EFFECTIVENESS OF CLIMATE CHANGE MITIGATION INTERVENTIONS ON CROP PRODUCTIVITY IN MOROGORO DISTRICT, TANZANIA

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DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN RURAL DEVELOPMENT OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

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ABSTRACT

Climate change mitigation interventions have been placed in many parts of the world including Tanzania aiming to mitigate extreme impacts of climate change. This study was conducted to determine effectiveness of climate change mitigation interventions on crop productivity in Morogoro District. Specifically, the study aimed at (i) identifying climate change mitigation interventions undertaken in the study area, (ii) assessing level of communities' awareness on climate change mitigation interventions, (iii) examining challenges of implementation of the climate change mitigation interventions, and (iv) examining the impacts of the climate change mitigation interventions on crop productivity. Data were collected by interviewing farmers through questionnaire as a main tool, which comprised closed and open - ended questions. Descriptive and Inferential statistics were used to analyze objective one and three, whereby the results for objective number one show that farmers in the study area are cultivating and implementing climate change mitigation interventions. Inferential statistics was used to analyze objective number two whereby the findings shown that 95.8% of the farmers are aware about climate change mitigation interventions due to the training and seminars which were conducting by CARE International. In regard to objective number three study findings show that most of the farmers lacked agricultural education and poor hand hoes leading to difficulties in implementation of interventions. A multiple linear regression was used to analyse objective number four. Results from the analysis shows that interventions such as zero tillage, crop rotation, agroforestry, improved seed, and forest conservation significantly contribute in crop productivity at $\rho \leq 0.01$, $\rho \leq 0.05$ and $\rho \leq 0.1$. The study concludes that, climate change mitigation interventions are important on crop productivity due to presence of adverse impacts of climate change in the study area. Although, these interventions need agricultural education and financial support from either government or any other development partners.

DECLARATION

I, **JOHN PETRO JOESEPH**, do hereby declare to the Senate of Sokoine University of Agriculture, that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted for degree award in any other institution.

_____ _____

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The above declaration is confirmed

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DEDICATION

This work is dedicated to the Almighty God, my mother Eunice Methusella, my wife Minza Renatus and my uncle, Zachayo and Dr, Baluhya who laid the foundation and invested a lot in my education since Primary School level.

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ABBREVIATIONS AND ACRONYMS

CBO	Community Based Organization
CDM	Clean Development Mechanism
CIFOR	Center for International Forest Research
CIMMYT	International maize and wheat improvement center
CO_2	Carbon dioxide
DFID	Department for International Development
DSI	Development Studies Institute
EACC	East Africa Climate Change
EACC	Economics of Adaptation to Climate Change
FAO	Food and Agriculture Organization
FFS	Farm Field School
GHG	Greenhouse Gases
GRAS	Green Resources AS
IFAD	International Fund for Agriculture Development
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change.
LDD	Land Development Department
LEAT	Lawyers Environment Action Team
MICCA	Mitigation of Climate Change in Agriculture
NEMC	National Environmental Management Council
NGO	Non Governmental Organization
NSGRP	National Strategy Growth for Reduction of Poverty
OECD	Organization Economic Cooperation Development
PFM	Participatory Forest Management

R&D	Rural and Development
REDD	Reduced Emissions from Deforestations and Forest Degradation
SIDA	Sweden International Development Agencies
SLM	Sustainable Land Management
SSA	Sub Saharan African
SUA	Sokoine University of Agriculture
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNFPA	United Nations Fund for Population Activities
URT	United Republic of Tanzania
US$	United States Dollar
VEO	Executive Officer Village
WB	World Bank
WCED	World Commission on Environment and Development

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity (IPCC, 2001). Climate change is currently at the forefront of debates and discourses on global environmental change (Olufunso *et al.,* 2011). According to Kok and De conck (2007), the global nature of causes and consequences of climate change imply the need for international collective action for an efficient, effective and equitable policy response.

The United Nations Framework Convention on Climate Change (UNFCCC, 2003) identified two policies responsible for addressing climate change which include mitigation of climate change by reducing greenhouse gases (GHGs) in the atmosphere and enhancing carbon sinks and adaptation to the impacts of climate changes in the world. Climate change mitigation intervention including Reduced Emissions from Deforestations and Forest Degradation (REDD) initiatives including economic diversification, disaster risk reduction and capacity development. However, the success of global mitigation initiatives to date is questionable and the impact of ever more severe emission control programs could potentially have enormous social consequences (Mc Evoy *et al.,* 2009).

The IPCC (2007) noted that, during the next decades, billions of people, particularly those in developing countries will face changes in rainfall patterns that will contribute to severe water shortages or flooding, and rising temperatures that will cause shifts in crop growing seasons.

Kangalawe (2012) underscores that, Tanzania like many African countries is highly vulnerable to global environmental change, particularly climate change. Further, the impacts of climate change are particularly related to food production, human health forestry and water resources. The URT (2009) asserted that, efforts are underway to strengthen the institutional capacity and coordination between governmental institutions, private sectors, civil society and other non governmental organizations such as CARE International organization in order to combat climate change and increase agriculture production.

Paavola (2004) reported that, people in Morogoro Region have lived with significant climate variability in the past and are likely to face increased climate variability and changing climate in future. Further to the above, people have used a number of livelihood strategies such as expanding land for cultivation, reducing fallow switching crops, engaging in wage employment, use of forest products and bricks production; temporary and permanent migration.

According to TerrAfrica (2009), there are many climate change mitigation interventions that have been implemented in Africa particularly in rural areas. In Morogoro District some of the mitigation interventions that have been implemented by government and other development partners including CARE International organization are: forest conservation, zero tillage, vegetation cover, soil carbon conservation, wetland restoration, crop rotation and use of perennial crops (Sida, 2010). Therefore this study aimed at examining the effectiveness of forest conservation, crop rotation, agroforestry, zero tillage, improved seeds, use of fertilizers and use of pesticides on crop productivity in Morogoro District.

1.2 Problem Statement

In Tanzania the impacts of climate change such as declining of crop productivity, deterioration of water quality and quantity and loss of biodiversity have been observed particularly in rural areas (Ngasongwa, 2007; Kangalawe, 2012). Thus, several necessary measures to mitigate the climate change such as agro forestry, crop rotation, zero tillage, increase land for cultivation (farm size) and forest conservation in Morogoro region were provided by governmental, private sectors and other developmental partners (Paavola, 2004). However, a little are known about the effectiveness of these interventions such a to reduce soil erosion, improve soil fertility and protect soil surface which contribute on crops productivity (FAO, 2011). Likewise, in Tanzania there is still of scarce empirical information to show the effectiveness of climate change mitigation interventions (Rioux, 2011). Therefore, to plug this evidence gap the study was necessary to examine the effectiveness of climate change mitigation interventions on crop productivity in Morogoro District.

1.3 Justification for the Study

The study was crucial due to the fact that severe impacts of climate change are now evident in many parts of the world, particularly in the developing countries including Tanzania. Further, the impacts of climate change undermine crop productivity in many parts of the world (URT, 2009). Thus, the study was useful because of the observed severe manifestation of climate change which needs serious actions to mitigate and combating. The study was also useful because it serves the goal of National Strategy Growth for Reduction of Poverty (NSGRP) whereby the study is in line with cluster II Goal Number 3 which aims at increasing access to clean, affordable, safe water and sustainable environment and thereby, reducing vulnerability from environmental risk and quality of life and social wellbeing for vulnerable groups (URT, 2010). Furthermore, the study was

in line with other National development strategies such as Rural Development Strategy (2001) which insists on the need of satisfactory performance of agricultural sector and the economic base of rural areas while the study strives to improve agricultural productivity in rural areas through climate change mitigation interventions.

The study was also in line with National Environmental Management Council (URT, 2004), agriculture policy and National Environmental Policy (URT, 1997) which insists on environmental conservation from grassroots' to national level. Likewise the study was in line with other studies including the best practices for smart small - scale agriculture which insist on investment in agriculture and practice to larger scale agriculture with the aim of increasing productivity and commercializing smallholder production (ActionAid, 2013). Therefore the study was useful to policy makers, Non Governmental Organization and other development partners.

1.4 Objectives

1.5 General Objective

The main objective of this study was to examine effectiveness of climate change mitigation interventions on crop productivity in Morogoro District.

1.6 Specific Objectives

i. To identify climate change mitigation interventions undertaken in the study area;
ii. To assess level of communities' awareness on climate change mitigation interventions,
iii. To analyse the challenges of implementation of the climate change mitigation interventions,

iv. To determine the impacts of the climate change mitigation interventions on crop productivity.

1.7 Research Questions

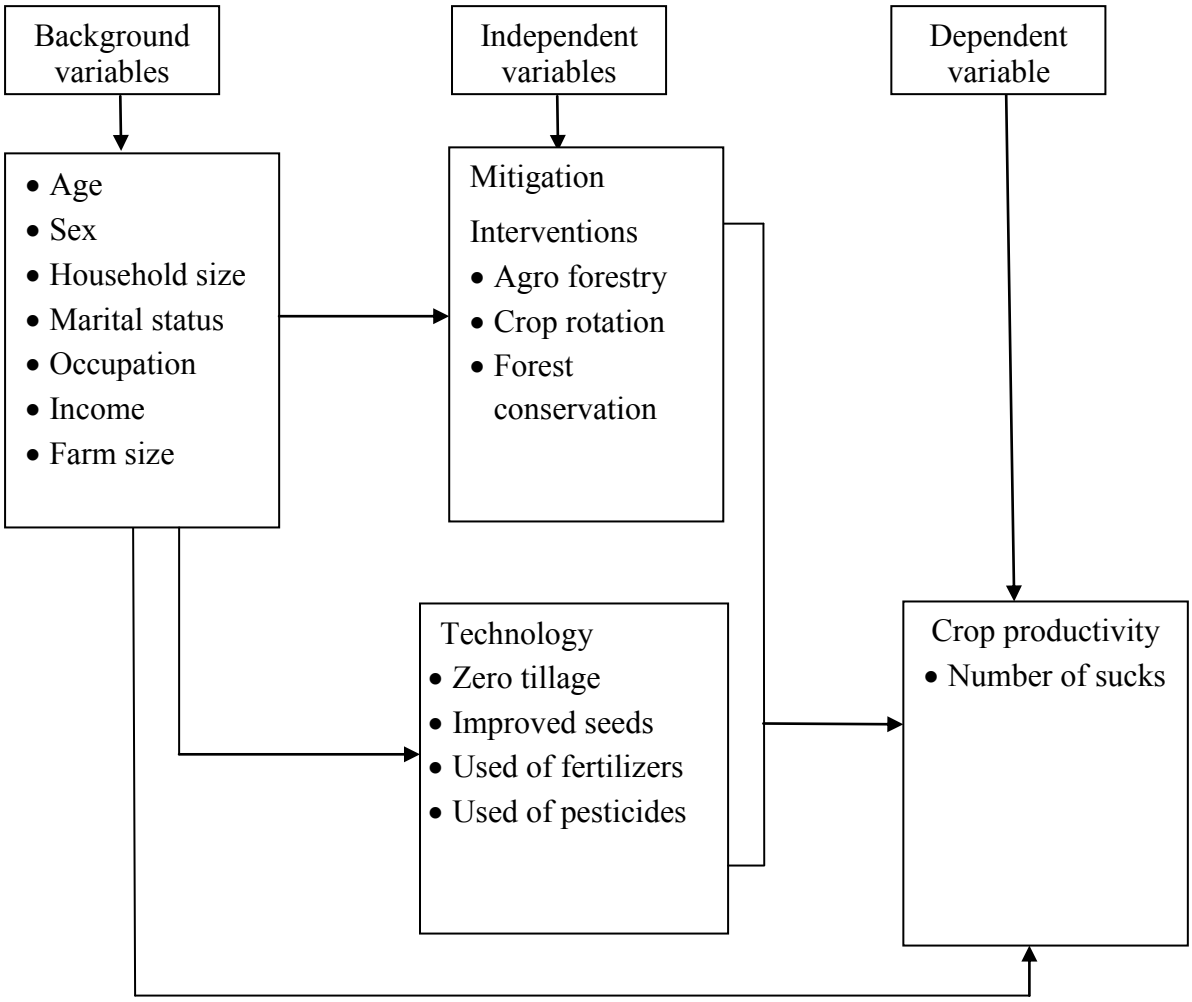
i. What are the climate change mitigation interventions undertaken in study area?

ii. What is the level of communities' awareness on climate change mitigation interventions?

iii. What are challenges of climate change mitigation interventions that are implemented in study area?

iv. What are the impacts of climate change mitigation interventions on crop productivity?

The conceptual framework below shows the relationship between variables which were studied in relation to the objectives of the study.



Source: Researcher's construct 2013

⟶ Direct relationship

Operation definition of the variables is shown in Appendix

Figure 1: Conceptual Framework for the Study

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Climate Change and Small Holder Farmers

Climate change, particularly severe flooding and droughts have been directly linked to the decline of economic activity (Brown *et al.*, 2008). According to Wassmann and Dobermann (2007) repoted that, Sub Saharan Africa region has experienced a series of extreme precipitation events that seem to be linked to changing climate. Further, the high dependence of the economies and rural people of SSA upon rain-fed agriculture, the prevalence of poverty, food insecurity and limited development of institutional and infrastructural capacities in this region make coping with natural climate variability a perennial challenge. According to Cline and Sanker (2009) agriculture and other land-based sectors are not only impacted by climate change, but are themselves major emitters of greenhouse gases (GHG).

IPCC (2009) observed that, rising temperature, drought, floods, desertification and weather extreme will severely affect agriculture, in the developing countries. Therefore climate changes have, and will continue to have, the greatest impact upon the lives of the poor. The poor are generally forced to inhabit land (floodplains, steep unstable slopes or exposed coastlines) that increases their exposure to climate risks. However, traditional and newly introduced interventions can help farmers to cope with both current climate variability and future climate change (IFPRI, 2010). .

2.2 Climate Change Mitigation Interventions

2.2.1 Global situation

For many farmers in rural settings, the main aim of agriculture is to secure their livelihoods and to produce products that can be used directly or sold in the market. Mitigation is not the first activity consciously undertaken, but can be integrated into the

current practices if it makes economic sense. According to FAO (2010), mitigation must be seen in the context of farmers' decision making. For most farmers, it will be a co-benefit whilst increasing agricultural productivity in a climate-smart manner.

Mitigation of climate change in agriculture (MICCA, 2010) states that, mitigation of GHG emissions in agriculture has several approaches which include firstly, emissions can be reduced; secondly, emissions can be avoided or displaced; and thirdly, sinks can be created to remove emission. Agricultural activities account for 10-15% of total global emissions of the three main greenhouse gases CO_2, CH_4, and N_2O although estimates vary. While agricultural, forest, and grazing land-management emit greenhouse gases, many opportunities exist to mitigate these emissions and to sequester carbon in the soil and in the biomass of perennial vegetation. Effective climate change mitigation strategies reduce emissions of GHG, while enhancing carbon sequestration from the atmosphere into stable forms in the soil and vegetation. The global mitigation potential for agriculture is estimated to range between 5 500 and 6 000 Mt CO_2-eq/yr through large-scale application of practices that improve productivity, reduce GHG emissions, and conserve soil. Increasing soil carbon sequestration will produce additional benefits, enhancing soil fertility, as well as the resilience and adaptability of agriculture.

United Nations Framework Convention on Climate Change (UNFCCC, 2008) reported that, 60% of the mitigation actions are related to agriculture, forestry and land which can also help people to adapt to climate change. TerrAfrica (2009) affirmed that, agroforestry activities can increase farmers' agricultural productivity and income security by improving soil fertility, reducing vulnerability to drought, and helping to diversify income. According to IPCC (2007), the main potential for mitigation lies in enlarging carbon sinks. Further, great potential lies in increasing the carbon content of soils. UNFCCC (2008) reports that,

large number of human activities that contribute to emissions, interventions to mitigate climate change are implemented across a range of sectors and industries, such as energy, transport, industrial production, waste management, agriculture and forestry.

2.2.2 Climate change mitigation interventions in Tanzania

Tanzania has engaged in various adaptation and mitigation projects, programmes and initiatives and has developed policies, programmes and strategies to demonstrate its commitment for contribution of global efforts in combating climate change (Yanda *et al.,* 2013). According to URT (2012), development of National Adaptation Programme of Action (NAPA) ensured an adaptation agenda that is put in higher place with clear strategies of implementation at local and sectoral levels. This provided the benchmark for stakeholders to contribute to their respective areas of operations and expertise in order to build resilience of both people and ecosystems against the impacts of climate change. On the other hand, mitigation has been implemented through Clean Development Mechanism and REDD+ initiatives Green resources AS (GRAS, 2010). At local level, other initiatives such as Participatory Forest Management and other various forms of forest management including farm forestry have been undertaken resulting into net carbon sinks (URT, 2008).

At the operational level especially in agricultural sector, there is higher synergy between adaptation and mitigation actions. According to URT (2002), agriculture accounts for about 80% of Tanzania's population are benefiting more when the synergy is maximized. For instance, zero tillage technology for soil and water conservation aimed at adaptation to drought can be maximized if water retention and percolation is enhanced through incorporation of shrub MICCA and FAO (2011). Compatibility of the National Adaptation Programme of Action (NAPA) and Nationally Appropriate Mitigation Actions (NAMA) in Tanzania especially in agriculture is feasible. In the current settings, most of these are

independently implemented, but with coming into force of the National Climate Change Strategy there is higher possibility of utilizing the synergy between adaptation and mitigation. In addition, in Morogoro region several climate change mitigation interventions introduced by both government and other development partners including CARE International organization under the project of conservation agriculture.

According to URT (2012) the climate change mitigation interventions in Tanzania covers adaptation, mitigation and cross-cutting interventions that will enable Tanzania to benefit from the opportunities available to developing countries in their efforts to deal with climate change. Therefore, Tanzania has undertaken several efforts to tackle the challenge including undertaking a Quick Scan on the Impacts of Climate Change in 2009; preparation of the National Adaptation Programme of Action in 2007, CDM Guide for Investors in 2004 and the Initial National Communication to the UNFCCC in 2003.

2.3 Crop Productivity

Crop production and food accessibility are key elements for determining whether an individual, a household or even a given region is food secured. These elements are affected by climatic change. Thus, climate change is a critical element for assessing a household's or regional crop productivity. According to FAO (2008) reported that, the impacts of climate change such as increasing risk of drought will affect crop production from local, national and globally.

URT (2011) reported that, majority of the people living in rural areas of Tanzania depend on agriculture and other natural resources, particularly forest products. However, Sen (1981) reported that, food insecurity may occur not because there is not enough food, but because people do not have access to enough food. Agriculture is highly vulnerable to

climate variability and long-term climate change, which could in many parts of the country result in food shortages, higher food prices, lower domestic revenues and climate change will only aggravate falling harvests (Devereux, 2000). As a result, climate change impacts can be a cause of food insecurity for poor household.

Fred *et al.* (2003) noted that, in Tanzania famine resulting from either floods or drought has become increasingly common since the mid-1990s, undermining food security. Kangalawe and Liwenga (2005) reported that, droughts and floods result into increased crop damages in combination with other stress factors lead to chronic food shortage.

2.4 Climate Change Mitigation Interventions and Crop Productivity

Innovations in agriculture have always been important and will be even more vital in the context of climate change (IFAD, 2007). The core challenge of climate change mitigation interventions in agriculture is to produce more food, more efficiently, and with net reductions in GHG emissions from food production. According to Center for international forestry research (CIFOR, 2011), climate change mitigation interventions are crucial to new crops and varieties extend to direct carbon sequestration. By increasing the organic matter in soils, conservation agriculture improves the moisture capacity of the soil and thereby increases water use efficiency. According to Dawson *et al.* (2014) interventions in the PFM have been such that sustainable use of the forests were advocated with clear focus on ensuring increased carbon stocks and leveraging provision of forest ecosystem services through extension of mitigation activities on farm for instance encourage agroforestry approaches, established community based income generating activities, promoting ecotourism and elevating the use of non-timber forest products.

2.5 Sustainable Land Management Technologies

Agricultural production systems are expected to produce food for a global population that will amount to 9.1 billion people by 2050 and over 10 billion by the end of the century

(Branca, 2011). Furthermore, to secure and maintain food security and agricultural systems there is a need to transform the productive capacity and stability of smallholder agricultural production. According to World Bank (2006), great attention must be given to alternative means of intensification, particularly the adoption of sustainable land management technologies. Elwyn (2011) underscored that, increasing the resilience of farming systems to climatic risk need to improve their capacity to sequester carbon and mitigate climate change. FAO (2010) observed that, sustainable land management can generate productivity increases, cost decreases and higher stability of production. According to Land Development Department (2011), sustainable land management practices contribute to improving soil fertility and structure, adding high amounts of biomass to the soil, causing minimal soil disturbance, conserving soil and water, enhancing activity, diversity of soil fauna, and strengthening mechanisms of elemental cycling.

2.6 Poverty and Environment

As pointed out by World Commission on Environment and Development (WCED, 1987), poverty is a threat to the environment, when there is a widespread of poverty in the country which creates pressure on the natural resource. Poverty contributes much on the global GHG through unsustainable utilization of forest resource. Many people entirely, particularly in developing countries rely on natural resources for food, energy and other purposes. This has created problems and increasing global warming due to the unsustainable utilization of trees resources and energy source for various uses. To a larger extent deforestation has been contributed by utilization of forests trees for energy in Tanzania. According to Michael (2006) underscored that, poverty seen from many perspectives, can constitutes lack of livelihood alternatives. Therefore, in this scope,

people can opt for immediate available ways such as unsustainable use of forests and other forest related resources.

2.7 Cost-effective Climate Change Strategies

The build-up of greenhouse gases (GHGs) in the atmosphere, much of it driven by human activity (EACC, 2008). Under current projections, concentrations of GHGs will continue to increase into the indefinite future, entailing a process of continued global warming. Estimates of the costs of inaction on climate change vary widely, but there is no doubt that beyond a certain level of global warming these costs will be large, particularly in many developing countries as sea-levels and storm surges rise, heat waves become more frequent and intense, and agricultural yields in rural areas decline (UNFCCC, 2008). Even more disturbingly, each degree of global warming increases the risk of more destructive climate events, causing large and possibly irreversible damage worldwide.

If we look at the costs and especially the risks of inaction, ambitious action to reduce GHG emissions makes economic sense (OECD, 2011). It is vital that such action stabilises GHG concentrations, to slow down and limit global warming Organization Economic Cooperation Development (OECD). According to Richard (1998) analysis could be based on a number of mitigation scenarios. They consider different target levels for long-term concentrations of GHGs, different time frames for achieving them and different ways of compiling the numbers. Any scenario designed to stabilise GHG concentrations at a level that keeps the risks of more destructive climate events moderate is an ambitious one. According to Bohringer and Fischer (2011), radical change requires a transformation of the economy that will not be either easy or cheap, and there is thus an enormous premium on developing a cost-effective set of policy instruments to achieve the required abatement.

Core issues for reducing global GHG emissions to be cost-effective, cuts in emissions need to be made where they are cheapest. More specifically, the costs of any additional emission cut need to be equal for all sources of emissions, so that it would not be possible to lower overall costs by redistributing cuts. Putting a price on GHG emissions is the most obvious way to achieve this. Equally important, such pricing establishes incentives to undertake research and development (R&D) and innovate more generally in energy-saving and climate-friendly technologies. Such innovation is the best hope for containing the costs of curbing GHGs in the long run (UNFCCC, 2009). However, in practice a broad mix of policy instruments will have to be deployed, because price measures cannot solve all problems effectively and the coverage of pricing schemes may be less than complete for some time.

One concern that arises when some countries take ambitious action to abate GHG emissions but others do not is that energy-intensive sectors in abating countries will see the costs as too high for them, due to loss of competitiveness vis-à-vis countries that do not take action Richard (2009). The amount of "leakage" of emissions to countries which are not taking part in the effort appears to be relatively small if the pool of abating countries is reasonably large. However, short-term concerns in these countries about the impact of job-losses in energy-intensive sectors on overall employment could hamper progress in implementing climate policies. According to Vuuren, and Warren (2007) the costs of both climate change and abatement action are unevenly distributed across regions and sectors. For this reason, incentives to participate in an abatement framework are also heterogeneous. A range of approaches and instruments may be helpful in providing support for action and generating buy-in, thereby achieving the wide country coverage required for cost-effectiveness.

The United Nations Framework Convention on Climate Change (UNFCCC) makes clear that cost-effectiveness is an important criterion to be used (among others) in formulating and implementing climate policies. As stated in Article 3.3 of the convention taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure that global benefits at the lowest possible cost (UNFCCC, 1992).

The cost of mitigation can depend significantly on the selection of a designated concentration target that, typically, is assumed to be achievable within 100 or 200 years. Most model-based studies indicate that the first units of abatement are fairly inexpensive; "low-hanging fruits" are easily picked. However, most studies show that additional units of abatement require more extensive changes and involve significantly higher costs. Thus, to lower the original concentration target is projected to result in a more than proportional increase in costs. Rising marginal abatement costs provide a rationale to employ broad-based, economically efficient mechanisms for GHG abatement. The cost of mitigation depends not only upon the cumulative emissions reductions required over the next century, but on the timing of these emissions reductions as well.

2.8 Where are we now and where are we heading in climate change mitigation?

World GHG emissions have roughly doubled since the early 1970s and on current policies could rise by over 70% during 2008-2050 World Bank (2010). Historically, energy-related GHG emissions were predominantly from the richer developed countries of the OECD, so that the rise in GHG concentration from the industrial revolution to today is largely accounted for by economic activity in these countries (OECD, 2008). Today, however, two-thirds of the flow of new emissions into the atmosphere is accounted for by developing countries outside the OECD, and without new policies this share is set to rise further to 2050.

Greenhouse gases are emitted by many economic activities. Quantitatively, the largest share is accounted for by power generation (electricity production and transformation were responsible for 26% of global emissions in 2004), followed by industry generally (about 19%) and transportation (13%) Sim, R. E. H., Schock, R. N. and Adegbululgbe, A. (2007). It is important to note that deforestation and forest degradation (about 17%) are estimated to account for more emissions globally than the entire transport sector. According to OECD (2008) baseline scenario assumes world economic growth averaging just over 3.5% in purchasing-power-parity terms up to 2050, with a gradual catch-up in living standards of developing countries to those of the developed ones (FAO, 2012). In terms of emissions and resulting concentrations, the baseline is quite close to the average of other recent studies; some are more optimistic, but others less so.

2.9 Climate Change Mitigation Challenges

The challenge of climate change mitigation from an equity perspective is to ensure that neither the impact of climate change nor that of mitigation policies exacerbates existing inequities both within and across nations. The starting point for describing this challenge is the vast range of differences in incomes, opportunities, capacities, and human welfare, both between and within countries. This is combined with the fact that carbon emissions are closely correlated to income levels–both across time and across nations–which suggests that restrictions on such emissions may have strong distributional effects (Parikh, 2000). Income and consumption, as well as vulnerability to climate change, are distributed unevenly both within and between countries concerns about the disproportionate impacts of climate change on developing countries are mirrored in similar fears with regard to poor and vulnerable communities within developing countries (Metz, 2001). Over 1.3 billion people, or more than one-fifth of the global population, are estimated to be living at less

than US$1 per day. Other measures of poverty and vulnerability – lack of access to health, education, clean water, or sanitation–yield higher estimates of poverty (Shaida, 2008).

Since poverty is concentrated in developing countries especially South Asia and Sub - Africa whose average per capita income is less than one-quarter (in dollars of constant Purchasing Power Parity) of the average for developed countries (World Bank, 1999), equity concerns have focused on differences between rather than within countries. The distributional dimension of global poverty was illustrated vividly by the Human Development Report 1989 UNDP (1989), in the form that has come to be known as the champagne glass. This representation of global income distribution shows that in 1988 the richest fifth of the world's population received 82.7% of the global income, which is nearly 60 times the share of the income received by the poorest fifth (1.4%).

The statistics indicate that inequality has widened further since then and that in 1999 the richest quintile received 80 times the income earned by the poorest quintile (UNDP, 1999). Besides average income levels, Annex I and non-Annex I countries differ in other ways, most importantly in terms of the capacity for collective action and access to technology and finance. Many non-Annex I countries face problems of governance because of weak administrative infrastructures, failure to invest in human and institutional capacity, lack of transparency and accountability, and a high incidence of civic, political, and regional conflicts (UNDP, 1997). They also house a less than proportionate fraction of R and D infrastructure, and consequently lack access to technology and innovation (IPCC, 2000). This is especially important on issues of global environmental change, which are strongly science-driven areas.

Finally, many (though not all) of these countries are over-exposed to international debt–and their governments to domestic debt–and thus have less flexibility in the choice of policy options (World Bank, 1998). According to Bowen and Ranger (2009),

notwithstanding the diversity of initial conditions in various countries, they share a common commitment to the goal of economic growth, partly for its own sake and partly because it is perceived as one of the means of poverty eradication and capacity development.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 The Study Area

3.1.1 Geographical Location

The study was conducted in Morogoro District. The district is located in North Eastern part of Morogoro region between 8°00' and 10°00' latitudes South of equator and between longitudes 28°22' and 37°00' East. It borders with Pwani Region to the north and east, by Kilombero District to the south, to the southwest Kilosa District, to the west by Mvomero District and Morogoro Municipality. Administratively Morogoro District is been divided into six divisions which are Mikese, Mkuyuni, Ngerengere, Matombo, Mvuha and Bwakira (URT, 2012). Mvuha Division is the one which was selected for the study whereby two wards Kolero and Kasanga were selected. From each ward two villages which are Kolero, Lubasazi, Kasanga and Kitonga were selected. Both Kasanga and Kolero wards are located on the eastern side of the Uluguru Mountains about 120 kilometers from Morogoro town as shown in Fig. 2.

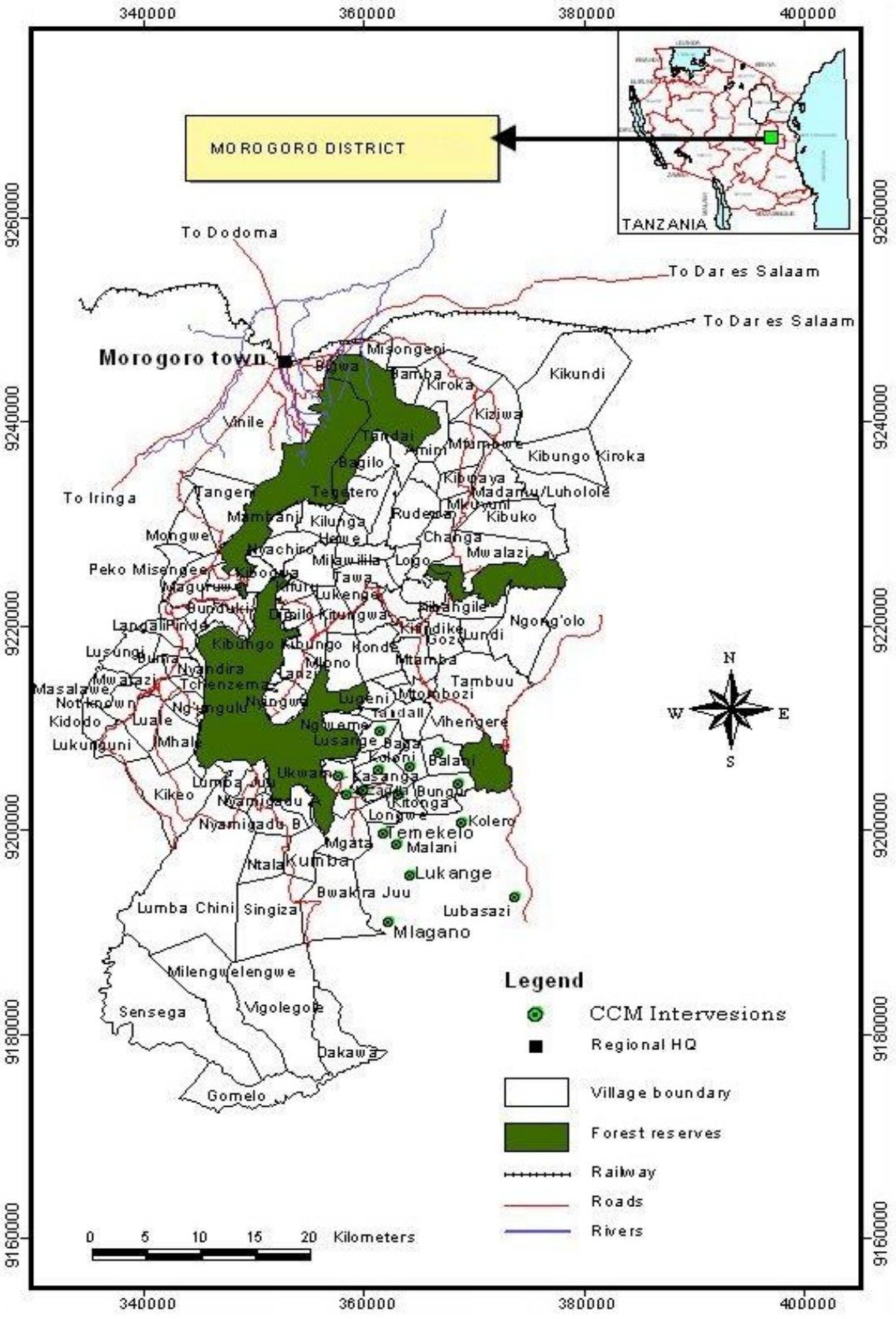


Figure 2 : Map of Morogoro District

Source: Adopted from Chamshama *et al*., 2008 with modification.

3.1.2 Soil and vegetation

The soils of the study area are generally described as acidic lithosols and ferralitic red, yellow and brown latosols that have developed over Precambrian granulite, gneiss and migmatite rocks. The vegetation type in the study area varies with altitude. Lower altitude areas of Kolero and lubasazi have sub-montane and coastal rain forests while high altitude villages such as Kasanga and Kitonga are also have black wattle or *Acacia mearnsii* growing on fallow land (Lovett, 1993).

3.1.3 Climate

In terms of climate, areas around the Uluguru Mountains are generally cooler on higher altitudes and warmer on lower altitudes. Based on this reason high altitude areas such as Kasanga and Kitonga are generally characterized by lower temperatures than Kolero and Lubasazi that are located at much lower altitudes. The Uluguru Mountains capture moisture passing inland from the Indian Ocean thus making the east facing slopes such as Kasanga and Kolero wet, with rainfall estimated at over 3 000 mm per annum (Wamba , 2008). Chamshama and Lovett (2008) indicate that rainfall varies between 1 200mm to 3 100 mm on the drier western slopes and from 2 500 to 4 000 mm on the wetter eastern slopes. According to URT (2010), there is no marked dry season on the eastern slopes, but on the west, two rain seasons are distinguished, the long rains falling from February to June and the short rains between October and January.

3.1.4 Social economic activities

The main economic activity in Morogoro District is agriculture for crop production. Consequently the land ownership among Waluguru is unique in the sense that, it is largely owned by the members of clan rather than individuals or households as it is the case with other ethnic group. Therefore, land is continuously decreasing because of being

subdivided to other members of family. However, in some instances land is bought, sold and developed privately if family members agree and the village government endorses. Majority of Morogoro rural farmers are peasants who produce by using hand hoe. The major crops that are grown include maize, paddy, cassava, sorghum, beans, banana and other cash crops including sisal, sesame and pigeon peas. Livestock keeping is another important employment sector of the people of Morogoro Districts. Most livestock keeping is practiced by the Masai and Sukuma tribes (Maugo, 2008).

3.1.5 Justification of the choice of study area

The study was conducted in Kolero and Kasanga wards where climate change mitigation interventions are being injected by Tanzania government and other non government organizations including CARE International. Meanwhile, the adverse impacts of climate change posses threat to crop production particularly to marginalized societies (URT, 2013). Therefore, the study also was strived to compare the situation of crop production before and after implemented climate change mitigation interventions in study area.

3.2 Research Design

Cross-sectional design was used in this study because it allows data to be collected at a single point in a time (Bailey and Mouton, 1998). Data were collected at a single point in time, though some of qualitative data were obtained by interviewing the sampled respondents in groups. The cross-sectional design was chosen because it is easier and economical to conduct especially where the constraints like resources and time dictate the results.

3.3 Population of the Study

The population of the study included households who are involving in farming activities and practicing in climate change mitigation intervention introduced by CARE International Organization and Tanzanian government.

3.4 Sampling Procedure

Multi-stage sampling technique was used in the study due to the fact that, it is easier to administer sampling frame as follows:

Stage1: Purposive sampling was used to select two wards from Mvuha Division, because the climate change mitigation interventions were implemented only in that area. Purposive sampling was used also to get 10 key informants who included 4 field officers from CARE, 4 experienced farmers and 2 extension officers from the villages.

Stage 2: Simple random sampling was used to select four villages from the two wards the two wards due to the fact that, climate change mitigation interventions were covered and implemented with both two wards. The reason for using simple random sampling is to make sure that every member has an equal chance of being selected (Kothari, 2004). Therefore, 30 respondents were selected randomly from each, 4 villages which make a total of 120 respondents.

3.5 Sample Size

According to Bailey and Mouton, (1998) a sample size of 30 respondents is the bare minimum for studies in which statistical data analysis is to be done regardless of the population size. Therefore the sample size for the study was 120 whereby 30 respondents from each 4 villages were selected.

3.6 Data Collection

Climate change mitigation interventions programme took place in farmers' fields where the farmers owned their farms. Therefore, primary data collected based on the climate change mitigation interventions and supplemented with secondary data as explained by the following sections.

3.6.1 Primary data collection

Primary data are those which are collected afresh and for the first time and thus happen to be original in character (Kothari, 2004). These were the main sources of information for this study which were collected through personal interviews by using a questionnaire and focus group discussions. The questionnaire was used to collected data on personal information about respondents, climate change and climate change mitigation interventions, economic activities and crop productivity. This information was collected through personal observation and interview of some key informants by writing and recording through phone.

3.6.2 Secondary data collection

According to Church (2002), secondary data refers to information that available in the statistical information, published articles, and data available in the text, table, graph, and appendices in the published article. For this study, secondary data comprised of various relevant literatures from journals, published and unpublished materials and other sources like internet. Therefore, secondary data were collected from District Agricultural Department and CARE International offices in order to examine climate change mitigation interventions on crop productivity.

3.7 Data Analysis

Data were analyzed by using Statistical Package for social science to get descriptive statistics such as frequencies and percentages. Qualitative data from key informants were analyzed by using content analysis technique. Descriptive statistics were used to analyze objectives number one which aimed at identifying climate change mitigation interventions undertaken in study area. Inferential statistics were used to analyze objective number two to gauge the level of awareness to community on climate change mitigation interventions and objective number three was used descriptive statistics to know the challenges of implementation of climate change mitigation interventions in study area. Further,

Inferential statistics were used to analyze objective number 4 which was determine the impacts of climate change mitigation interventions in study area, through multiple linear regression model, to test whether there is a significant impact of climate change mitigation interventions on crop productivity.

Multiple linear regression model used because, it can contain many variables that operate independently, or in concert with one another to explain variation in the dependent variable. Therefore, multiple linear regression model was run to measure the effectiveness of the climate change mitigation intervention factors that contribute to crop productivity as independent variables including to gauge the role of each variable in explaining the variances in the dependent variable. The factors used as predictors included respondent's sex, respondent's age (years), respondent's education level, respondent's marital status, household size, occupation, fertilizers application, improved seeds, pesticides, zero tillage, agroforestry, crop rotation and forest conservation. The dependent variable was crop productivity.

3.8 Model Specification

$$Y=\beta_o + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3\,i} \ldots\ldots\ldots\ldots\ldots + \beta_k\ X_{ki}\ + \varepsilon_{1\ldots\ldots\ldots\ldots\ldots\ldots i}$$

Where, Y = crop productivity measured in number of sacks per acre

i = 1, 2, 3,……120

β_o = constant of the regression equation without the independent variables

β_1 to β_k = coefficients of the independent variable

k = number of independent variables

X_1 to X_k =independent variables entered in the models which are:-

X_1 = Gender (1= Male, 0= Female)

X_2 =Age measured in years

X_3 = Education of HH (1= if is formal, 0 if non formal)

X_4 =Marital status (1=married, 2= otherwise)

X_5 = Household size measured in total number of individuals living in the household

X_6 = Occupation measured (1= if an individual is farmer, 0= if otherwise)

X_7 =Income measured in Tshs

X_8 = Size of the land measured in acre

X_9 = Agro forestry (1= if one practice in Agro forestry, 0= if otherwise)

X_{10} =Crop rotation (1= if one practices in crop rotation, 0 = if otherwise)

X_{11} =Forestry conservation, (1= if one practices Forestry conservation, 0 = if otherwise)

X_{12} = Zero or minimum tillage. (1= if one practices zero tillage, 0 = if otherwise)

X_{13} =Use of Improved seeds (1= if one use improved seeds, 0= if otherwise)

X_{14} = Use of fertilizer (1= if one use fertilizer, 0= if otherwise)

X_{15} = Use of pesticides (1= if one use pesticides, 0= if otherwise)

3.9 Limitation of the Study

During conducting this study, some setbacks were encountered. These included problem of farmers recalling the data or information. Data collection depended on the respondents' memory, especially on the number of sacks harvested per acre before and after climate change mitigation interventions. This required asking of some questions more than once in different ways and use of key informants to make farmers understand questions, get the information and provide answers precisely.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Socio Economic Profile of Respondents

The socio-economic characteristics of respondents are important elements of any community as they reflect its behaviour in decision making. Household characteristics have significant social and economic implications on agricultural production in a family (Ferris and Malcolm, 2000). Table 1 describes the household characteristics of sampled respondents in respect of their age, gender, education level, marital status and occupation.

4.1.1 Age of the respondents

The findings in Table 1 shows that 55.0% of the respondents were 41 years old and above. This probably holds that such age group is aware about the climatic condition in the respective area and enough experience in farming activities while age group between 36-40 years were 17.5% of the respondents also aware with climate change. This implies that, the older group have enough experience in agriculture activities and indigenous knowledge which play an important role in application of climate change mitigation interventions. These observations is similar to Makawia (2003) who reported that, age and experiences of an individual contribute much in application of indigenous knowledge and innovations. The same case was reported by Kalinda (2011) that, the older groups are aware and enough experience to impacts of climate change compared to all other younger age group. Other age groups were those between 26-30 years (13.3%), between 31–35 years (10%) and between 20–25 years (4.2%). Therefore, the respondents were asked to indicate their age in order to gain deeper insight on views of climate change impacts and agriculture activities as presented in Table 1.

Table 1: Shows the distribution of respondents by age, sex, education, marital status and occupation (n=120)

Category	Frequency	Percent
Age of respondent		
20 - 25	5	4.2
26 - 30	16	13.3
31 - 35	12	10.0
36 - 40	21	17.5
41 and above	66	55.0
Gender of respondent		
Male	72	60.0
Female	48	40.0
Education of respondent		
Non formal	46	38.4
Primary	63	52.5
Secondary	11	9.1
Marital status		
Single	44	36.7
Married	76	63.3
occupation		
Farmer	118	98.3
Non farmer	2	1.7

4.1.2 Gender of the respondents

The gender dimension of climate change comprises primarily two aspects; women particularly in developing countries are more affected by the impacts of climate change than men. According to Baten and Khan (2010) who reported that, women perform some infrastructures development to conserve soil, water and also to avoid floods by building embankments which presumably make a large contribution to the efforts required to confront climate risk. The observations in Table 1 show that 60% of the respondents are

males while 40% of the respondents are females. This implies that most household were headed by men than women. These findings are similar to Ishengoma (2002) who noted that most of the households in Morogoro District headed by men. Thus, heads of the household are the decision makers for the different activities undertaken within the household. From the study, the majority of the women not being heads of the households, marginalization of their contribution in decisions made in the households. This is due largely to the fact that, in most partrilinear African societies, a woman has no decision and right over land (Salami *et al.,* 2002). Therefore the findings show that participation of women in development and other agriculture activities including climate change mitigation interventions compared to men is still low though women play pivotal role in agriculture and development activities.

4.1.3 Education of the respondents

Education is one of the important factors in creating awareness of climate change mitigation interventions. Therefore to serve the purpose, the findings in Table 1 show that 52.5% of the respondents had primary education while 38.4% had no formal education and 9.1% of the respondents had secondary school education. This implies that majority of the respondents have primary education that can enable them to read leaflets related to agriculture and environment while few of them had secondary school education but the rest have no formal education.

According to URT (2005), education equips people to face the existing challenges of the world which is most likely to affect their participation in resources conservation. The level of education generally not enough to face the existing challenges of the world that affect the surroundings environment. Therefore, there is a need of government to put more effort to build schools, colleges and provision of education in rural areas including agricultural

education which will help to undergo the existing current situation and hence to adapt the climate change mitigation interventions. However the respondents were asked to indicate their level of education and found that many of the respondents have primary education.

4.1.4 Marital status of the respondents

Data in Table 1 show that majority (63.3%) of the respondents were married couples while 36.7% were single. These findings imply that majority of the respondents are married couples. This reflects that the society is stable as it is commented that marital status has implication on social organization and economic activities such as agriculture and resource management. Likewise, marital status induces someone to work hard due to family responsibilities (World Bank, 2009). Thus, marital status led to involve the society in production and economic activities.

The study findings also is similar to Koso and Wilmoth (2002) who noted that married couples are likely to be more productive than a single person because often people who are married comes into responsibility and commitment to common goods and socio - economic transformation. This implies that the mutual efforts characterising marital life can be brought about improvement in production activities.

4.1.5 Occupation of the respondents

The findings show that 98.3% of respondents are farmers and 1.7% of respondents are engaging in other economic activities such as petty trade due to the fact that, climate have already changed and pose challenges to agriculture activities. This is similar to URT (2012) which noted that 85% of the residents in Morogoro District engage in farming activities. These imply that the main economic activity in Morogoro District is agriculture

though some of the rural people are involved in other economic activities due to extremely impacts of climate change that undermine farming activities.

4.2 Household Size

The findings in Table 2 show that the largest household had eighteen member of 0.8%, and the smallest family had one member of 2.5% respectively. The findings in Table 2 show that families with more than two members are many compared with families of 1 member. Therefore, the family of more than two members are engaged in agricultural production and committed to household food security due to the presence of labour force in the households and seemed to be with adequate of food than the family of a single member. Therefore the findings also is similar to Ojo and Babayo (2013) who opines that, food security depend on adequate of assets including land and other productive factors like labour force owned.

Table 2: Respondents' household size (n=120)

Members of family (Household size)	Frequency	Percent
1 - 4	59	49.1
5 - 7	48	40
8 - 18	13	10.8

4.3 Economic Activities of the Study Area

The findings in Table 3 show that, the respondents in the study area are engaged in different economic activities. The majority of the respondents are engaged in agriculture 54.2% and 45% of the respondents involved in petty trade while the rest are employed 0.8%. The main crops include maize and sorghum 76.7%, paddy 2.5%, cassava and other

tubers 20.8%. This correlates to Maugo (2008) who noted that maize and paddy were the predominant crops in Morogoro District. The respondents were asked to indicate their crops that cultivating as presented in the Table 3.

Table 3: Agricultural production in the study area (n=120)

Crops	Frequency	Percent
Maize and sorghum	92	76.7
paddy	3	2.5
Cassava and tubers	25	20.8

4.4 Climate Change Mitigation Interventions Undertaken

Climate change mitigation interventions are actions to lessen the magnitude and/or rate of long-term. Mitigation may also be achieved by increasing the capacity of carbon sink, through reforestation. In Table 4 the respondents were asked to give out mitigation interventions which are undertaken in the study area**.** The aim was to find out if there were mitigation interventions in the respective area.

Table 4: Climate change mitigation interventions undertaken in Kolero (n=120)

Mitigation interventions	Frequency	Percent
Planting tree	47	38.8
Zero tillage	16	13.8
Agroforestry	5	4.7
Crop rotation	33	27.2
Forest conservation	19	15.5

The findings in Table 4 show that 38.8% of the respondents planted trees acacia species generally for forestry and forest products such as charcoal, timber, fire wood and medicine and 13.8% of respondents practice zero tillage for minimal soil disturbance and surface

permanently covered. While 4.7% of the respondents practice agrosilviculture as a system of agroforestry whereby respondents integrate wood perennials with agriculture crops on the same land for food and forest products and 27.2% of the respondents practice crop rotation and 15.5% of the respondents were practicing forest conservation to protect the presence of watershed in forest area. The findings show that all the farmers in the two wards who were in project of conservation agriculture have accepted to practice and adopt climate change mitigation interventions. Meanwhile training, seminars and close supervision which were provided by CARE International contribute much to change mind set of farmers and hence set up farm field school in their farms. Therefore, farmers implemented such interventions by organized groups to conduct farm field school in their farms as shown in plate 1 and plate 2.

Plate 1: Farmers practice conservation agriculture in Kolero village

Plate 2: Tree seedlings nursery in Kolero village

4.5 Community Awareness on Climate Change Mitigation Interventions

Effective climate change mitigation interventions among other factors depend on the presence a critical mass of knowledgeable individuals on climate change issues. That will take part in addressing adaptation challenges and proactively exploit available opportunities to address both adaptation and mitigation, thereby enhancing Tanzania's efforts in climate change mitigation and adaptation. To serve the above purpose the respondents from the four villages were asked on awareness of climate change mitigation interventions. The findings from the respondents are summarized in Table 5.

Table 5: Level of community awareness of the respondents on climate change mitigation interventions (n=120)

Knowledge about climate change mitigation interventions	Respondent Village			
	Kolero	Lubasazi	Kitonga	Kasanga
Yes	32	28	30	25
No	1	0	3	1

Pearson Chi-Square $\chi^2 = 3.335$

The findings on communities' awareness on climate change mitigation interventions in Table 5 show that 95.8% of the respondents in respective area were aware about climate change mitigation interventions while 4.2% were not aware. The findings imply that among the four selected villages the level of awareness on climate change mitigation interventions was the same from one village to another, though there were a few numbers of people who were not aware. Likewise, the chi-square test shows that there were no significant differences ($p< 0.343$) between awareness on climate change mitigation interventions among villages surveyed. Thus, there is a need to conduct further training on mitigation interventions among farmers who are not aware with the interventions.

4.6 Advantages of Climate change Mitigation Interventions

Climate change mitigation interventions are designed to promote sustainable farming. In the study area the respondents were asked to indicate other advantages of climate change mitigation interventions as presented in Table 6 below.

Table 6: Major function of climate change mitigation interventions in study area (n=120)

Categories	Frequency	Percent
To improve soil fertility	87	86.1
To increase crop yield	1	1.0
To minimize the adverse impacts of climate change	11	10.9
Do not know	2	2.0

The findings in Table 6 show that 86.1% of the respondents were benefiting directly from climate change mitigation interventions because of some places in their farms are increasing soil fertility while 10.9% 0f the respondents also realized the advantage of practice climate change mitigation interventions in their farm and 1.0% of the respondents also observed the contribution of climate change interventions, despite of 2.0% of the respondents do not understand anything about climate change mitigation interventions activities. These findings imply that majority of the respondents obtain direct positive advantage of climate change mitigation interventions particularly in farming activities. The findings are similar to DFID (2012) who noted that climate change mitigation interventions yield positive developmental and environmental impacts that can spill-over benefit into wider communities.

4.7 Challenges for Implementing Climate Change Mitigation Interventions

To ensure successful implementation of climate change mitigation interventions need several efforts within and across nations. According to Parikh (2000) who opines that, the starting point for describing this challenge is the vast range of differences in income, opportunities, capacities and human welfare, both between and within countries.

Generally, income and consumption as well as vulnerability to climate change are distributed unevenly both within and between countries. Concerns about the disproportionate impacts of climate change on developing countries are mirrored in similar fears with regard to poor and vulnerable communities within developing countries. Similarly, issues of intergenerational equity have been raised to caution against shifting the burden of adjustment to future generations, which cannot influence political choices today. Therefore the respondents in study area required to identify the challenges that

facing during the implementation of climate change mitigation interventions as indicated in Table 7.

Table 7: Challenges for implementing climate change mitigation interventions (n=129)

Category	Frequency	Percent
Lack of financial support	1	0.8
Lack of extension services	17	14.2
Lack of agricultural education	77	64.2
Poor hand hoes	25	20.8

The findings in Table 7 show that 64.2% of the respondents lack agricultural education which makes many farmers practice traditional agriculture in many rural areas by using indigenous knowledge to face the current situation as shown in plate 3. While 20.8% of the respondents use poor agricultural tools such as hand hoe and machetes. These findings also agree with those of Mvena and Kilima (2009) who reported that, other farmers in Kolero and Kasanga wards slash and burn during preparation of their farms due to lack of knowledge and poor tools including hand hoes. The same case reported by Ngasongwa (2007) that, majority of the farmers in Morogoro are faced with the problem of poor tools. Furthermore, 14.2% of the respondents had a challenge of inadequate of extension services such as extension officers. Another group of respondents 0.8% had a challenge of lack of pesticides.

Plate 3: Farm preparation by slashing and burning in Lubasazi village

4.8 Impacts of Climate Change Mitigation Interventions on Crop Productivity

Climate change mitigation interventions have significant impacts on crop productivity. The findings in Table 8 show that, 99.2% of the respondents observed improvement of crop productivity after practising climate change mitigation interventions in their farms while only 0.8% of respondent did not observe any changes. This finding implies that, application of mitigation interventions in farming activities constitute to improved food production as shown in plate 4. The findings are also similar to FAO (2009) who affirmed that, mitigation interventions contribute to improved crop productivity. Respondents were asked to signify the impacts of climate change mitigation interventions as shown in Table 8.

Table 8: Impacts of climate change mitigation interventions on crop productivity (n=120)

Categories	Frequency	Percent
Increase of crop yield	119	99.2
Decrease of crop yield	1	0.8

Plate 4: Demonstration plot of Farm Field School (FFS) in Kitonga village

4.9 Crop Productivity Before and After of Climate Change Mitigation Interventions from 2009 - 2013

The Fig. 1 of the findings shows that, 52% of the respondents harvested an average of 2 sacks per acre and 29.7% of the respondents also harvested 4 sacks per acre while 16% of the respondent harvested 6 sacks per acre and 2.5% of the respondents harvested 8 sacks per acre before the interventions. The findings imply that, the trend of crop productivity in the study area before climate change mitigation interventions declined gradually. The finding also is similar to Kangalawe (2012) who noted that, the impacts of climate change undermine agricultural production which contributes to food insecurity. While the graph with red bar in Fig. 1 of the findings shows the number of sacks, the respondents harvested after mitigation interventions that ranged from 2 to 8 as per acre.

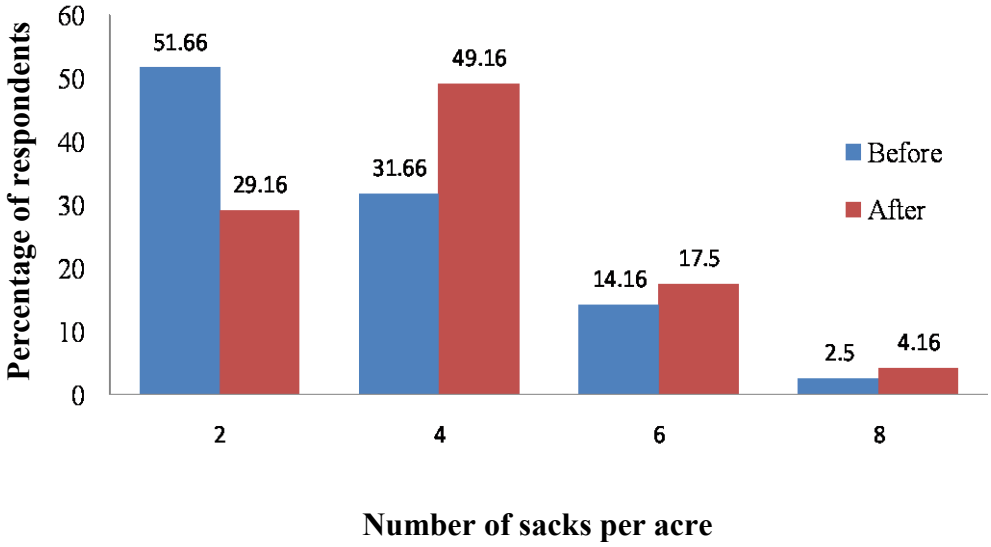


Figure 3: The crop productivity before and after climate change mitigation interventions from 2009 – 2013

These findings in Fig. 1 show that, 29.6% of the respondent's harvested average of 2 sacks per acre and 49.4% of respondents harvested average of 4 sacks per acre while 19% of respondents harvested average of 6 sacks per acre and 4.3% of respondents harvested average of 8 sacks per acre. The findings imply that, the trend of crop productivity after climate change mitigation interventions has been increasing gradually. This tremendous progress has been acknowledged by FAO (2011) who reported that, climate change mitigation interventions contribute much in crop productivity due to control land degradation, soil fertility and soil conservation.

4.9.1 Multiple Regression Model for Selected Predictors

Multiple regression analysis represents a logical extension of two variables of regression analysis. Instead of a single independent variable, two or more independent variables are used to estimate the values of a dependent variable (Gupta, 1990). Table 9 presents predictors contributing to crop productivity whereby regression was significant at ($p \leq 0.01$), ($p \leq 0.05$) and ($p \leq 0.1$).

Table 9: Multiple Regression Model for Selected Predictors

Variables	Unstandardized coefficients		Standardized coefficients	t	sig
	B	**Std. error**	**Beta**		
(Constant)	2.555	.087		29.354	.000
Age	.002	.001	.247	2.998	.003*
Gender	-.013	.018	-.061	-.727	.469
Education	-.029	.027	-.087	-1.064	.290
Household size	-.006	.004	-.135	-1.481	.142
Occupation	-.033	.084	-.040	-.390	.697
Income	4.171 Exp-7	.000	.134	1.308	.194
Farm size	.045	.010	.409	4.484	.000*
Fertilizer	.048	.037	.113	1.297	.197
Improved seeds.	.057	.030	.155	1.884	.062***
Pesticides	-.049	.032	-.123	-1.511	.134
Zero tillage	.163	.068	.642	2.398	.018**
Agro forestry	.194	.093	.234	2.085	.040**
Crop rotation	.180	.066	.839	2.704	.008*
Forest conservation	.133	.069	.484	1.938	.055**

R Square (R2) =0.352

Adjusted R Square (R2) =0.266

* = significant at 0.01 level

**= significant at 0.05 level.

***= significant at 0.1 level

Dependent Variable: Crop productivity measured in number of sacks harvested per acre.

Crop rotation was the highest predictor on crop productivity with standardized regression coefficients of 0.839 and significant at $p \leq 0.01$. The positive regression coefficient implies that, crop rotation and crop productivity are positively related. Thus, many crops may have positive effects on succeeding crops in the rotation, leading to greater production overall (John, 2008). Crop rotation must be considered a key component in crop productivity systems, irrespective of the method of soil cultivation for crop establishment, with maximum use made of break crops that contribute to soil structural stability, soil quality, resilience, and soil fertility. Therefore, Crop rotations are a vital part of direct seeding systems and maximize the moisture conservation and reduce the impacts of diseases, weeds and insect pests. The results are similar to FAO (2008) who noted that, integrated crop rotation in farming activities has potential to improve soil fertility and reduce greenhouse gas emission.

Zero tillage farming is defined as farming where the soil is left relatively undisturbed from harvest to planting (Turi, 2009). It is a system of planting (seeding) crops into untilled soil by opening a narrow slot trench or band only of sufficient width and depth to obtain proper seed coverage. During the planting operation, a narrow seedbed is prepared or holes are drilled in which seeds are planted. As a result, zero tillage had been positive relation with crop productivity because have standardized regression coefficient of 0.642 and significant at ($p \leq 0.05$). This regression coefficient implies that, zero tillage and crop productivity are positively related as shown in plate 5. It mainly involves reducing the number and intensity of tillage operations, improved soil health thereby improving infiltration, reduced time and labour requirements, reduced weed populations over time and increased yields. This result also is similar to Derpsch (2005) who reported that, combination of zero tillage and permanent soil cover increases water infiltration, reduces

the shocks of drought stress and decreases soil and water erosion whereby crops allow roots to penetrate deeper.

Plate 5: Conservation agriculture project area in Kolero Village

Forest conservation has a standardized regression coefficient of 0.484, with significant at ($p \leq 0.1$). The positive regression coefficient implies that, forestry conservation and crop productivity are positively related. These results show that practicing forest conservation contributes to increased crop productivity. Results are also similar to Emmanuel and Fulbright (2001) who reported that, forests mitigate against global warming by storing thousands of tons of carbon and contributes to the livelihoods of many people by improving subsistence.

Farm size has a standardized regression coefficient of 0.409, significant at ($p \leq 0.01$). The positive regression coefficient implies that, farm size and crop productivity are positively related. These results show that, increase farm size in cultivated also lead to increased more crop production. These results are similar to IFPRI (2010) who opines that, increase in cultivated farm size leads to increase in crop productivity.

Respondent's age has a standardized regression coefficient of 0.234, significant at ($p \leq 0.01$). The positive regression coefficient implies that, respondent's age and crop productivity are positively related. These results show that, farmers who are grown up in a number of years leads to increase crop productivity. The results also imply that, as farmer grown old get enough knowledge and experience in agricultural activities. Results on age are similar to CIMMYT (1993) who stated that, older farmers may have enough experience in agricultural activities.

Agroforestry has a standardized regression coefficient of 0.234, with significance at ($p \leq 0.05$). The positive regression coefficient implies that, agroforestry and crop productivity are positively related. These results also show that practicing agro forestry leads to increase in crop productivity. The results are similar to FAO and MICCA (2010) who underscored that, agro forestry contributes to food security by providing multiple products and benefits to farmers such as food, shade for livestock and timber. Moreover, agro forestry supports to enhance agriculture production by improving soil conservation, soil water and soil fertility.

Improved seeds have a standardized regression coefficient of 0.155, significant at ($p\leq 0.1$). The positive regression coefficient implies that, improved seeds and crop productivity are positively related. These results implies that, the use of improved seeds in farming system contribute to increase crop productivity. The result also is similar to FAO (2014) who are affirmed that improved seeds contribute much to improve food security. However, sex, education, income, household size, use of fertilizers and use of pesticides did not contributed significantly to crop production at $p \leq 0.01$, $p\leq 0.05$ and $p\leq 0.1$. These results of gender, education, income, and household size, use of fertilizers and use of pesticides contradict with Hannan (2011) who argue that, gender education, income and

household size are critical inputs in contribution of increase agricultural production. Furthermore the results of fertilizers and pesticides also similar to FAO (2008) who underscored that, fertilizers and pesticides have failed to optimize soil carbon sequestration or to moderate greenhouse gases.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Climate change may be seen as a challenge around the world particularly in developing countries such as Tanzania, but the respective governments and relevant stakeholders should vigorously pursue, adopt and push for mitigation interventions that will not only mitigate further food insecurity, but could also diminish which had already set in (Thompson, 2010). There is no doubt that action and investment of governments is needed for effective climate change mitigation interventions.Therefore, results suggest that a better and more consistent of climate change mitigation interventions in farming activities where currently crop productivity declining will lead to improve food security.

However, it is marked that climate change mitigation interventions are important factors and contribute much to improve agricultural productivity particularly in rural areas including Kolero and Kasanga wards. Further, climate change mitigation interventions such as forest conservation, agroforestry, improved seeds and crop rotation with minimal cultivations increases root system development, improve soil fertility and reduce soil erosion thus, crops were able to take up moisture more effectively.

Furthermore integration of different cultivation systems also helps to achieve crop productivity, and provides increases in species diversity which has implications for natural regulation of antagonists. Although majority of farmers in rural areas are failed to implement effectively the interventions in their farms because of lack financial support, poor hand hoes, skiving of close supervision and agricultural education and lack of extension services in the field areas. On the other hand the interventions in other rural areas performing poor in mitigation of climate change and agriculture activities because of poor supervision.

5.2 Recommendations

In view of the findings of this study and the conclusions made the study recommends the following.

i. Mitigation interventions should be intervened into government policies and plan in order to help smallholder farmers in rural areas and to improve agriculture sector.

ii. Increase number of extension officers and they should provide close supervision and agriculture education from preparation of farm throughout the farming season.

iii. Farmers should be encouraged to change mind set in order to adapt modern and profitable agriculture.

iv. Government should provide an excellent entry point on environmental and climate change mitigation interventions awareness across the villages or farmers and to initiate community adaptation program from the grassroots level.

v. To ensure the effectiveness of implementation of climate change mitigation interventions the government should also introduce or establishment CBO's which will help the smallholder farmers to meet and discuss various matter of climate change mitigation interventions for implementation.

vi. The Government should demonstrate serious implementation actions such as reforestation and drought mitigation measures. This will show high level government commitment to climate change mitigation interventions issues.

vii. Mitigation Interventions should be implemented in all places in order to improve food security and minimize the number of people who run away from rural to urban whose, sometime lead to decrease the number of manpower in rural and hence constitute crime in city centers due to presence of jobless in urban.

viii. Mitigating global climate change requires not only government action but also cooperation from consumer.

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APPENDICES

Appendix 1: Operational definition of key variables, their indicators and level of measurements

Variables	Definition	Indicator	Level of measurement
Age	Number of years one has lived.	Number of years	interval
Sex	State of being male or female	1=Male 2= Female	nominal
Household size	Number of members in household.	Total number of people living in one household	Ordinal
Marital status	Situation of being married or unmarried.	1=married 2=single 3=separated 4=widow	Nominal
Occupation	State of being employed or unemployed	1=employed 2=unemployed	Nominal
Income	Access of money	1=yes 2=no	Nominal
Education	Level of education one attained in school	1=primary 2=secondary 3=high education 4=non-formal	Ordinal
Agro forestry	System of planting mixed crop and tree at the same farm.	Presence of soil fertility and minimum soil erosion	Nominal
Crop rotation	Change the crops in a farm	Decrease of diseases and pests	Nominal

Zero tillage	No deep tilling	Presence of hardened impervious layer	Norminal
Forest conservation	Situation of reserving trees indicator presence of watershed and reduce flooding.	Presence of watershed and rain	Nominal
Improved seeds	Use of quality seeds	Increase in crop yield	Nominal
Use of fertilizers	Chemical or organic compound that is applied to plant .	Increase in crop productivity.	Nominal
Use of pesticides	Applying pesticide in the farm.	Absence of pathogen and pests.	Nominal
Effectiveness	Situation of being successful increase of crop productivity.	Increase of crop productivity	Nominal
Climate change	change in climate over time,	Presence of unpredictable rainfall, drought, floods and diseases.	Interval
Crop productivity	Quality and quantity of producing crops.	Number of sacks harvested per acre	Nominal

Appendix 2: Questionnaire for household survey

Questionnaire No..... Respondent No....

District.....

Division.....

Ward.....

Village.....

SECTION A. GENERAL INFORMATION

1. Demographic information

1.1 Name of household; ..... 1.2 Name of

respondent..... 1.3 Age of

respondent..... 1.4 1.5 Gender of respondent

(1) Male

(2) Female.....

1.6 Level of education of respondent (1) Primary

(2) Secondary [ ]

(3) High education

(4) Non formal education

1.7 Marital status (1) Single

(2) Married [ ]

(3) Widow

(4) Divorced

1.8 Household size.....

1.9 How many years have you lived in this place? .....

2.0 What is your occupation? .....

2.1 What is your monthly income? .....

B. ECONOMIC FACTORS

2.2 What is your major economic activity in your household?

S/N	Economic activity	Rank
1	Agriculture	
2	Livestock keeping	
3	Wage employment	
4	Petty trade	
5	Beekeeping	
6	Art and craft	
7	Hunting	
8	Tourism	
9	Masonry	
10	Carpentry	
11	Mechanics	
12	Others(specify)	

*Order of importance to household: 1= most important, 2= less important

2.3 What is the size of the land that you cultivate? (in acres)

1) ½ -2

2) 2- 4 [ ]

3) 4- 6

4) Above 6

2 .4 What is your household main land use activity?

1) Crop production

2) Livestock production [ ]

3) Forest production

4) Others (specify)

2.5 How many years have you engaged in agriculture? Mention

2.6 Have you cultivated in 2010, 2011 and 2012? Yes/No

2.7 If yes what type of crops did you cultivated in that periods? Mention

.....

2.8 What is size of your farm?.....acre

2.9 Which type of crops do you cultivate for food?

1= maize

2= paddy [ ]

3= cassava

4= others (specify)

3.0 Which type of cash crops do you cultivate in this area? Mention

.....

3.1 Do you use fertilizers in your Farm? Yes/No

3.2 If yes what is the impact of the uses of fertilizers? (skip to 3.4)

1=increase of crop production

2= decrease of crop production [ ]

3= remain constant

3.3 f no why?.....

3.4 Have been ever use improved seeds in your farm? Yes/ No

3.5 IF yes how was the situation in term of crop productivity? Explain

.....

3. 6 Do you use pesticides in your crops? Yes/No

3.7 If yes how about crop yield after use pesticides increased or decreased? .....

3.8 If no why.....

3.9 Is there other economic activities do in this area? Yes/No

4.0 If yes mention? .....

C**. CLIMATE CHANGE AWARENESS**

4. Do you know anything about climate change? Yes/No [ ]
5. If yes in above question, what is it?

……

6. Are there any adverse effects from climate change? Yes/No [ ]
7. If yes in above question, mention the effects

……

8. Is there any relationship between climate change and crop production? Yes/No
9. If yes what is it?

……

10. Do you know anything about mitigation of climate change? Yes/No [ ]
11. If yes what is it?.....
12. What is the major activity of mitigation intervention of climate change? Mention

.....

13. What is relationship between mitigation of climate change and crop production?

Explain.....

D. MITIGATION INTERVENTION FACTORS

14.Is there any intervention strategies to reduce adverse impacts of climate change in your village? Yes/No [ ]

15. If yes mention

……

16. Have you get training on how to use that interventions? Yes/No
17. If yes from whom?.....
18 If yes how do you implement?.....
19.What are challenges that face you during implementation of that interventions? Explain

.....

20.Do you practice those interventions in your farm? Yes/No [ ]

21.If yes which do you practice in your farm from the last season? Mention

.....

22.How do you practice through those interventions?

.....

23.How many years since you start to implement those interventions in your farm? Mention

24.How do you rate the weather condition in the past three years?

Year	Conditions (code below)
2010	
2011	
2012	

Code

1=received excessive rains

2=received adequate rain

3= Inadequate rains

4=Drought

5=Unreliable rains

25. Have you seen any changes in crop productivity since you started to cultivate by using croprotation/agroforestry/wetlandrestoration/plantcover/conservationagriculture/ forstry conservation? Yes/No

26. If yes what are changes? Mention

.....

27. In general how do you see the trend of crop productivity in this area?

.....

28. What do things to strengthen those interventions? Mention

.....

29. What other activities that led to increase crop production in this area? Mention

.....

30. Is there any governmental intervention imposed to alleviate climate change effects in you village? Yes/No [ ]

31. If yes what are they? mention .....……

32. Is there any other interventions apart from those of CARE projects which are implemented in this area? Yes/No

33. If yes mention……

34. Is there any other intervention planned by the village communities to alleviate the situation? Yes/No

[ ]

35. If yes in the question above, what are those?……

36.. The crop productivity currently increased? Yes/No [ ]

37. If yes explain.....

38. If no

why.....

39.What is your opinion on these interventions? Explain

……

E.CROP PRODUCTIVITY

40. How do you rate your crop productivity before and after mitigation interventions?

1. Food was inadequate before interventions

2.Food is adequate after the interventions [ ]

3.No changes before and after the interventions

4.Food is inadequate after interventions

41.How much sacks of crops do you harvest each year after mitigation intervention? Mention .....

42.How much sacks of crops did you harvested before mitigation intervention? mention

.....

43.Currently how much sacks of crops do you harvest per acre? Mention

.....

44.Before mitigation interventions how much sacks did you harvest per acre? Mention

.....

45. Is there any crops currently are growing much because of mitigation interventions? Yes/No [ ]

46.If yes mention.....

47.Is there any crops currently are disappeared just because of mitigation interventions that are being implemented in this area? Yes/No [ ]

48. If yes mention.....

49.What is the household food consumption in last 12 months?

1. Adequate [ ]

2. Inadequate

50.Which of the following major crop productivity problems?

1.Climate change

2.Crop pests and diseases [ ]

3. Natural calamites

4.Thefts

5.Land conflicts

6.Others (specify)

51. What other local alternative way to increase crop productivity and decrease impacts of Climate change?

Mention .....

52.What is your opinion on current crop productivity?

.....

53. What is your comment in general on crop productivity in rural area?

.....

Appendix 3: Checklist

CHECKLIST FOR FIELD OFFICERS FROM CARE INTERNATIONAL

1. Why these projects are implemented in this area?
2. What are mitigation interventions that are implemented from your projects?
3. How do you implement it?
4. How mitigation intervention strategies relate with crop production?
5. To what extent mitigation interventions can improve the crop productivity?
6. In which way the farmers can survive in climate change?
7. Since starting to implement projects in this area, are there any changes in term of climate? Explain
8. What is the reason behind that contributes much in environmental degradation in this area?
9. In which way the farmers are involved in your projects?
10. What is your opinion on climate change?

CHECKLIST FOR EXTENSION OFFICERS

1. What is your major activity in this area?
2. What are major challenges that facing during the implementation of your activities?
3. Is there any mitigation measures of climate change in this area? Identify
4. Are there farmers that implementing mitigation interventions?
5. Since starting to implement those interventions, are there any changes in term of crop production to farmers?
6. Do you think that the farmers are enough skills to implement mitigation intervention in their farm?
7. How do you see now the situation of food after farmers involved in mitigation measures?

8. Which are challenges that facing farmers during implementing mitigation interventions?
9. In which way the farmers be empowered in order to clear out the shortage of food?
10. What is your general comment on climate change to farmers?

CHECKLIST FOR FARMERS REPRESENTATIVES

1. For how long be involved in agriculture activities?
2. What climate change effects that being facing you in crop production?
3. In what way being controlling that impacts in agriculture activities?
4. For how long being implementing mitigation interventions in your farm?
5. How do you rate the situation of foods before and after mitigation measures?
6. For one acre before mitigation measures how many sacks did you harvest per year?
7. Now how many sacks do you harvest per acre after mitigation interventions per year?
8. What challenges that facing you when implemented mitigation interventions in your farm?
9. What other local way that are using to fight against adverse impacts of climate change in this area?
10. What is your general comment on climate change in crop productivity?

THANK YOU FOR YOUR ATTENTION!!