general introduction of the research, which includes background of the research, statement of the problem, objective of the research, significance of the research, research question, and scope of the research and organization of the research. The second and the third chapter were about reviewing related literature and research design and methods respectively. The fourth chapter was data presentation, analysis and interpretation. Lastly in chapter five major conclusions and recommendations was addressed.

CHAPTER TWO

LITERATURE REVIEW

2.1. Theoretical Literature Review

2.1.1 Definitions and Concepts

Climate: climate usually defined as the average weather or more rigorously as statistical description in terms of the mean and the variability of relevant quantities over 30 years, as defined by World Meteorological Organization (WMO.2007).

Weather: is a short term phenomenon, describing atmosphere, daily air temperature. Pressure on humidity, wind speed (IPAC, 2007). E.C terms

Climate variability: variation in mean state and other satisfied (Fleineal, 2007) E.C. **Climate change**: A change in the state of climate that can be identified (example by using satisfied tests) by change in the mean or variability of its properties and that exists for an extended period, typically decades or longer. Climate change can be due to natural internal process or external force to persistent anthropogenic changes in the composition of the atmosphere or in land use (IPACC, 2008).

2.1.2. Impact of Climate Change on Agriculture

Changes in temperature as well as rainfall patterns and the increase in CO_2 levels projected to accompany climate change was have important effects on global agriculture especially in the tropical regions. It is expected that crop productivity was alter due to these changes in climate, weather events and changes in patterns of pests and diseases. The suitable land areas for cultivation of key staple crops could undergo geographic shifts in response to climate change (Aydinalp and Cresser, 2008). Temperature, precipitation, atmospheric CO_2 content, incidence of extreme events and sea level rise are the main climate change related drivers which impact agricultural production. Extreme events also play a role for example where droughts and floods become more severe, agricultural losses would increase (Adams et al., 1998).

In particular, soil moisture loss is determined by temperature and maintenance of a constant water supply given any temperature increases need to be offset by precipitation increases and/or expansions in applied irrigation water. Furthermore, microbial decomposition is stimulated by warmer temperatures so the availability of soil nutrients and organic matter which helps hold the soil moisture may be negatively affected by warmer temperature. Irrigation water supply was be influenced by changes in the volume of water supplied by precipitation as well as by temperature alterations effects on evaporation also changes in temperature regimes can alter the timing of sno w melt based runoff and thus both the seasonality of available water supply and the needed size of impoundments holding water for summer supplies (Aydinalp and Cresser, 2008).

2.1.3. Crop Yield and Climate Change

Plant physiology has been greatly influenced by climate variability by several means. Environmental extremes and climate variability enhanced the chances of numerous stresses on plants (Thornton *et al*., 2014). Climate change affects crop production by means of direct, indirect, and socio-economic effects. Furthermore, climate change (drought, flood, high temperature, storm etc.) events are increased dramatically as reported by Food and Agriculture Organization (FAO). Boyer reported that the climate changes have reduced the crop yield up to 70% since 1982. According to the study of FAO 2007, all cultivated areas in the world are affected by climatic changes and only 3.5% of areas are safe from environmental limitations (Van, 2007).

In future, the productivity of the major crops is estimated to drop in many countries of the world due to global warming, water shortage, and other environmental impacts (Bonan and Doney, 2018). Wheat production is heavily affected by the temperature extremes due to climate change in many countries, and may reduce the crop yield by 6% for each ◦C rise in temperature (Assenget al., 2015). Drought and high temperatures are key stress factors with high impact on cereal yields (Barnabás*et al*., 2008) and Rubisco, the central enzyme of photosynthesis, is disrupted if the temperature increases from 35◦C and stops the photosynthetic process (Griffin *et al*.,2004).

Due to climate change, water deficit and temperature extremes influence the reproductive phase of plant growth. It was described that the flower initiation and inflorescence is badly affected by the water stress in cereals (Winkel*et al*.,1997). Similarly, if the temperature increases of about 30◦C during floret development it can cause sterility in cereals (Saini and Aspinall*et al.*,1982). During the meiotic phase, wheat and rice suffered from the 35-75% reduction in grain set due to water deficit (Sheoran and Saini, 1997). In rice, drought stress greatly disturbs the process of fertilization and anthesis. Zhao *et al*. (2017) carried an experiment to analyze the climate change impact on major crop yields and showed considerable yield reductions of 6%, 3.2%, 3.1%, and 7.4% in wheat, rice, soybean, and maize respectively.

2.1.4. Effect of Climate Change on Livestock

Climate change could affect livestock and dairy production. The pattern of animal husbandry may be affected by alterations in climate, cropping patterns, as well as ranges of disease vectors. The higher temperatures would likely result in a decline in dairy production, reduced animal weight gain and reproduction and lower feed-conversion efficiency in warm regions. More mixed impacts are predicted for cooler regions. If the intensity and length of cold periods in temperate areas are reduced by warming, feed requirements may be reduced, survival of young animals enhanced and energy costs for heating of animal quarters reduced (Aydinalp and Cresser, 2008).

Incidence of diseases of livestock and other animals are likely to be affected by climate change, since most diseases are transmitted by vectors such as ticks and flies, the development stages of which are often heavily dependent on temperature. Cattle, goat, horse and sheep are also vulnerable to an extensive range of nematode worm infections, most of which have their development stages influenced by climatic conditions. In general; intensely managed livestock systems have more potential for adaptation than mixed livestock cropping systems. Adaptation may be more problematic in pastoral systems where production is very sensitive to climate change, technology changes introduce new risks and the rate of technology adoption is slow. Livestock production may also be affected by potential changes in grain prices brought on by changing yields in some areas or by changes in rangeland and pasture productivity. For developing countries, livestock are better able to survive severe weather events such as drought than are crops and therefore a better option in terms of income protection and food security (Aydinalp and Cresser, 2008).

Livestock producers can adapt to climate change by the provision of shading, sprinklers, improved air flow, lessened crowding, altered diets, and more care in handling animals. Herds or the locus of livestock production may also be moved to more hospitable locations. In the longer term, new crop varieties and livestock breeds may be developed that perform better under the anticipated future climate regime (IPCC, 1996).

2.1.5. Agriculture and Climate Change Mitigation

Regardless of the projected or actual impacts of climate change, agriculture is also likely to be directly or indirectly involved in climate change mitigation efforts. Greenhouse gas emissions (GHGE) constitute a global production externality which is likely to adversely affect climate. Actions under that convention yielded the Kyoto Protocol which represents the first significant international agreement towards GHGE reduction. Agriculture (using a definition including forestry) is mentioned as both an emitter and a sink in the protocol. Agriculture as an emission sources from enteric fermentation, manure management, rice cultivation, soil management, field burning and deforestation. The protocol also lists agriculturally related sinks of afforestation and reforestation. Additional sources and sinks are under consideration including agricultural soil carbon (McCarl *et al*., 2001).

2.1.6. Countermeasures against Climate Change

It has been known that climate change has resulted from the disruption of the energy balance for the global climatic system caused by the increase of greenhouse gases and aerosol in the atmosphere and the changes in land covering and solar radiation. Especially, it has been suggested by the results of scientific analyses that global warming is very likely to have resulted from human activities (IPCC,2007). Countermeasures that the agricultural sector can consider in the face of risks and challenges of climate change, represented by global warming, are largely divide into the mitigation method that reduces the scale and rate of climate change by mitigating and absorbing the greenhouse gas emission and the adaptation method that admits the inevitability of global warming, understands the impacts of climate change, and minimizes the damages it could cause,. Mitigation measures for the agricultural sector include the improvement of cultivation methods through improved irrigation and fertilization control for the arable sector to suppress major greenhouse gases such as methane (CH4) and nitrous oxide (N2O), improvement of animal excretion treatment technologies in the livestock sector, and carbon fixing for the farmland soil.8 In relation to the countermeasures against climate change for the agricultural sector, this study focuses on the adaptation plans based on the analysis of the impacts of climate change.

2.2. Empirical Literature Review

Fankhauser and Tol (2005), carried out a study on the effect of climate change on agricultural productivity especially on livestock production. The study found that the impact of climate change can only be measured to the extent of a given period and the social welfare of that period. The study considered the dynamic effect of climate change on livestock production and the wellbeing of the society as a whole. The variables considered in the study were precipitation and temperature as independent variables while livestock production as the dependent variable. The study adopted diagnostic research design with panel data across some countries in Africa. The study assumed constant savings rate, so that a reduction in output as a results of climate change was proportionately lead to reduction in level of investment which in turn depress future livestock production level, this is due to capital accumulation effect, in return affecting future level of consumption per capita. If the rate of savings is taken as an endogenous variable, then forward looking agents would most likely alter their rate of savings to match with the effect of future changes in climatic conditions.

The variables of the study were crop productivity as the dependent variable and rainfall, temperature and soil type were independent variables. The main climatic factor that affects crop productivity was found to be temperature but not rainfall as it was easily predicted than rainfall which usually changes from time to time. A cross-sectional study design was used in order to obtain the data across various crops for the study. The study recommended introduction of drought resistant crop to cub crop vulnerability to climate change.

Tol (2011), while carrying out a study on effect of climate change on crop production, found out that, moderate climate change brought net benefits. Some of the benefit included carbon dioxide, fertilization of crops and reduced energy demand. Climate change has had a negative effect on water sources and (by and large) human health. Most rich and poor countries benefitted from effects of climate changes until early1980s, after which the trend become negative for most poor countries and positive for financially stable nations. Thereafter, the trend became negative for both poor and rich nations.

Future changes in world"s climatic condition are a concern for most developing countries as the impact was be greater on productivity. The effect of climate change on human health was found to be more negative than positive; the study also found out that there is a negative relationship between climate change and human health; and that the growth rate of most poor countries would be reduced by 0.6 per cent points. Climate change affects accumulation of capital and people" propensity to save, which, subsequently, reduces production level of the world developing nations. The study adopted descriptive research design with cross-sectional data across various crops. The data was analyzed using multi variate regression model to analyze the effect of climate change on crop production.

Variables used in the study are carbon dioxide, rainfall amount and net crop production, however, the study failed to consider the effect of other climatic variable such as precipitation and temperature which the study seek to undertake Baumgard, Rhoads, Gabler, Lenka and Sejian (2012), while carrying out a study on the impact of climate change on livestock production found out that climate change adversely affects livestock industry and ultimately impacts the production of animal protein which is a crucial ingredient dietary required by human for health yproduction. The study used a cross-sectional data across countries from published sources for analysis using descriptive research design, the study also considered mean temperature as the independent variable. The study found that climate change directly and indirectly affects the livestock welfare and productivity.

The direct effects of climate change on livestock production are post-absorptive metabolism, nutrient portioning, and eventually production while the indirect effects are reduced feed intake, alteration of immune systems, reduction in feeding habits, water body availability and quality, and increased environmental interaction with disease causing parasites and vectors. The negative effects of climate change on livestock production was be on the rise as long as global warming is on the upper hand.

The greatest impediment to livestock production that the study found out is the heat stress (high temperature) in regions which is agriculturally rich in animal production and particularly in tropics and sub-tropic regions of developing countries. Even though the study analyzed the effect of temperature on livestock production, the study failed to consider the effect of humidity and rainfall variability on livestock production which the study seek to incorporate in the model and analyze their effect on livestock production.

Bowen, Cochrane and Fankhauser (2012), while carrying out study on the impacts of climate change on economic growth and its adaptation across countries found out that changes in climate has both positive and negative impacts on economic growth and development but in the long-run, negative effects out-do positive effects. The study also found out that growth and development reduce vulnerability to changes in climate but only right growth policies was have such reduction. Climate change can alter the growth path of a country especially the agricultural sector and also interfere with investment plans since the priorities was be directed to adaption. High temperatures and extremes of climate change tend to lower growth rates in less developing countries by affecting growth factors such as human capital accumulation and fiscal and monetary stability of a country. The ability of a country to handle climate change highly depends on quality of the institutions handling climate change, education level of the citizens and per capita income that is brought about by improvement in economic growth. The study found that a 1 per cent increase in temperature reduced economic growth by about 1.1 per cent point per year using panel data across countries.

The variables used in the study were temperature, economic growth and income from various countries, the study adopted descriptive research design with cross-sectional data across countries. However, the study failed to consider time-series data and the effect of humidity on production which the study analyzed.

Smith, Pete and Peter, (2013), carried out a study on the impacts of climate change on sustainable food production found out that changes in climatic conditions greatly affect food production negatively. The study adopted descriptive research design with panel data, the variables used in the study were rainfall, temperature and carbon dioxide. The study found out that problem of food security, reduction of climatic impacts and provision of resilience to future changes in climatic conditions, meanschoosing between capital and consumption-based food production systems is aproblem in the world that intensively depends on agriculture as the main source oflivelihood; indeed, we clearly need both. The more the management of the demandfor land-intensive food production, the less production is intensified.

Reducing GHG emissions in agricultural sector, the more reduction potentials are realized through a combination of technological and food consumption-based measures. The study suggested that measures that deliver on sustainable food production was also deliveron reducing GHGs emission in agriculture together. According to the United Nations‟definition; „food security exists when all people, at all times, have physical andeconomic access to sufficient, safe and nutritious food to meet their dietary needs andfood preferences for an active and healthy life‟. As the focus on delivering of foodsecurity on top gear, we must also endeavor to reduce the environmental impacts of food production that are associated with GHGs emissions as future climate change was make a great impact on food production since agricultural production nearly contributes about 30 per cent of anthropogenic GHGs emissions that contributes toclimate change. The variables of the study were temperature, rainfall and carbondioxide as food production highly dependent on them, therefore, very vulnerable. Thestudy failed to incorporate relative humidity which the current study incorporated andanalyzed its effect on agricultural productivity in Kenya. Kasimba (2014), carried out a study on the impacts of climate change on cropproduction, found out that climate change affects crop productivity as a result ofinsufficient rains, high temperatures and sometimes too much rain resulting to theoutbreak of various crop diseases. The study was carried out in Guruve district in Zimbabwe and used qualitative and quantitative research design methodologies to analyze the impacts of climate change on crop production practices and tried to comeup with best approaches to improve crop production. The data used in the study was collected across farmers in the region using structured questionnaires and one on oneinterview. The variables considered under the study were rainfall, temperature and disease. The study found out that rainfall variability causes decline in crop productionas a result of drought, occasional occurrence of extreme low temperature also found tohave the same effects as rainfall while frequent change in climate also led towidespread of pest and diseases as a result of high temperature which adversely lowers crop production. The study failed to consider the effect of climate change onlarge scale farmers which the current study considered as climate change affect allfarmers irrespective of the type of farming being carried out.

Kabubo, Mariara and Kabara (2015), while carrying out a study on impacts of climate change on food security in Kenya found out that climate variability and change reduces food security through food availability, food accessibility, food utilization and food stability. During the study, the country was divided into three major regions that is high potential region, medium potential region and arid and semi-arid region. The study found that high rainfall is necessary for increased crop yield hence food security while excess leads to flooding and water logging which is harmful to crops at initial stages and during harvest it leads to rotting of mature crops.

The study adopted descriptive research design with a panel data collected from published sources from county to county basis was used on major crops such as beans, sorghum and maize, the climatic variables used in the study were precipitation, temperature, and run-off and cloud cover over the years. The study adopted Ricardian regression model to estimates the impacts of climate change on food security. The variables considered during the study were crop agricultural land as dependent variable while crop productivity and the factors affecting climate were used as independent variables. Regression analysis was used to show the effects of climate change on food security.

The study did not consider the effect of relative humidity as a climatic variable on food security; the current study took to incorporate relative humidity and analyzed its effect on crop production. Study carried out by Nkonde (2014) on the impacts of climate change on livestock production in Mpolonjeni Area in Swaziland found out that climate change does affect livestock production and livestock system particularly in less developed countries. The study found that high temperatures and unpredictable rainfall patterns translates to an increased spread of vector-borne diseases and parasites as well as emergence and spread of new diseases, it also has effects on natural pastures which livestock owners majorly depend on for feeding their livestock. Variables of the study were livestock production as an independent variable, rainfall, temperature and land use as independent variables. The study utilizes both qualitative and quantitative research design. Primary data was used where a stratified sampling design was used to obtain required sample after which the data for livestock was collected using personal interviews while temperature and rainfall data was collected from published documents from Swaziland Meteorology Department.

Ricardian regression model and descriptive statistics was used to show the impacts of climate change on livestock production. Adams, et al., (2015), carried out a study on the effects of climate change on agriculture, considered effects on crop productivity and livestockproduction across countries in Africa. The study found out those climatic factors such as temperature, precipitation change and high amount of carbon dioxide concentration in the atmosphere have greater effect on crop productivity, temperature was found to25both positive and negative impacts on yield, but generally, increases in temperaturewas found to reduce crop yields and quality of grains. Increase in precipitation wasfound to be useful in drier areas buy increasing soil-moisture, therefore increasingcrop yield while high levels of carbon dioxide concentration were found to results tohigher net photosynthesis rates. Generally, these climatic factors were found to haveeffects of crop productivity. The study also considered the effects of climate changeon livestock productivity, climatic changes affects livestock productivity in two ways,that is, through the quality and amount of forage from grasslands and highertemperatures. Livestock production were affected in terms of milk production, heiferand meat production. The study adopted descriptive research design with stratified sampling design. The variables of the study were temperature, precipitation, rainfalland carbon dioxide as independent variables while net livestock and crop productivityas dependent variables. The study utilizes time series data for analysis using structuralapproach where crop simulation models were used to factor in effects of carbondioxide. The study found out that holding all the other factors constant, temperaturechanges results to a decrease in crop yield while precipitation increases results to increases crop yield.

CHAPTER THREE

RESEARCH METHODS

3.1. Description of study area

The study was carried out at Kobo district, North Wollo zone, Amhara region, Ethiopia. According to the meteorological data of the site, the area is situated at 39°38.45'N and 12°8.5' N latitude. The study area was in the northeastern tip of the Amhara region. It is hemmed in the Tigray region in the north and northeast, the Afar region in the east, Gidan Woreda in the west, and Gubalafto Woreda in the south. It is about 570 Kilometers northeast of Addis Ababa astride on the highway from Addis Ababa to Mekele. The administrative map of Kobo Woreda is given in Figure 1 below.

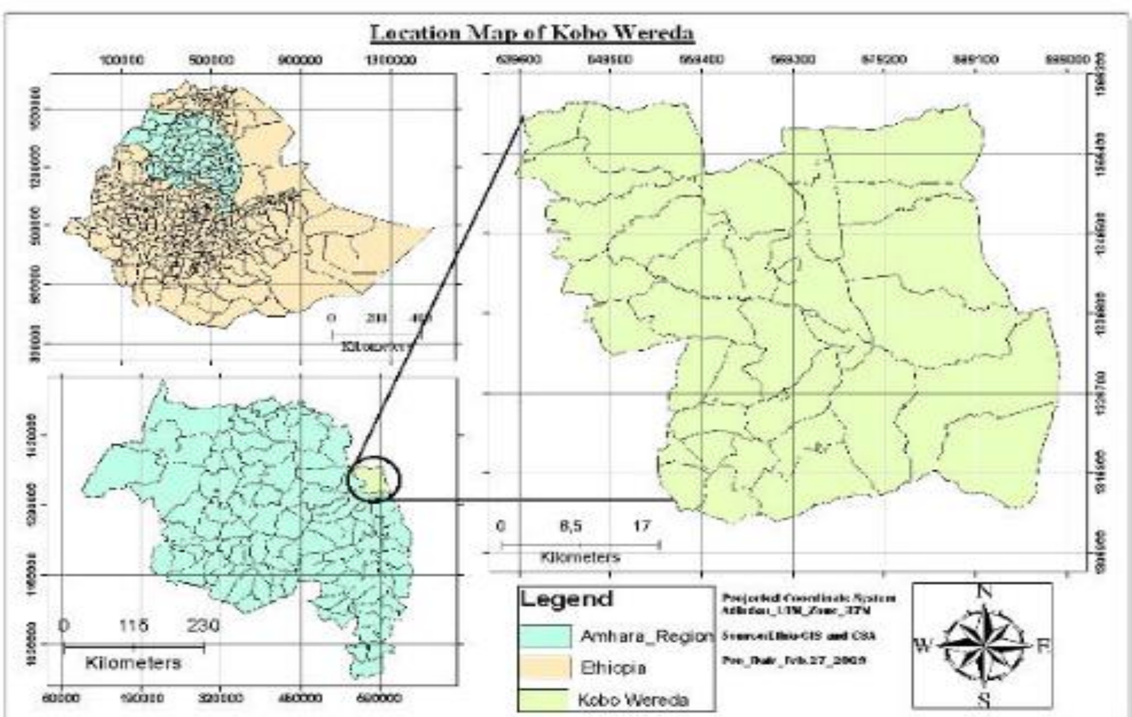

Figure 1 The administrative map of Kobo Woreda

Based on the 2007 national census conducted by the Central Statistical Agency of Ethiopia (CSA, 2007), this district has a total population of 221,958, an increase of 26.43% over the 1994 census, of whom 111,605 are men and 110,353 women; 33,142 or 14.93% are urban inhabitants.

With an area of 2,001.57 square kilometres, Kobo has a population density of 110.89, which is less than the Zone average of 123.25 persons per square kilometers. A total of 54,466 households were counted in this district, resulting in an average of 4.08 persons per household, and 52,108 housing units. Most of the inhabitants practiced Ethiopian Orthodox Christianity, with 82.88% reporting that as their religion, while 16.5% of the population said they were Muslim.

The study area is characterized by pronounced variations in scenery. The landscape has two main features namely and western mountainous terrain and the eastern low-lying flat plain squashed in between the two ridges. Altitude ranges between about 1468 (Qolla) meters above sea level at Kobo town and 2230 meters above sea level in Shaway which is a Woina dega agro-climatic zone. The mean annual rainfall is around 500mm. It is agro-ecologically characterized as a warm sub-moist midland with an altitude of 1450 masl. The mean annual maximum and minimum temperatures are 30.4^0c and 15.3^0c respectively. The district is mainly known by the production of cereals like teff, sorghum, and maize and livestock rearing.

3.2. Research Approach and Design of the Study

The research approach applied to this study was a mixed research approach. The reasons for combining both qualitative and quantitative designs are to develop a complete understanding and to develop measurement instruments (Creswell, 2012). The data collection involves gathering numeric or quantitative information by structured questionnaires so that the final data was presented with both quantitative and qualitative information. The main reason for using a mixed approach was be the nature of the data gathered from the respondents which is both qualitative and quantitative in nature. The uses of this method enable extraction of relevant and adequate data on the effect of climate variability on crop production.

3.3 Types and Sources of Data

Primary data was collected from farm households with structured interviews. Secondary data was also be obtained from the district agricultural office, North Wollo Zone Agricultural Office, CSA, and the National Meteorological Agency of Ethiopia. The temperature and rainfall data of Kobo Woreda was obtained from NMA for the last 29 years (1990-2019) which was help the researcher to analysis climate variability. The rainfall and temperature data for the study area on monthly rainfall, monthly mean maximum temperatures (calculated from the maximum temperatures observed each day), and monthly mean minimum temperatures (calculated from the minimum temperatures observed each day) was collected from meteorological archives of the National Meteorological Services Agency of Ethiopia (NMSA).

3.4 Sampling Procedures and Sampling Techniques

To select a representative sample, a three-sampling technique was employed. First, considering the nature of the study, three kebeles was be purposively selected from 36 total kebeles in the woreda. Shaway, Gedeba, and Bewa kebeles was selected based on the assumption that these sites was suit the intent of the study. These kebeles are selected because the kebeles are typical of rainfed agriculture in Woreda, meaningful insight to the researcher about the kebeles' contexts, and the proximity of the Kebeles to the Woreda town hence minimizing the cost of the research. As a result, the three kebeles have a total of 3825 households. Using Yemane (1967), 363 sample size was selected from which the data was be collected. The Yemane formula is given by n=N/1+N (e) 2), where n is the sample size, N= Population, and e = (0.05%)) is the sampling error.

Secondly, using a stratified sampling technique, households from each of the three kebeles was proportionately selected. As a result, the total households in the three kebeles become 363 then which was be arranged into three kebeles as N1 (Shaway), N2 (Gedeba), and N3 (Bewa) and become 123, 142, and 98, respectively. Finally, the researcher was use systematic sampling methods used to select farmers from each *Kebeles*. The use of this sampling method involved three steps. In the first step, sample interval (kth) was determined by dividing the farming population of various *Kebeles* by their respective sample sizes. The second step involved a random sampling of respondents from various *Kebeles*. To begin the random process, the first number was picked between 1 and kth numbers using a simple random sampling technique through the lottery method. Here, the first number to the kth number was written on pieces of paper and folded in a bowl. Afterward, a blindfolded person was asked to pick the first number from the bowl, which served as the basis for selecting the rest of the respondents using sample intervals. Finally, the kth term was selected successively from the list until the total number of samples was obtained (Kothari, 2004). The allocation of samples into the three kebeles is presented in the following table (table 1).

Table 1. Table 1: Summary of the Sampling Procedures and Sample Size Across Kebeles

Woreda	Total household	Total kebeles	Kebele in the Woredas		
			Name of Kebeles	No. of households	Sample size
Kobo	13,617	36	Shaway	1292	123
			Gedeba	1501	142
			Bewa	1032	98
			Total	3825	363

3.5. Data Collection Instruments

The structured questionnaire was designed in line with the stated objectives and research question and includes diverse issues that could provide an understanding of the socio-economic attributes of the study households, climate variability, and the impact of climate variability on crop productivity in the area. First, the questionnaire was prepared in English and translated into the *Amharic* language before interviewing households. This is because some respondents may be unable to read and write. To maintain the validity and reliability of the data, the questions were carefully reviewed by experts working in offices of agriculture, and experts in the areas.

Table. Definitions and Measurement of Variables

Variable	**Definition**	**Measurement**
Crop production	Farm production aggregate of cereals and legumes	Annual percentage cropproduction in tones per unit area
Livestock production	Animal output in terms of hides, meat and milk	Annual percentage animal output per unit sales
Rainfall	Amount of rain realizedover a given period of time	Average annual rainfallreceived in milliliters
Temperature	Hotness or coldness of agiven region	Average annual temperature in degrees Celsius

Source; Literature and author development

3.6. Data Analysis

Both descriptive and inferential analysis was employed to analyses the collected data. Data generated by questionnaires, crop yield data, and meteorological data was analyzed using descriptive statistics and inferential statistics such as correlation and regression analyses with the help of Excel and Statistical Package for Social Sciences (SPSS) version 20 to assess the effect of meteorological variables on crop and livestock yield. The relationship between climate variability and productivity was analyzed through the regressing of climate variables (rainfall and temperature) on crop yields. Finally, mean, SD and CV was employed with the help of Microsoft Excel to analyze climate variability in the study area.

Standardized anomaly index, precipitation concentration index, and coefficient of variation were used as descriptors of rainfall variability (Bewket and Conway, 2007; Ayalew *et al*., 2012). The standard anomaly index was calculated for rainfall and temperature by:

$$SAI = \frac{P_t - P_m}{\sigma}$$

Where P_t is annual (rainfall or temperature) in year t, P_m is the long-term mean annual (rainfall or temperature) over the period of observation, and σ is the standard deviation of rainfall. McKee *et al.*, (1993) used the classification system shown in the SAI value as extremely wet if, $SRI \geq 2$ very wet if $1.5 \leq SRI \leq 1.99$, moderately wet if $1 \leq SRI \leq 1.49$, near normal if, $-0.99 \leq SAI \leq 0.99$ moderately dry if$-1 \leq SAI \leq -1.49$, and severely dry if $-1.5 \leq SAI \leq -1.99$ and extremely dry if≤ -2. This index is used to examine the nature of the variability and enables the determination of the dry and wet years in the record.

The coefficient of variation (CV) was also calculated to evaluate the variability of rainfall and its characteristics by dividing the standard deviation of the event by its long-term mean. This is used to compare the variability of any two distributions which may be measured in different units. According to Hare (1983), CV (%) values are classified as follows: < 20% as less variable, 20- 30% as moderately variable, and > 30% as highly variable. The coefficient of variation was calculated by the formula:

$$CV\% = \frac{\delta}{\mu} * 100$$

Where CV is the coefficient of variation, σ is the standard deviation, and μ long-term mean annual (rainfall or temperature) over the period of observation. On the other hand, standard deviation is computed as the square root of variance. Using the classification of Reddy (1990), the stability of rainfall is examined as follows: when the standard deviation <10 as very high stability, 10-20 as high stability, 20-40 as moderate stability, and >40 as less stability. Where SD can be computed as

$$SD = \sqrt{\left[\sum_{i=1}^{n} 1\langle x - \bar{x}\rangle 2\right]}$$

Seasonal rainy and dry day's variability**:** Even though the smallest recorded amount of rainfall is 0.1 mm, a threshold value of 1mm was used to define days as wet or dry because 0.1mm of rainfall value almost does not affect the growth of crops (Robel *et al*.,2013). Thus, in the other study, the number of rainy and dry days was determined by counting all days with rainfall ≥1.0mm as rainy and those days with < 1.0mm as dry days respectively. Different researchers used the same definition (Segele and Lamb, 2005; Mesay, 2006; Hadgu *et al*., 2013).

To understand the household perception of climate variability in Kobo Woreda, they were asked to indicate what they used to observe regarding year-to-year fluctuation in temperature and rainfall around the normal. They were asked to specify whether they have noted: (i) temperature condition (increase, decrease, no change), (ii) rainfall condition (increase, decrease, no change, do not know (iii) change in the timing (duration) of the rain (comes early and goes late, comes late, and goes early, comes late, and goes early, comes early, and goes early. Additionally, the perceptions of farmers of various climatic variables for the last 29 years were collected using a 5- 5-point Likert scaled attitude items: strongly agree, agree, unsure, disagree and strongly disagree. In the case of adaptation strategies, the respondents were asked about their range of practices. Descriptive statistics and Likert scale measurement was be used to characterize household perceptions of changes in long-term temperature, rainfall, and other aspects.

The statistical correlation coefficients between crop yield and climatic variables namely rainfall and temperature was be used to assess the strength and the direction of the relationship, and the significance of the relationship between yield production and the climate variables. Focus was made on annual data (1990-2019) to understand how the events impact crop yields.

Correlation Analysis: This method provides the degree of relationship between two variables. Pearson Correlation coefficient (r) analyses were used to analyze the correlation between crop yields expressed in qt/ha with maximum temperature, minimum temperature, mean annual temperature, and rainfall characteristics, the value of r ranging between -1 to +1, a correlation coefficient close to +1 indicates a strong positive correlation, a correlation coefficient close to -1 indicates a strong negative correlation similarly a correlation coefficient of 0 indicates no correlation (Armi Collins, *et al.*,1994; Agrawal *et al.*, 1986; Odekunle *et al.*, 2007). For this study, the value of r was calculated using the Pearson correlation coefficient equation.

$$r = \frac{n\sum xy - \sum x \sum y}{\sqrt{n\sum x^2 - (\sum x)^2 \times \sqrt{\sum y^2 - (\sum y)^2}}}.$$

Where r = Pearson Correlation Coefficient between X (climate variables) and Y (maize yields); $\sum X$ = Sum of the data in X distribution; $\sum Y$ = Sum of the data in Y distribution; $\sum XY$ = Sum of the product of X and Y; $\sum X^2$ = Sum of the squared X; $\sum Y^2$ = Sum of the squared Y; $(\sum X)^2$ = Squared of sum of X; $(\sum Y)^2$ = Squared of sum of Y; n = Number of pairs of the measurement.

Regression Analysis: The simple linear regressions of the random variable Y on time X. The regression coefficient of the interpolated regression line slope coefficient was computed from the climate data based on (Mongi *et al.*, 2010). This type of trend line used the following linear equations to calculate the least square fit for a line using MS Excel.

$$y = \beta_x + c$$

Where Y is the physical factor (annual crop yield) β is the slope of the regression equation, X is the climatic variable of years from 1990-2019 (29 years), and C is the regression constant. Multiple regression is an extension of simple linear regression in which more than one independent variables (X) are used to predict single dependent variables (Y). The predicted value of Y is a linear transformation of the X variables such that the sum of squared deviations of the observed and predicted Y is a minimum. With n independent variables,the prediction of Y_n is expressed by the following Equation.

$$y_n = b_o + b_1x_1 + b_2x_2 \ldots \ldots + b_nx_n$$

Where Y is the dependent variable b_0 is an intercept, b is the coefficient of independent variables X and n refers to the n^{th} observation. The coefficient of determination (R^2) indicates the variation of the climate variable with time in the linear regression model which is defined as:

$$R^2 = \frac{SSR}{SST} = 1 - \frac{SSE}{SST}$$

Where SSE is the sum of squared error, SSR is the sum of squared regression; SST is the sum of squared total. In general, R^2 measures how successful the fit is in explaining the variation of the data. Coefficients of multiple determinations (R^2) were used to determine the percentage of variation explained jointly by the climate variability. If the P-value of F exceeds 0.05 (confidence level) the explanatory variable does not predict the response variable (Wilks, 2006).

CHAPTER FOUR

DATA PRESENTATION,ANALYSIS, AND INTERPRETATION

4. Introduction

This chapter presents a discussion of the results and the process through which the results were obtained. In addition to this, background information of respondents was presented. Finally, the statistical methods of analysis were argued, which included descriptive analysis, using percentiles, frequency and percentage and graphs.

4.1. Response Rate

To determine the number of the respondents who filled and submitted back the questionnaires, and analysis of the response rate was conducted. The researcher has distributed 363 copies of the questionnaire to respondents. From those copies of the questioner, 41 questioners of employees did not return properly. Therefore, 322(88.72%) respondents were considered for this study. The response rate of 88.72% was considered appropriate since according to Mugenda & Mugenda (2003) a response rate of 30-50% of the total sample size provides enough data that can be used to generalize the characteristics of a study problem as expressed by the opinions of few respondents in the target population. The study hence considered 88.72% response rate suitable to examine the effect of climate change on agricultural productivity on Kobo woreda.

4.2. Demographic Characteristics of Respondents

Demographic characteristics including: gender, age, current educational background, and working experience, occupation of the respondents and the income source of households were summarized using frequencies and percentages.

Table 2. Gender composition of the sample respondents

		Frequency	Percent
Sex	Male	210	65.22
	Female	112	34.78
	Total	322	100

Source: Sample Survey May 2024

The demographic data for gender shows that out of the 322 respondents there were 210 males and 112 females. Table 2 shows that the male respondents formed the majority of the target population with a percentage of 65.22%, while female respondents were represented 34.78%.

4.1.2 Age categories of the sample respondents

The researcher wanted to establish the age of the respondents to ensure that the view of different age range was taken into consideration. The results are presented in Table 4.2

Table 3. Age categories of the sample respondents

		Frequency	Percent
Age category	Less Than 25	2	0.62
	26-30	109	33.85
	31-35	136	42.24
	36-40	48	14.91
	More Than 40	27	8.38
	Total	322	100.0

Source: Sample Survey May 2024

The age distribution of the participants shows that, 0.62% of them to be in the age group of less than 25. Whereas 33.85% of the respondents were in the age group of 26-30 and 42.24 % of the respondents were between the ages 31 and 35 while 14.91% of the respondents were in the age group between 36 and 40. Only 8.38% of them are above 40. This shows that the majority of the participants i.e. 42.24% were in the age between 31 and 35. This implies that the large proportions of respondents in the woreda were considered nearly productive and energetic.

4.1.4 Educational backgrounds of the respondents

The researcher sought to establish the level of education of the respondents. The level of education encompasses knowledge and skills, which enabled the researcher to understand the perception levels of the respondents. Table 4.3 shows the results.

Table 4. Educational status

		Frequency	Percent
Educational status	Illiterate	96	29.81
	Diploma and below	109	33.85
	Degree	83	25.78
	Masters	32	9.94
	PhD	2	0.62
	Total	322	100.0

Source: Sample Survey May 2024

From the findings 25.78% of the respondents had a degree; 9.94% had masters; 0.62% had doctorate degrees, 33.85% had a diploma and below and 29.81 were illiterate. It was concluded that a majority of the respondents had diploma and below. Moreover, since the majority of the respondents were farmers, it can be concluded that most of the respondents are in the area of agriculture and provided basic information regarding the objectives of the study.

4.1.4 Work experiences of the respondents

The study sought to determine the length of service of the respondents to create whether they had attained adequate experience to provide accurate and reliable information. Table 5 outlines the results.

Table 5. Table 5. Working experience of respondent

		Frequency	Percent
Working experience	1-5	37	11.48
	6-10	39	12.11
	11-15	36	11.18
	16-20	63	19.57
	21-25	95	29.51
	More than 25	52	16.15
	Total	322	100.00

Source: Sample Survey May 2024

The length of service/working experience in an organization identifies the extent to which one is aware of the issues sought by the study. In the wake of technological advancements and globalization, there are likely to be many changes in an institutional and operating environment that the respondents should know when answering the issues required by the study. The study results depicted in table 4.4 revealed that almost all of the respondents indicated that they had an experience of greater than five years even 16.15% of them had an experience of more than 25 years. This shows that the respondents had reach experience and confidently express the the impact of climate change on agricultural production.

Table 6. The income source of households

		Frequency	Percent
Income source	Crop production	122	37.88
	Cattle	91	28.26
	Non-farm activities	27	8.38
	Daily labor	19	5.91
	Trade	33	10.25
	Others	30	9.32
	Total	322	100.00

Source: Sample Survey May 2024

From the findings the largest proportion (37.88%) of the respondents were participated in crop production followed by livestock production (28.26%). It was concluded that a majority of the respondents were engaged in agrarian.

4.3 Results of Inferential Statistics

4.3.1. Production status of major crop Productivity in raya Kobo woreda

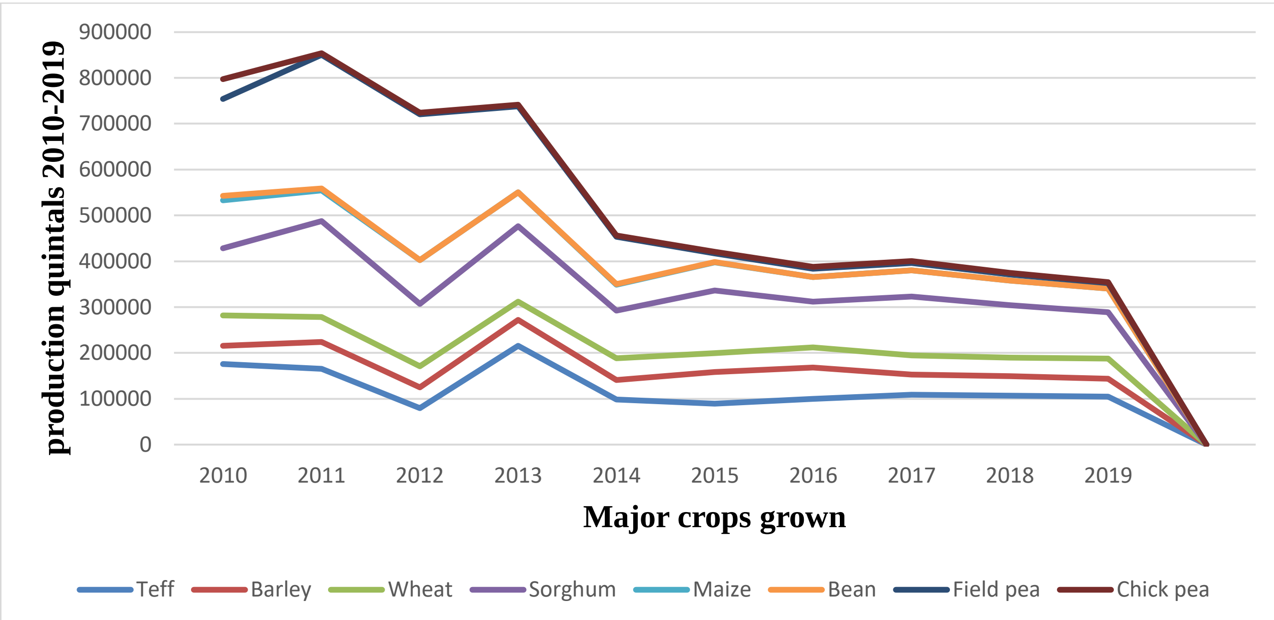

Figure 2. Production status of major crops in the study area over years

As shown in the graph above production of majorly grown crops in Raya Kobo Woreda appeared inconsistent with remarkable reduction over time which indicate the significant effect of climate variability on crop production in the area. Following the declining trends in annual and seasonal rainfall totals, Teff, wheat, sorghum, , Bean, Field pea and chick pea statistically significant decreasing trends while no trend was observed for maize and Barley in the study area . This finding is in line with Adhikari *et al.* (2015) who projects the effect of climate change on maize production to be least in Ethiopia; and it will be the crop least affected by climate change.

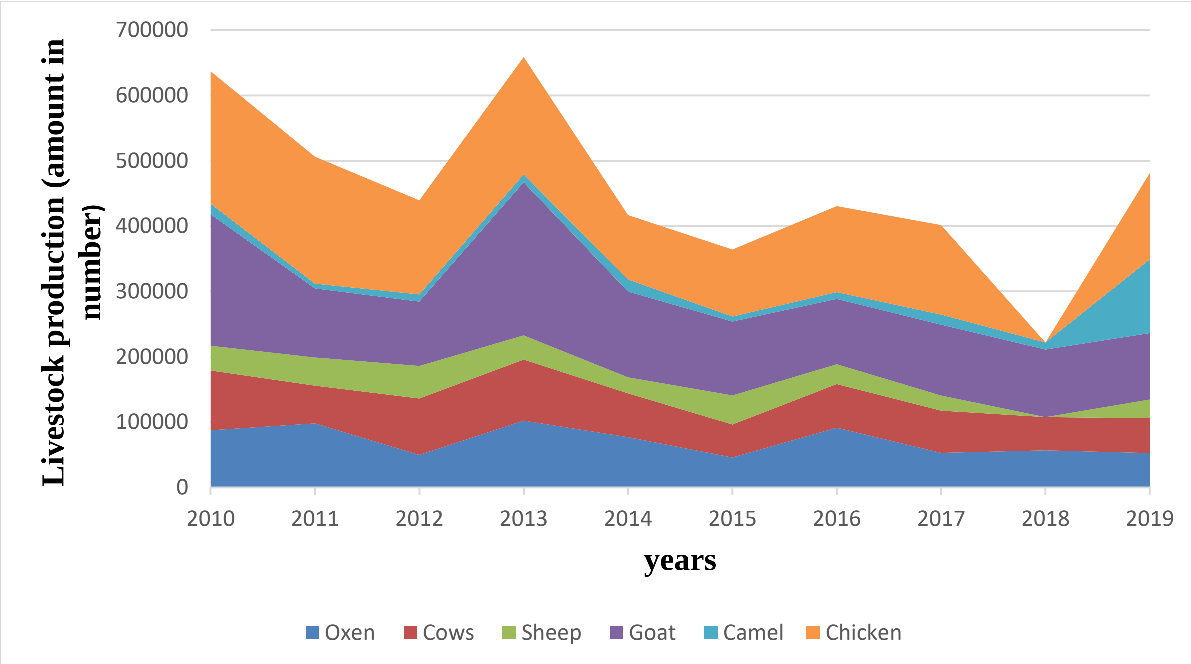

Figure 3. Livestock production status in the study area over years

Livestock Production in Raya kobo Woreda appeared inconsistent as shown with coefficient of variation 30%, 24%, 26%, 36% 44% and 22% for oxen, Cows Sheep Goat, camel and chicken respectively. The graph clearly depicts that the production of livestock in Raya Kobo Woreda was significantly affected by climate change for chicken, goat, sheep and camel but less affected the production of oxen and cows, and was an indication that they are less sensitive to changes in climate change.

4.3.2 Rainfall variability and pattern

The average annual rainfall of Raya kobo Woreda ranges between 167.9mm as the minimum and 957.68 mm as maximum for the past 29 years respectively. The amount of rainfall showed yearly fluctuation between 1990 and 2019. Rainfall pattern is the major $y = 1.73x - 365.6$ $R^2 = 0.54$. The correlation coefficient also revealed that rainfall has decreased slightly with time. The annual rainfall patterns in the area appeared to decrease at a significant rate. This might have a negative impact on crop production, and livestock production. This result in line with the finding of Orindi and Murray, (2005), stated that both temporal variability and decreasing rainfall pattern pose effects on the environment and affect negatively the agro biodiversity of the area. The observed SD values showed rainfall was less stability (SD= 167.9mm). Due this climate change was major determinant factor in study area. This study aggress with the study of Welde (2014), the variability of seasonal rainfall is a main determinant of crop production. Therefore, the coefficient of variation (CV) of Raya Kobo woreda shows that 36.17% and 16.13 % respectively. Moreover, the graph below(), clearly concluded that the average daily and annual precipitation was in erratic distribution.

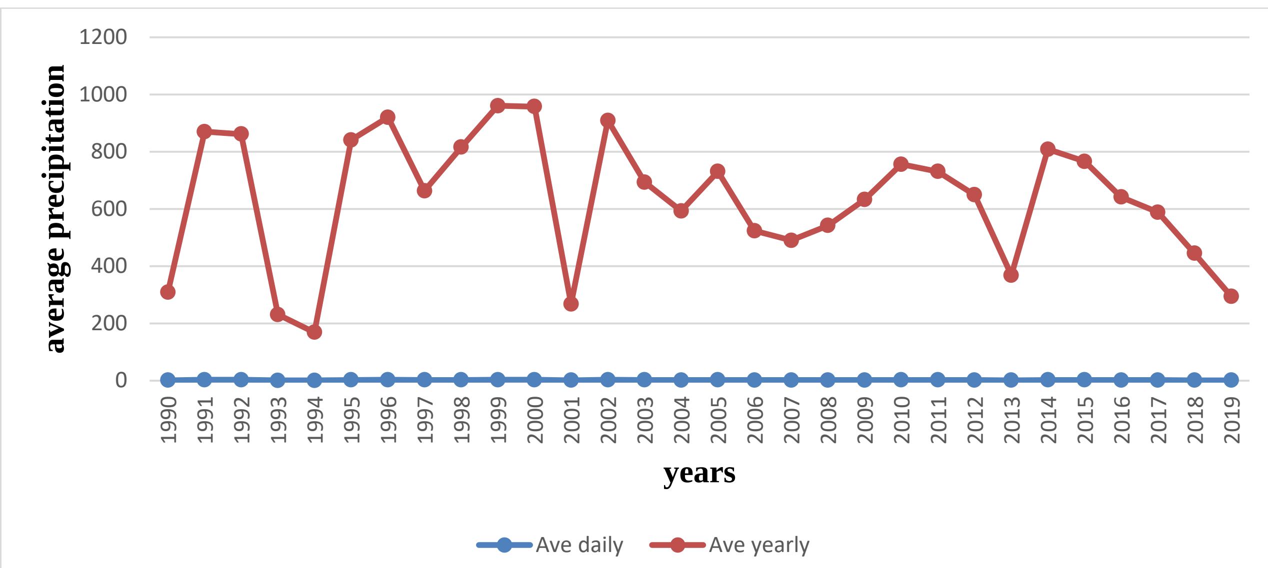

Figure 4. Average Precipitation rate of Raya Kobo Woreda (Daily and Yearly)

4.3.3 Patterns of Temperature in Raya Kobo Woreda

Maximum temperature has shown an increasing trend at Raya Kobo Woreda during seasonal time scale. However, anon-significant trends were detected during annual time scale season.

Majority of respondents perceived there were changes in annual mean temperature in the last twenty-nine years period (1990 – 2019). In this regard, 76% of the respondents strongly agreed that temperature increased through time while 14 % of the respondents disagreed about an increase in temperature and the rest 10 % were unsure about the issue as compared to previous decades. Therefore, results might confirm the farmer‟s perceptions that the temperature was becoming hot and hot in recent days which affects their agriculture a lot and is very likely an indication that the climate is changing. This implies that agricultural activities are highly vulnerable to such changes in study area.

Annual average temperature from 2000-2019 showed an increasing trend with the lowest temperature being 10.61 ^{o}C , while highest temperature 33.21^{o}C and the average was 21.91^{o}C.

The mean value of annual temperature and its standard deviation over the period were 19.2 ^{0}C and 1.04 ^{0}C respectively. It implies that in the study area, the average annual and average seasonal maximum and minimum temperatures showed a consistent increasing trend in the study area over the studied period. It also revealed that the recent years are getting warmer as compared to the earlier years. These increasing average maximum temperatures were reduced yield of major crops in the study area.

4.3.4 Movement of crop Production with Precipitation and temperature

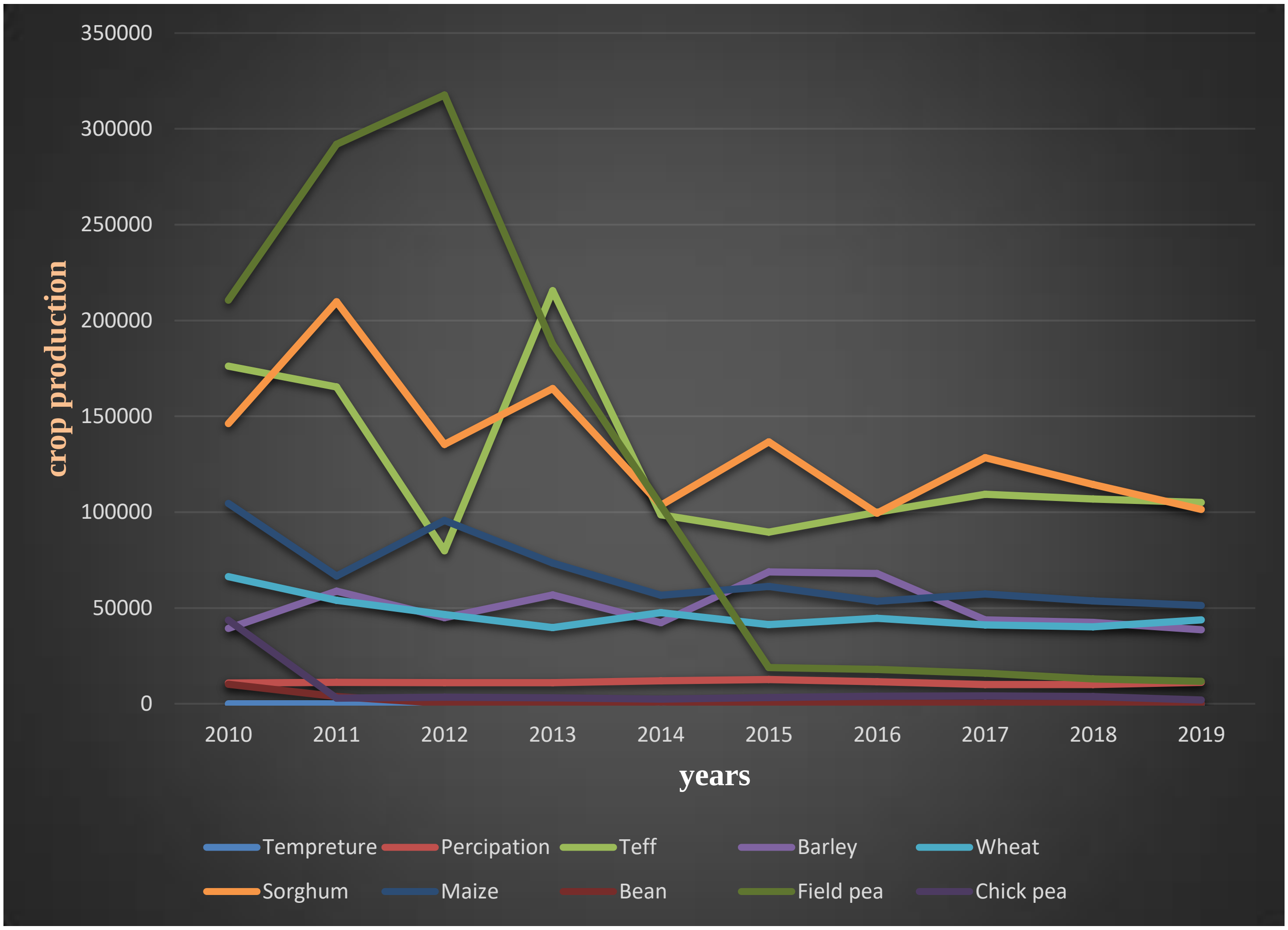

Figure 5. Average Precipitation rate of Raya Kobo Woreda (Daily and Yearly)

Generally temperature and precipitation have shown a significant reduction in crop production and livestock production (Figure 4 above). The variability of seasonal rainfall and temperature causes fluctuations in production of major crops. Due to high correlations between crop production and seasonal rainfall and temperature, small changes in amount and distribution of seasonal rainfall, increasing temperature causes significant negative impacts on crop production that varies from reduced yield to the total loss of the crop. The results of the regression analysis showed rainfall and temperature contribute 71% and 59% in explaining the variation in the yield of the selected items in the study area.

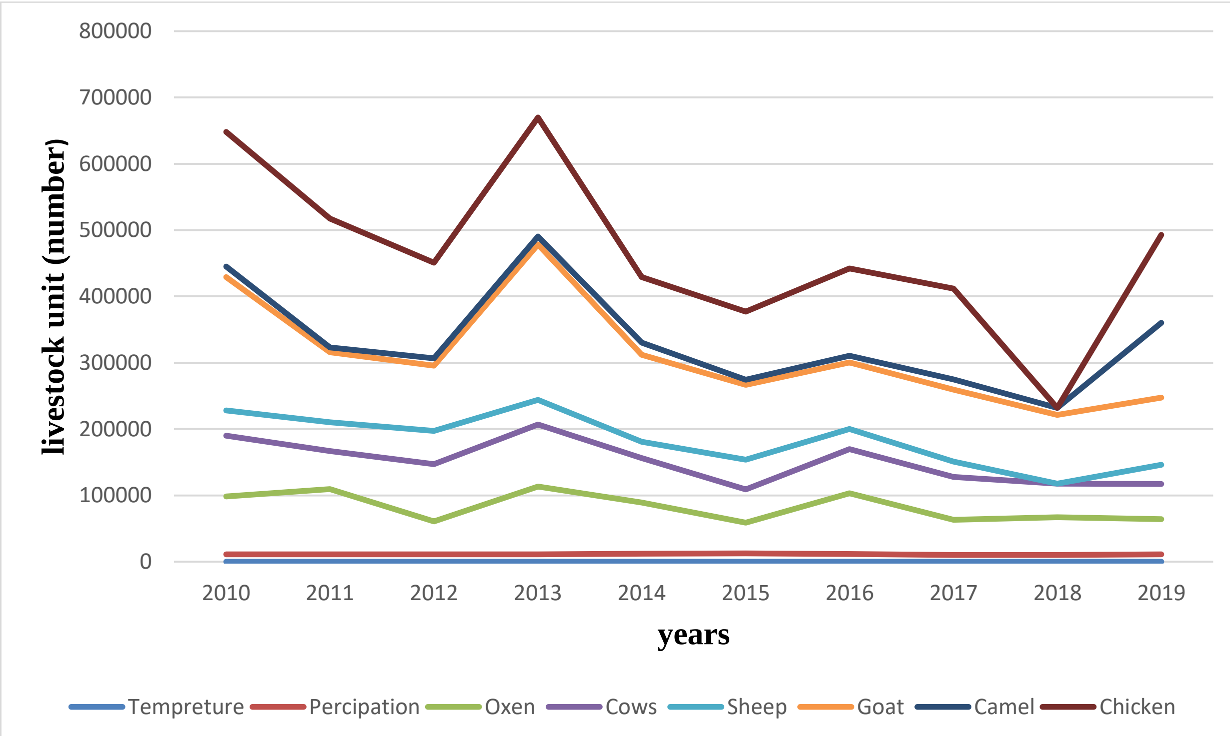

Figure 6. Movement of livestock production with precipitation and temperature

The graph above showed that Livestock Production in Raya kobo Woreda appeared inconsistent as shown with the mean value of 45900, 50455, 23202, 98418, 7289 and 98,564 for oxen, Cows Sheep Goat, camel and chicken respectively. The current study showed that livestock production in Raya Kobo Woreda was significantly affected by changes in climatic condition.

Indicators of rainfall variability as stated by respondents

The researcher wanted to conclude whether the physical workplace condition had an effect on the employees' performance. The results are provided in Table 4.5 below.

Table 7. Indicators of rainfall variability as stated by respondents

Item	Strongly disagree		Disagree		Neutral		Agree		Strongly agree		N
	Freq.	%	Freq.	%	Freq.	%	Freq	%	Freq	%	
Is their rainfall decrease or increase in amount	5	1.56	14	4.34	31	9.63	108	33.54	164	47.49	322
There were decline of agricultural productivity	13	4.03	21	6.52	30	9.32	98	30.43	160	49.7	322
Lack of water availability	3	0.93	7	2.17	12	3.72	106	32.92	194	60.26	322
Loss of livestock and plant species	2	0.62	55	17.08	11	3.42	146	45.34	108	33.54	322
Shortening of growing period	7	3.17	43	13.35	29	9	87	27.02	156	47.46	322
Rainfall comes lately and goes early	8	2.48	34	10.56	26	8.07	111	34.47	143	44.42	322

Source: Sample Survey April 2024

Table 7 illustrates that 5 (1.56%) of the respondents tented strongly disagree but 164(47.49%). Strongly agree that there was rainfall decrease or increase in the study area. Majority of the respondents strongly agree that There were decline of agricultural productivity, Lack of water availability, Loss of livestock and plant species, Shortening of growing period and Rainfall comes lately and goes early.

Table 8. Indicators of temperature variability as stated by the respondents

Item	Strongly disagree		Disagree		Neutral		Agree		Strongly agree		N
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	
Drying up of river and stream	32	9.94	44	13.66	29	9.01	109	33.85	108	33.54	322
reduce crop productivity	26	8.07	30	9.32	16	4.97	83	25.77	167	51.87	322
Damage of crop by pests	22	6.83	35	10.86	18	5.59	116	36.02	131	40.7	322

Source: Sample Survey April 2024

In item 1, Drying up of river and stream up on temperature variability 109(33.85%) of the respondent tended strongly agree, whereas 32(9.94%) and 29(9.01%)remain strongly disagree and neutral respectively. It means that temperature fluctuations leads to drying up and of river and stream.

4.3.5 Adaptation Strategies to Climate change

Respondents were asked to indicate their degree of agreement or disagreement on reports concerning to their use of adaptation strategies in mitigating climate change effect. Results are shown in Table 9.

Table 9. adaptation strategies to mitigate climate change

Item	Used		Not used		N
	Freq.	%	Freq.	%	
Soil and water conservation	209	64.91	113	35.09	322
Use of resistant crop and livestock	109	33.85	213	66.15	322
Afforestation (planting trees)	225	69.87	97	30.13	322
Mixed cropping	198	61.49	124	38.51	322

Source: Sample Survey April 2024

According to respondents, they are using different adaptation options to reduce the negative effect of climate change. So majority of the respondents used adaptation strategies in the study area like , soil and water conservation (64.91%), planting trees (69.87%), mixed cropping (61.49%) and using resistant crop varieties and adaptive livestock units (33.85%). (Table 9).

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS,AND RECOMMENDATIONS

5. Introduction

This chapter presents an overall summary of the main findings of the analysis part, followed by the conclusion of the study through which the research objective was addressed. Furthermore, this part also includes possible recommendations and suggestions for further studies.

5.1 SUMMARY OF MAJOR FINDINGS AND CONCLUSION

In Ethiopia, agriculture is about 47% of the country's Gross domestic product (GDP) and more than 70million that is people (85% of the Ethiopian population) depend on agriculture directly or indirectly for their livelihoods. This study aimed at analyzing the effect of climate change on crop production in the case of Raya Kobo Woreda and thus the following result have been concluded. Precipitation and temperature are the two widely studied and very important climate parameters in climate research because of their huge impact in many socio-economic sectors including agriculture, hydrology, and environment. Climate change and variability impacts directly or indirectly on all economic sectors to some degree, but agriculture is among the sectors most sensitive and inherently vulnerable to climate variability. In the current study there is a positive relationship between the amount of rainfall and major crop yield, thus an increase in rainfall amount leads to increase in yield or vice versa. The results of the regression analysis showed rainfall and temperature contribute 71% and 59% in explaining the variation in the yield of the selected items in the study area.

The result of analysis of multiple regressions showed a significant 71% and 59%r relationship between crop yield and rainfall and temperature respectively. Being rainfall and temperature variability adversely affects crop and livestock production, farmers in the study area used various adaptive strategies like soil and water conservation, livelihood diversification environme ntal rehabilitation, irrigation and water harvesting schemes, planting trees mixed cropping, chang ing varieties and small irrigation to sustain economic growth and reduce those risks.

Since most of the house-holds engaged in rainfed agricultural production, they could harvest only once a year and this can be the major reason for their crop failure. Thus the dependency of their agricultural production heavily on rainfall exposed them to induced climate change. The survey of household revealed that there has been increased rainfall variability's and temperature raise over the years. The majority of the house-holds have replied that the degree of climate change in crop production is quite large. Climate change causes crop production per hectare to decrease significantly. Furthermore, it causes the problem of drought and flood to increase. The main adaptive strategies of farmers to climate change identified in study area were soil and water conservation, use of resistant crop and livestock, afforestation (planting trees) and mixed cropping.

5.2 RECOMMENDATIONS

Based on the above summary of findings and conclusions of the study, the researcher has forwarded the following recommendations for the concerned stake holders as follows.

- ❖ The farmers should adopt and implement possible adaption measures so as to mitigate the diverse effect of climate change on reducing crop yields and livestock lose.
- ❖ As the issue of climate variability and climate change are sensitive it was found paramount important if more researches undergoes to estimate the long term impact on crop production and livestock production using time series data spanning extended times.
- ❖ The Government of the Federal Democratic Republic of Ethiopia has to design appropriate adaptation measures across all the regions including reducing vulnerability of and to realize the ambition of the farmers.

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APPENDIXES

1. Questionaires used in the study

FACULITY OF BUSSINESS AND ECONOMICS

DEPARTMENT OF ECONOMICS

TITLE: THE EFFECT OF CLIMATE CHANGE ON AGRICULTURAL PRODUCTIVITY IN THE CASE OF KOBO WOREDA, ETHIOPIA

1. **Questionnaires to be filled by respondent**

Dear Respondent,

I am a student of Woldia University pursuing Master of Science degree in development Economics. The questionnaire is intended to help the researcher get information on the effect of climate change on agricultural productivity in the case of kobo woreda, Ethiopia. The purpose of the study is purely academic and the information that you are going to give will be treated with the highest degree of confidentiality. You have been selected as a key respondent for this study. Kindly, complete the questionnaire to enable the researcher complete the study. Please tick the answer, which represents your opinion on the subject. Your cooperation is highly appreciated.

Adane Mekonen

Thank you!!

General Instruction

I. No need of writing your name.

II. Simply respond by putting a tick (√) mark in a box.

III. The information to be obtained will certainly be used only for academic purposes, i.e. your responses will be kept confidential.

I. Demographic Information

Name of your Sector --

1.1. Sex Male □ Female □

1.2. Age in years A) Less than 25 □ B) From 26-30 □ C) From 31-35□ D) From 36-40 □ E) More than 40 □

1.3. Educational status A) Illiterate □ B) below diploma □ C) degree □ D) masters E) PhD □

1.4. Working experience A) From 1-5 □ B) From 6-10 □ C) From 11-15 □ D) From 16-20 □ E) From 21-25 □ F) More than 25 □

1.5. Occupational of the respondents A) Self-employed □ B) Agriculture □ C) Landless labor □

D) Service□

1.6. The Income Source of Households A) Crop production □ B) Cattle□ C) Nonfarm activities□ D) Daily labor □ E) Trade □ F) others □

PART II: LIKER SCALE Questions

Please indicate your responses to each of the following statements by using a sign of (√) in the appropriate answer box

A/ climate change

1. Are you familiar with the terminology of climate change? A) Yes B) No

No	Description of items	Increasing	decreasing	No change	Indeter minate
1.	If your answer for question no 1 i yes, how do you describe the pattern of rainfed compared to the last year?				
2.	Is there any change noticed by you in temperature change if no 1 is yes?				

2. The impact of climate change on crop productivities and others

No.	Question	High	Low	Medium
1.	How do you describe the degree of climate change effect on your crop production?			
2.	Shortage of food and making environment more vulnerable			
3.	Loss of plant species			
4.	Shortage of drinking water			

<table>
<tr><th>No.</th><th colspan="2">Question</th><th>Yes</th><th>No</th></tr>
<tr><td>1.</td><td colspan="2">Do you observe any impact of climate change on your crop production?</td><td></td><td></td></tr>
<tr><td rowspan="4">2.</td><td rowspan="4">If your answer for question 1 is yes, what impacts did you observe?</td><td>Production per hectare is decreasing</td><td></td><td></td></tr>
<tr><td>Crops are sometimes failing</td><td></td><td></td></tr>
<tr><td>Increasing the problem of drought and flooding</td><td></td><td></td></tr>
<tr><td>Crops are totally failing</td><td></td><td></td></tr>
</table>

B) Adaptation strategies taken to climate change

<table>
<tr><th>No.</th><th colspan="2">Question</th><th>Yes</th><th>No</th></tr>
<tr><td rowspan="3">1.</td><td rowspan="3">Is possible to adopt strategies to cope up with the effect climate change?</td><td>Adaptation</td><td></td><td></td></tr>
<tr><td>Mitigation</td><td></td><td></td></tr>
<tr><td>Both</td><td></td><td></td></tr>
<tr><td rowspan="4">2.</td><td rowspan="4">If your answer for question no 1 adaptation, what type of adaptation strategies have you been practiced?</td><td>Temporary Migration</td><td></td><td></td></tr>
<tr><td>Crop diversification</td><td></td><td></td></tr>
<tr><td>Use of fertilizers and manure application</td><td></td><td></td></tr>
<tr><td>If other specify</td><td></td><td></td></tr>
</table>

C. Crop production (for the Year 2023/24)

(A) Type of crop	Land size cultivated (Hectare)	Amount produced (quintal)	Others specify
Teff			
Barley			
Wheat			
Sorghum			
Maize			
Bean(Bakela)			
Field pea (Ater)			
Haricotbeans (boloke)			
Chickpeas(shenbera)			
Lentils (Misir)			
Niger seed(nug)			
Linseed (telba)			
other pulses			
Potato (dinich)			
Onions(shenkurt)			
Other root crops			
Cabbage (gomen)			
Green peppers (Karia)			
Redpeppers (berbere)			
Others specify			

D. livestock production

Type	**Number owned now**	**Number sold in 2023/24**
Oxen		
Cows		
Heifers (gider)		
Young bulls (weyfen)		
Calves		
Sheep (adult)		
Goats (adult)		
Camel (Adult)		
Donkeys (adult)		
Horses (adult)		
Mules (adult)		
Chicken (adult)		
others (Specify)		

Open ended questions

1. Is there any change in cultivated area of crops due to climate change? A) yes B) No
2. If your answer no 1 is yes, what are the crops and its magnitude of change?

____

____

____

3. Kindly list and explain the long term effects of *decrease* of Rainfall availability on Crop and livestock productivity

____

____

____

4. Kindly list and explain the long term effects of decrease of temperature fluctuation on Crop and livestock productivity in futures
5. What adaptive strategies do you implement so far to mitigate the effects of climate change

____

____

____

____

6. Please give general suggestions/recommendations towards the effects of climate change on agricultural productivity and its adaptation strategies

____

____

____

____.

'THANK YOU FOR YOUR PARTICIPATION'

Mean, SD, CV of the studied variables

NAME	Element	YEAR	Ave daily	Ave yearly
Kobbo (IAR)	PRECIP	1990	0.842857143	307.6428571
Kobbo (IAR)	PRECIP	1991	2.376666667	867.4833333
Kobbo (IAR)	PRECIP	1992	2.353333333	858.9666667
Kobbo (IAR)	PRECIP	1993	0.63	229.95
Kobbo (IAR)	PRECIP	1994	0.46	167.9
Kobbo (IAR)	PRECIP	1995	2.296666667	838.2833333
Kobbo (IAR)	PRECIP	1996	2.513333333	917.3666667
Kobbo (IAR)	PRECIP	1997	1.811111111	661.0555556
Kobbo (IAR)	PRECIP	1998	2.22890873	813.5516865
Kobbo (IAR)	PRECIP	1999	2.62375	957.66875
Kobbo (IAR)	PRECIP	2000	2.616666667	955.0833333
Kobbo (IAR)	PRECIP	2001	0.73	266.45
Kobbo (IAR)	PRECIP	2002	2.482718254	906.1921627
Kobbo (IAR)	PRECIP	2003	1.893154762	691.0014881
Kobbo (IAR)	PRECIP	2004	1.618611111	590.7930556
Kobbo (IAR)	PRECIP	2005	1.996111111	728.5805556
Kobbo (IAR)	PRECIP	2006	1.429642857	521.8196429
Kobbo (IAR)	PRECIP	2007	1.337566138	488.2116402
Kobbo (IAR)	PRECIP	2008	1.48	540.2
Kobbo (IAR)	PRECIP	2009	1.7275	630.5375
Kobbo (IAR)	PRECIP	2010	2.065502646	753.9084656
Kobbo (IAR)	PRECIP	2011	1.995714286	728.4357143
Kobbo (IAR)	PRECIP	2012	1.773617737	647.3704739
Kobbo (IAR)	PRECIP	2013	1.005333333	366.9466667
Kobbo (IAR)	PRECIP	2014	2.208703704	806.1768519
Kobbo (IAR)	PRECIP	2015	2.093	763.945
Kobbo (IAR)	PRECIP	2016	1.751666667	639.3583333
Kobbo (IAR)	PRECIP	2017	1.607142857	586.6071429
Kobbo (IAR)	PRECIP	2018	1.214285714	443.2142857
Kobbo (IAR)	PRECIP	2019	0.803809524	293.3904762
Mean			1.732245812	632.2697213
SD			0.626575619	228.7001009
Min			0.46	167.9
Max			2.62375	957.66875
CV			0.361712879	0.361712879
%cv			36.17128786	36.17128786

Crop Items	**YEAR**															
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	mean	SD	Min	Max	CV	%percentage
Teff	176277	165433	79867	215589	98671	89687	99989	109344	106966	105100	124692.3	44769.39	79867	215589	0.359038943	35.90389435
Barley	39304	58767	44912	56777	42321	68900	67980	43877	42574	38675	50408.7	11651.23	38675	68900	0.23113521	23.113521
Wheat	66457	53971	46576	39800	47687	41298	44577	41234	40202	43864	46566.6	8202.038	39800	66457	0.176135646	17.61356455
Sorghum	146231	209768	135400	164549	103674	136723	99488	128399	114424	101396	134005.2	34028.35	99488	209768	0.253933079	25.39330786
Maize	104576	66784	95691	73467	56700	61355	53467	57300	53656	51343	67433.9	18599.6	51343	104576	0.275819788	27.58197875
Bean	10233	3899	287	344	987	300	308	293	260	291	1720.2	3195.891	260	10233	1.857860173	185.7860173
Field pea	210677	291967	317664	187600	103485	18989	17897	16024	13043	11761	118910.7	123058.9	11761	317664	1.034884859	103.4884859
Chick pea	43721	2988	3467	3233	2456	3290	4030	4100	3824	2008	7311.7	12810.06	2008	43721	1.751994769	175.1994769

Live stock Items	**YEAR**															
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**mean**	**SD**	Min	Max	**Cv**	**%CV**
Oxen	8762	9809	4983	1023	7698	4590	9147	5298	5682	5270	**71475.**	**22065.**	45900	102324	**0.3087073**	**30.870730**

	3	0	9	24	4	0	3	9	9	5	**6**	**04**			**07**	**71**
Cows	91395	57699	86344	93399	67000	50455	66721	64588	50851	53300	**68175.2**	**16556.38**	50455	93399	**0.242850479**	**24.28504794**
Sheep	37876	43239	49851	37091	24656	44574	30399	23202	29,195	28700	**35509.78**	**9337.09**	23202	49851	**0.26294418**	**26.29441804**
Goat	201062	105581	98418	234158	131084	113021	99963	108361	103418	101510	**129657.6**	**47922.91**	98418	234158	**0.369611268**	**36.96112684**
Camel	16148	7289	10978	12089	18553	7687	10349	15431	10755	112808	**22208.7**	**32038.38**	7289	112808	**1.442604925**	**144.2604925**
Chicken	202877	194291	144043	179709	98564	102544	131723	137010	145,136	132273	**147003.8**	**37599.46**	98564	202877	**0.255772028**	**25.57720277**