THE ROLE OF INDIGINEOUS KNOWLEDGE SYSTEM (IKS) ON ADAPTATION TO CLIMATE CHANGE TO SMALLHOLDER FARMERS IN KILEMA WARD IN KILIMANJARO REGION, TANZANIA

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A DISSERTATION SUBMITED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ENVIRONMENTAL STUDIES OF THE OPEN UNIVERSITY OF TANZANIA

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CERTIFICATION

The undersigned certifies that had read and hereby recommends for acceptance by the Open University of Tanzania a dissertation titled: **"The Role of Indigenous Knowledge Systems (IKS) on Adaptations to Climate Change to Small Holder Farmers in Kilema Ward in Kilimanjaro Region, Tanzania"** in partial fulfillment of the requirements for the Degree of Master of Environmental Studies (Management Stream) of the Open University of Tanzania.

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Dr. Irene Tarimo

(Supervisor)

.....

Date

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DECLARATION

I, **David John Shirima**, do hereby declare that this dissertation is my own original work and that it has not been presented and will not be presented in any other University for a similar or any other degree award.

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Signature

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Date

DEDICATION

This dissertation is dedicated to my wife and children for their moral and material support throughout this study.

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First and foremost, I would like to thank the Almighty God through His Grace and Blessing throughout the period of the study, may his name be glorified.

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Last but not least, I would like to express my appreciation to my wife, children and all my family for their encouragement, moral and support which made my study successful.

GOD BLESS YOU ALL

ABSTRACT

The study examined the role of IndigenousKnowledge Systems on adaptations to climate change. Oncopingstrategiesby small farmers and their perceptions in Kilema ward in Kilimanjaro Region, Tanzania.A sample of 58 people was involved out of 100 registered farmers. Purposive and simple random sampling was employed in identifying the samples. Data was collected using questionnaires, interviews, observation and documentary literature review. Data was analyzed using SPSS version 20 and content analysis. The results showed having knowledgeabout (85%) of weather related information, coping strategies/adaptations (29%) and entirely dependent on farming for their livelihoods.About 95% drought incidence was increasing (Table 4.4) with 74% causes of changes. About 95% temperature was increasing, 98% rainfall was decreasing, 64% (Table 4.5)deforestation was increasing; 21% do use CSA,10%doaforestations; 9% make terraces,35% dotrenches digging, 26% do mulching and2% harvest rain water, 6% do irrigation with 4% plant drought resistance crops. About69% rear domestic animals and chickens, 38% do businesses and 4% do motorcycles transportations.About 29% do agro-forestry,21% do soil management, 29% do improved water management, 50% do crops management, 60% do livestock management, 71% do croprotations, and 45% do better weather forecasting.Indicators of climate change are fresh water scarcity 57%; Low harvests 11% and disappearance of some plant species 89% (Table 4.4). This recommendsimpartingknowledge to the farmers on CSA technologies. It recommendstraining farmers do Aforestation and doinggood farming practices. It recommendsraising awareness on rain water harvest. It is recommendedto secure loansfrom banks and SACCOS.

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AAN	Action Aid of Nepal
AgMIP	Agricultural Model Inter-comparison and Improvement Project
CO_2	Carbon dioxide
CH_4	Methane
FAO	Food Agriculture Organization
FGD	Focus Group Discussion
HIV/AIDS	Human immunodeficiency virus/ Acquired Immunodeficiency Syndrome
IPCC	Intergovernmental Panel on Climate Change
LDC's	Less Developed Countries
NIDOS	Network of International Development Organization in Scotland
NGO's	Non-government Organization
N2O	Nitrogen oxide
SSA	Sub- Sahara Africa
UNDP	United Nation Development Programme
UNFCC	United National Framework Climate Change
ENSO	El Niño-Southern Oscillation
SOI	Southern Oscillation Index
CSA	Climate Smart Agriculture

CHAPTER ONE

BACKGROUND OF THE STUDY

1.1 Introduction

Globally, Small scale farmers are considered vulnerable to the negative effects of climate change and variability. There are limited knowledge's of understanding on how climate change variability affects the livelihood of small scale farmers' communities in Kilema ward in Kilimanjaro region.Climate change refers to change in the state of the climate that can be identified by change in the means and the variability of its properties and that persists for external period, typical decades or longer, (IPCC, 2014). According to IPCC, 2014, climate change may be due to natural internal process or external forcing such as modulation of the solar cycles, volcanic eruption and persistent anthropogenic change in the composition of the atmosphere or inland use (IPCC, 2014).

Human activities such as burning of fossil fuels, industrial production and cut down of rainforests change the atmosphere's composition by increasing the amount of greenhouse gases, which, in turn, traps heat in the atmosphere and thereby facilitating climatic changes (Hope, 2009). Mubaya *et al.* (2010)noted that, the United Nations Framework Convention on Climate Change (UNFCCC) uses the term climate change for human-caused change and climate variability for other changes. In last 100 years, ending in 2005, the average global airtemperature near the earth's surface has been estimated to increase at the rate of 0.74 +/- 0.18 °C (1.33+/- 0.32 °F) (IPCC, 2007).

Perry*et al.* (2009) points out that the climate variability is affecting farming ecosystems and the human societies that depend on them.The effects is of two-folds,

bio-physical and socio-economic, whereby biophysical impact includes rising sea waters level, more frequent and intense storms, altered frequencies and intensities of precipitation, increased water temperatures and more intense storm events. The impact of climate change leads to loss of species, drought, crop failure, as well as changes in cloud cover, melting of polar ice caps and glaciers, and reduced snow cover as that of MT. Kilimanjaro in Africa (Mendelssohn and Dinah, 2005; UNDP, 2004; UNFCCC, 2007). These effects, impacts the health of coastlines, global biodiversity, ecosystem and availability, accessibility and quality of resources which human population depends on, both directly and indirectly. Other biophysical impacts of climatic change on fisheries include surface winds, high CO_2 levels, and variability in precipitations (IPCC, 2007).

There is a linkage between biophysical and socio-economic impacts of climate change. Biophysical factors of climate are altered due to human activities. The socio-economic well-being of people in rural areas depending directly on the agriculture ecosystem to acquire their livelihoodsis also negatively affected by climate changes. Irrigation operations are also affected. The environmental degradation caused by biophysical impacts creates socio-economic impacts as a result effects of small- scale subsistence farming, as well as other productive sectors in terms of productivity, food security and family income(Mubaya*et al.*,2010).

Africa is among the continent most vulnerable to climate variability. Socio-economic developments exacerbate the effects of climate change on ecosystems and humanity (IPCC, 2007). Boko *et al.* 2007 indicate that endemic poverty, poor governance, limited access to capital and global markets, complex disasters, ecosystem

degradation, conflicts, and urbanization are factors that may undermine community's ability to adapt to climate change. Developing countries like Tanzania are most vulnerable to extreme climatic events and rainfall variability due to high dependence on rain fed agriculture and natural resources for their livelihoods.

1.2 Causes of Climate Change

From the data of Institute for Environmental Studies, the effects of emissions ofCO_2 and other greenhouse gases on the global climate are causing the changesin temperature, sea level rise, atmospheric circulation patterns, ecosystems and so onthe influence of climate change caused by greenhouse gas are:-Global average surface temperature raised 0.6°Cin 20^{th} Century,global Sea Level Increased 0.1 to 0.25 meter, The extent and thickness of Arctic ice Reduced by 10-15% in spring and Summer,precipitation in the high latitudes ofthe Northern Hemisphereincreased by 0.5%-1.0% annually, andfrequency of heavy rain raised to 2%-4%.Total global economics losses from natural disasters, Increased by 10 times over the past 40 years.

History records widespread disasters, famines and disease outbreaks triggered by droughts and floodsdue to climate change.Extremes based on simple climate statistics, such as very low or very high temperatures; Impacts on health of climate change extremes are: -Outbreaks of cholera, typhoid and diarrheal diseases can occur afterflooding if the floodwaters become contaminated with human or animal waste, while drought reduces the water available for washing and sanitation and alsotends to increase the risk of disease, (Hales, Edwards, Kovats, 2009, and Wellington School of Medicine, University of Otago, and Wellington, New Zealand; London School of Hygiene and Tropical Medicines, London, England).

ENSO (El Niño Southern Oscillation) due to climate change cause droughts and floods leading to disruption of food and water supplies. Alsopathogens are affected by effects of temperature and rainfall on abundance, behavior and distribution of vector ecology: (e.g. mosquitoes, ticks) and intermediate hosts (e.g. mammals, birds).

Economic factors leads to: poverty, population displacement/travel,housing/urbanization/population density, public health infrastructure, herd immunity, nutritional status.Social factors leadto: - human behaviorchange, (water storage practices), land use (irrigation/forest clearance/livestock selling)

This chapter summarizes what is known about the historical effects of climateextremes on human health. The following section describes studies of infectiousdiseases and climate extremes related to El Niño Southern Oscillation. The nextconsiders the impacts of short-term extremes of temperature. The final sectioncontains a discussion of climate-related disasters.El Niño(climate change) and infectious diseases. There is a well-studied relationship between rainfall and diseases spread by insect Vectors which breed in water, and are therefore dependent on surface water availability.Mechanisms by which the above-average rainfallsdue to climate change can affect health.Heavy meteorological “extreme event” increased mosquito abundance or decreased precipitationif breeding sites are washed away eventMechanisms by which below-average rainfall can affect health.

Drought meteorological evaporation exceeds water absorption changes in vector abundance if vectorsoil moisture decreases. Breeds in dried up river beds.Drought and

food shortage can lead to deaths due to starvation/malnutritionincreases famine/drought risk of infection disaster. Temperature also may affect the behavior of the vector and human populations, affecting the probability of transmission.

Warmer temperatures tend to increase biting behavior of the vector and produce smaller adults, which may require multiple blood meals in order to reproduce.The 1997/98 El Niño was associated with heavy rainfall and flooding in Kenya,after two years of drought. From January to May 1998, a major epidemic of falciparum malaria occurred. Brown*et al.;*Engelthaler *et al*., in the Four Corners region, USA, concluded that above-average precipitation during the winter and spring of 1992–1993 may have increased rodent populations and thereby increased contact between rodents and humans and viral transmission.

Certain rodent- borne diseases are associated with flooding including leptospirosis, tularaemiaand viral hemorrhagic diseases. Other diseases associated with rodents and ticks due to climate changeinclude plague, Lyme disease, tick borne encephalitis (TBE) and Hantaviruspulmonarysyndrome (HPS).Rodent populations have been shown to increase in temperate regions following mild wet winters (climate change). One study found that human plague cases in New Mexico occurred more frequently following winter-spring periods with above-average precipitation (rainfall during El Niño years. In summary, there is good evidence of associations between several important communicable diseases and climate change on several temporal and geographical scales. This is true of vector-borne diseases, many enteric illnesses and certain water-related diseases. These associations are not found everywhere—hardly surprising given the complexity of the causal pathways involved. Relationships

between year-to-year variations in climate change and communicable diseases are most evident where these climate variations are marked, and in vulnerable populations in poor countries. Major scientific reviews agree that El Niño can provide a partial analogue for the effects of global climate change on communicable diseases. Physiological studies in the elderly indicate that low temperatures are associated with increased blood pressure and fibrinogen levels(IPCC, 2007).

The Heatwaves can kill. In July 1995 a heatwave in Chicago, USA, caused 514 heat-related deaths 12 per 100, 000 population and 3,300 excess emergency admissions. A study of waterborne disease outbreaks in the United States has shown that about half were significantly associated with extreme rainfall.The dramatic increase in malaria and associated deaths was related indirectlyto the prolonged and severe drought created by the prevailing 1997–98 El Niño affecting the Australasian region.Vibrio cholera in Bangladesh (1987–90) found that abundance increases with the abundance of copepods (which feed on phytoplankton boom) in coastal waters.

Agriculture as natural resources are known to be influenced by climate variability (Zhang *et al.*, 2012). Climate variability thus refers to variations in the mean state of climate on all temporal and spatial scales beyond that of individual weather events (IPCC, 2001c; 2007b). It includes seasonal variability as well as inter-annual variability, sometimes manifested in extreme events such as droughts, floods, intensity rainfall, cyclones, heat and cold waves (Joubert and Hewitson, 1997).

Climate change Problems that are experienced by poor people due to droughts and heat waves, for example, include those of feeding and watering animals, and a lack of

water for crops, as well as water scarcity for consumption and health problems both in rural and urban areas. Flooding heavy rainfall,cyclones and hurricanes and sea level rise destroy property and productive assets, as well as causing injuries and deaths (Mallick *et al.*,2005).

Third Assessment Report of Intergovernmental Panel on Climate Change (IPCC, 2007), report that `global average surface temperature has increased over the 20th century by about 0.76°C since pre-industry time. There is a high level of certainty in the assertion that climate change is a result of global warming that has significantly been caused by increased emission of carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), and other greenhouse gases, (IPCC, 2007).

The Intergovernmental Panel on Climate Change (IPCC, 2007) reported that more than 90% of the current global warming is a result of greenhouse gases emissions from human activities including burning of fossil fuels for industrial manufacturing and other consumption as well as land use practices. There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to an anthropogenic activities (IPCC, 2007). The global average temperatures are expected to further increase by 1.8°C to 4°C (IPCC, 2007; 2011). Surface temperature is expected to increase by 1.4°C to 1.7°C by 2100 (Action Aid Nepal, 2007), depending largely on the scale of fossil-fuel burning (IPCC, 2001).

Several climate models project are accelerated:the rate of sea level rise over the coming decades, decreased cereal productivity and coastal flooding in low latitudes;

animal and plant species extinction threats and total destruction of marine ecosystems particularly coral bleaching (IPCC, 2007).

IPCC 2007 stated that, Africa is one of the most vulnerable continents to climate change because of multiple stresses and low adaptive capacity. The multiple stresses may arise from current climatic hazards, poverty and unequal access to resources, food insecurity, trend in economic globalization, social and political conflicts and incidences of diseases such as malaria, tuberculosis, and HIV/AIDS. Nevertheless, the overall climate will largely be defined by the change in precipitation corresponding to what appears to be a marked increase in temperature. This will lead to extreme rainfall events with dire consequences to agricultural production, especially for the vulnerable smallholder farmers.

In eastern and southern Africa, climate change vulnerability is heightened by a large number of people who depend on the already marginalized natural resource base for their livelihoods. The predicted effects of climate change must be introduced into development planning (e.g. soil erosion, land sliding, dryness of crops and indicators forindigenous farmers in Kilema ward), including land-use planning, infrastructure design, natural resources management and measures to reduce vulnerability in disaster reduction strategies.

The dependence on crops, meat, beans, fish protein in diets, limited alternative sources of food and employment, and small weak economies many African countries are highly vulnerable to the effects of climate change onirrigation, fisheries and aquaculture, socially and economically as well as ecologically (World Fish Center, 2009). Inland irrigation and fisheries will be strongly be affected by changes in

rainfall and increased temperatures. Coral damage, particularly in East Africa, will affect reef fisheries and could result in increased Ciguatera poison (IPCC, 2010).
Low-lying coastal areas will suffer the effects of rising sea levels and damage to important coastal ecosystems such as mangroves.In Tanzania, climate change has also been observed in different areas. For example, a mean annual temperature increase of 100c has been recorded since 1960 and rainfall decreased at an average rate of 2.8 mm per month and 3.3% per decade (Mashingo, 2010).More decrease in rainfall occurred in a southern part of Tanzania (ibd., 2010). It is predicted that extreme events such as drought, floods, tropical storms and cyclones are expected to become more frequent, intense and unpredictable in future (ibd., 2010). Other adverse effects will include negative impacts on food production, energy and water supplies, as well as a decrease in the population health, particularly in rural households, which represent the majority of the country's inhabitants (Maclean, 2009).

In turn, the negative impacts of climate bring about the socio-economic impact on people, especially in poor smallholder communities Kilema ward in Kilimanjaro region. There have been attempts to reduce the greenhouse gases in order to reduce the negative effects of global warming and climate change. This has not been successful so far and the focus has shifted to ways of adapting to already negative impacts of climate change. In this respect, this study covers this gap by looking at the knowledge effects of climate change on small-scale farmer's and effectiveness of adaptation strategies they use in Kilema ward in Kilimanjaro Region.

Also to explore what adaptation strategies farmersthink the government should introduce in order to reduce the impact of climate change.Worldwide, most Small

Islands are vulnerable to rising sea levels, increased extreme weather events, erosion of beaches, coral damage and reduced water availability, all of which threaten homes and infrastructure, lives and livelihoods. The World Bank (2005) highlights Tuvalu, Tonga, and Kiribati in Tanzania as being particularly vulnerable to the effects of climate change. Also the Mt. Kilimanjaro glaciers and ice is disappearing and destruction of Kilimanjaro environments including shortage of water and foods in Kilema ward.

1.3 Statement of the Problem

Climate change is a global environmental challenge,which has caused effects on natural and human systems across the world (IPCC, 2014). At its worst case, climate change interferes with human livelihood opportunities and economic development at large. The impacts of climate change are more severe in less developed countries (LDCs) whose economies depend on rain-fed agriculture, pastoralism, fisheries, and forestry (World Bank, 2010). In this arid region, climatic variations negatively impact human health, the environment and other livelihood sources (IPCC, 2014).

In Tanzania, different regions and sectors suffer severely due to the persistent variability in rainfall and temperature. Changes in wind patterns, occurrence of severe storms, changes in temperature andwater level reduction in lakes,river, streams and furrows level as a result of weather and climate variability effects on crops production, species composition, distribution, safety and efficiency of agriculture. These would also have significant effects on the livelihood activities of the neighboring farming community. In Tanzaniawhere majority of the farmingfolk are small scale, weather and climate variability especially changes in temperature, rainfall

and wind patterns make the farmers folk more vulnerable because of heavy reliance in farmingas well as poor adaptive capabilities with lowknowledge and poor equipments.Although there are a number of studies which have investigated the vulnerability and adaptive capacity of farming community to climate change, there has been little directed analysis at the local scale on how weather and climate variability is affecting the lives and livelihoods of the tropical majority of small scale-farmers, who make up more than 90% of the World agriculture and crops trade (Badjek *et al.*,2009).Generally the climate change in Kilema ward had caused fruits like oranges, some banana species, tangerine, custard-apple fruit, guava tree, pawpaw,jackfruits, oranges and tomatoes to become less growing and flourishing due to white flies which affect many fruits. Also sweet potatoes, cassava and yams are affected by many parasites. Due to climate change loss of fertility has led to loss of finger millet,sorghum and bulrush millet which are now imported from other regions to this area. Also sunflower plants are attacked by white flies, which reduce the production of sunflower oils.

It is against this backdrop that, this study aim to assess the role of Indigenous Knowledge System (IKS) on adaptations to climate change by small holder farmers in Kilema ward, Kilimanjaro region, Tanzania.

1.3 Objectives of the Study

1.3.1 General Objective

The general objective of this study was to assess the role of Indigenous Knowledge System (IKS) on adaptations to climate change by small holder farmers in Kilema ward, Kilimanjaro region, Tanzania.

1.3.2 Specific Objectives

(i) To identify the IKS on climate change indicators from small scalefarmers.

(ii) To examine the impacts of climate change on farmingpractices by small scale farmersthat affects their livelihoods.

(iii) To establish the adaptive/copping strategies to climate changes for mitigation measures of the impacts.

1.4 Research Questions

(i) What isIKS that is known by small scale holder farmers on climate change indicators?

(ii) What are the impacts of climate change on farming practices by small scale farmersthat affects their livelihoods?

(iii) What are the adaptive/copping strategies to climate changes for mitigation measures of the impacts**?**

1.5 Basic Research Assumptions

The impacts of climate change in water availability has increased the life expenses and poor livelihood in Kilema ward whereby irrigation knowledge, short terms seeds, pipe water use are utilized for adaptations.Adaptation strategies like blocking river waters from going downriver (e.g. Himo and Mue rivers) and digging new water trenches including connecting new pipe water system per house for more than 2.0 millionhave increased lifeexpenses, accelerated land degradation and loss of biodiversity as well as increasing more finance problems.Indigenous local activities like bush cutting, burning for fire woods, burning bushes for honey in high altitudes

of Mt. Kilimanjaro lead to contaminations of water springs, streams, rivers with black ashesand deforestation contribute to desertification.Water shortages problem can be solved by many small dams construction, rain water harvesting, reforestation and aforestation as well as digging underground waters for pipe water.Water shortage inrivers, wetlands, streams, trenches and furrows theseproblems have led to personal,family, community and government conflicts as indicator of climate change.Knowledge on planting dry resistance and short term cropscan lead to adaptations to the climate change scenarios.

1.6 Significance of the Study

Climate variability goes hand in hand with climate change and can be used interchangeably.This study wascarried out inKilema ward in Kilimanjaro Region where farming is the major economic activity and source of incomelivelihood. This study contributed scientific knowledge on the resilience of small-scale farmers to effects of climate change on farmers' communities, policy makers, and socio-economic activities. The study provides an understanding of adaptation and coping strategies of farmers to the effects of climate change.

The studyalso proposed appropriate interventions in addressing the problem in associated climate change as in controlling global climate change, internationallytradeable CO_2 emission permits ar e emerging as a major source for transferring financial andtechnological resources fro m North to South of which indigenous small scale farmers can benefit by planting trees for CO_2 sinks.

This study documented community-based adaptation options used in the areas and be scaled up to the other communities. Communities can use this approach to help prepare for climate change adaptations and coping strategies. This mean that, the study enabling policy makers, researchers and community have more knowledge,understand of the past and current respond adaptation mechanisms to climate change, as well as indicators, adaptation in order to designing appropriate policies and management strategies in the sector to face a new challenges of global climate change. Researchers benefit in that they can use the result and compare them with the other areas of the similar climatic conditions.

Moreover the indicators of climate change in Kilema ward were recorded.In addition; the study findings will contribute knowledge on climate change and add literature on the area of climate change.

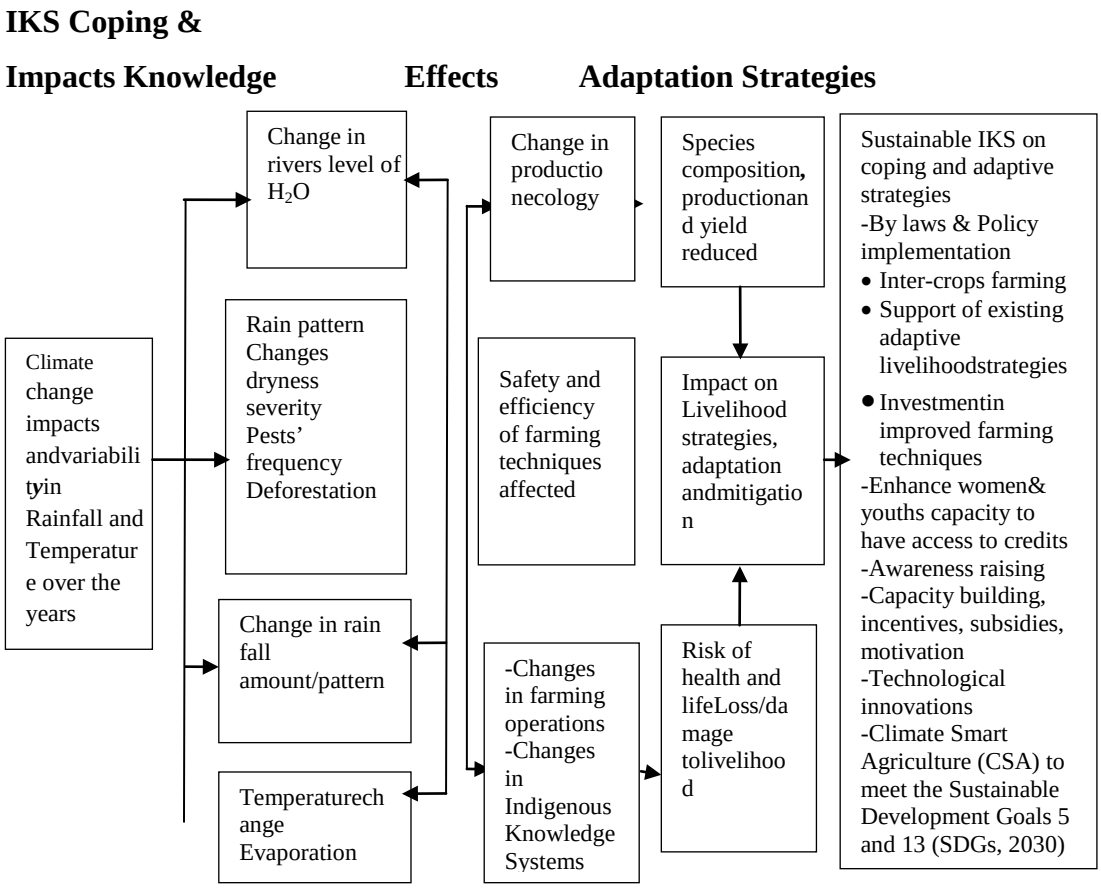
1.7 Scope of the Study

This study was confined in the assessment of theeffects of knowledge, adaptation and indicators on climate change, specifically changes in rainfall pattern, temperature variation, soil erosion, dryness of wetlands and streams, deforestation; disappearance ofmedicine plants, wild fruits, wild trees, yams and some banana species in the lower areas including activities and the coping and adaptive strategies of the small scale farmers in Kilema ward in Kilimanjaro Region.

1.8 Conceptual Model

Conceptual Framework

The study adopts a framework by Badjeck *et al.*, (2009). In their work, analysis of the effective knowledge on climate change on farming activities and the farmers coping and adaptive strategies were studied as modified by this study in (Figure 1.1). The basic relationship explored in this study was how the Indigenous knowledge affectsthe climate change on farming activities and the small-scale farmers' knowledge of coping and adaptive strategies in Kilema ward in Kilimanjaro region, Tanzania. Climate change manifests through direct and indirect pathways whose importance varies depending on the type of ecosystem and farming. In local farming, for example, where the majority farmers are small-scale, climate change effects manifests through many ways such as changes in rainfall pattern, occurrence of droughts, changes in rain pattern, changes in temperature, changes in river water levels, increased flooding event around water banks, and drought among others (Badjeck, *et al.*, 2009). These changes have effects on the crop production, ecology, farming operations, safety and efficiency of farming infrastructures as in (Figure 1.1).



Independent V. **Dependent Variables** **Intervening Variables**

Figure 1.1: Conceptual Framework

Source: Adapted and Modified from Badjeck, *et al.*(2009)

These effects show impacts on crops species composition, production, yield, and risk of health and socio-economic life of small-scale farmers, and loss and damage to livelihood assets and loss of harvests. Therefore, the small-scale farmers have to seek indigenous knowledge of sustainable adaptations and mitigation strategies in order to sustain their livelihoods.

This conceptual model therefore gives an analysis of the effects of climate change on farming activities and the small scale farmers' indigenous knowledge of coping strategies to the adaptive agricultural production for sustainable development of their livelihoods.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents the literature surveyed from other researchers in order to find the research gap for this study.

2.1.1 Impacts of Climate Change on Agriculture

Climate change has already significantly impacted agriculture (Lobell *et al.* 2011) and is expected to furtherimpact directly and indirectly food production. Increase of mean temperature; changes in rain patterns; increasedvariability both in temperature and rain patterns; changes in water availability; the frequency andintensity of 'extreme events'; sea level rise and salinization; perturbations in ecosystems, all will have profound impacts on agriculture, forestry and fisheries (Gornall, 2010; IPCC, 2007a; Beddington, *et al.,* 2012b;HLPE, 2012a; Thornton *et al.,* 2012). The extent of these impacts will depend not only on the intensity and timing (periodicity) of the changes but also on their combination, which are more uncertain, and on local conditions. Anticipating appropriately the impacts of climate change on agriculture requires data, tools and models at the spatial scale of actual production areas.

Emissions of global warming gases continue to rise as the world clear big farms for agriculture, deforestation for timber and firewood burns of coal, oil andgas for energy.

From the data of Institute for Environmental Studies, the effects of emissions ofCO_2 and other greenhouse gases on the global climate are causing the changesin temperature, sea level rise, atmospheric circulation patterns, and ecosystems.

The influences of climate change caused by greenhouse gases are:Global average surface temperatureraised 0.6°Cin 20th Century,global Sea Level Increased 0.1 to 0.25 meter, the extent and thickness of Arctic ice reduced by 10-15% in spring andsummer.Precipitation in the high latitudes of the Northern Hemisphere Increased 0.5%-1.0% annually, and frequency of heavy rain raised 2%-4% Total global economic losses from natural disasters Increased by 10 times over the past 40 years.

In 1998, drought and widespread wildfires caused by extreme weatherconditions resulted in US $276 million worth of damage. In the same year, floods along theYangtze River in China induced 4,000 deaths and US $30 billion economic losses. ComparedLosses in 1950s with losses in the 1990s, Munich (2000) and Francis (1998) concluded a largepart of the increase in losses was resulted from extreme weather events. Taken inflation, insurance penetration and price effects into account, while real global GDP increased by a factorof three since 1950, the total sum of extreme weather-related damage increased by a factor ofeight.China, as the world’ssecond largest emitter of carbon dioxide, its attitude and actions will become the focus of thecoming negotiations.

There is increased risk of extinction for many species due to the synergistic effects of climate change and habitat fragmentation.Africa has a low adaptive capacity to both climate variability and climate change exacerbated by existingdevelopmental challenges including:–low GDP per capita,– widespread, endemic poverty–weak

institutions–low levels of education– low levels of primary health care**,** little consideration of women andgender balance in policy planning markets, infrastructure andtechnology.

Ecosystems degradation–complex disasters–conflicts–limited access to capital, includingClimate change is an added stress to already threatenedhabitats, ecosystems and species in Africa, and is likelyto trigger species migration and lead to habitat reduction.Africa is vulnerable to a number of climates sensitivediseases including malaria, tuberculosis and diarrhea (Guernier *et al.,* 2004).

National communications report that climate changewill cause a general decline in most of the subsistencecrops, e.g. sorghum in Sudan, Ethiopia, Eritrea andZambia; maize in Ghana; Millet in Sudan; and groundnutsin Gambia. Of the total additional people at risk ofhunger due to climate change, although already a largeproportion, Africa may well account for the majorityby the 2080's (Fischer *et al.,* 2002).

Collaboration between national and internationalproviders of climate information and the users, in allsectors, of such information for adaptation to climatechange is vital as well as generating awareness among different user communities of the usefulness of climateinformation/knowledge and services and improving national andregional coordination. Data needs to be carefully packagedso that it can be used effectively. Rescuing historicalmeteorological data is important. Education and trainingand improved national planning and reporting wouldalso help build capacity.

Climate change is a catalyst for rising costs for humanhealth, the global economy and the Earth's life supportsystem.Erroneous extreme poverty andhunger:-caused by

damage to livelihood assets, including homes, water supply, health, and infrastructure which can undermine peoples' ability to earn a living.–Reduction of crop yields affects food security:as changes in natural systems and resources, infrastructure and labor productivity may reduce income opportunities and affect economic growth;– Social tensions over resource use can lead to conflict, destabilizing lives and livelihoods and forcing communities to migrate.

2.1.2 Achievement ofUniversal Primary Educations

This is undermined by Loss of livelihood assets and natural disasters due climate change reduce opportunities for full time education, more childrenespecially girls are likely to be taken out of school to help fetch water, earn an income or care for ill family members –Malnourishment and illness reduces school attendance and the ability of children to learn when they are in class; –Displacement and migration can reduce access to education.

2.1.3 Un-promotedGender Equality and Empowered Women

Exacerbation of gender inequality as women depend more on the natural environment for their livelihoods, including agricultural production. This may lead to increasingly poor health and less time to engage in decision making and earning additional incomeresulting from climate change damage. – Women and girls are typically the ones to care for the home and fetch water, fodder, firewood, and often food. During times of climate stress, they must cope with fewer resources and a greater workload; – Female headed households with few assets are particularly affected by climate related disasters.

2.1.4 ReducedChild Mortality

Deaths and illness due to heat-waves, floods, droughts and hurricanes i.e. climate change; –as children and pregnant women are particularly susceptible to vector-borne diseases e.g. malaria and dengue fever and water-borne diseases e.g. cholera and dysentery which may increase and/or spread to new areas likeanemia resulting from malaria is currently responsible for one quarter of maternal mortality.

2.1.5 Improve MaternalHealth

This isundermined by reduction in the quality and quantity of drinking water, which exacerbates malnutrition especially among children. Natural disasters affect food security leading to increased malnutrition and famine, particularly in sub-Saharan Africa.

2.1.6 Combat HIV/AIDS, Malaria andother Diseases

When there is water stress and warmer conditions due climate change encourage diseases. The households affected by AIDS have lower livelihood assets.Climate change and malnutrition accelerates the negative effects of the disease as heat waves.

2.1.7 UninsuredEnvironmental Sustainability

Alterations in ecosystem-human interfaces due to climate change and interactions lead to loss of biodiversity and loss of basic support systems for the livelihood of many people, particularly in Africa.

2.1.8 Develop a Global Partnership for Development

Climate change responses require global cooperation, especially to help developing countries adapt to the adverse effects of climate change. International relations may be strained by climate impacts but this could be reduced through bilateral or multilateral cooperation.

2.1.9 Preserving Indigenous Knowledge

Preserving indigenous knowledge that isrelevant to community level responses, studies on coping strategies, and gender specific vulnerability assessments are todetermining adaptation options. As a complement to the top-down approach is avulnerability-based, bottom-up, approach, which recognizesand builds upon local coping strategies and indigenous knowledge and technologies (Carruthers, UNFCCC CGE12 http://unfccc.int/2719.php).

2.1.10 Technology Transfer

Technology transfer can include “hard” forms of technology,such as new irrigation systems or drought-resistant seeds, or “soft” technologies, such as insurance schemes or crop rotation patterns.Some social indicators of climate change are: - lowlife expectancy,low adult literacy and scarcity of freshwateraccess. However, adaptive capacityis limited by high infant mortality, lowsecondary school enrolment and highLevels of inequality both in income andin access to fresh water and health careas well as gender inequalities.(Mozaharul Alam, UNFCCC. <http://unfccc.int/3955.php> Carlos Nobre, UNFCCC*).*

2.2 Definition of Concepts

2.2.1 Climate Change

Climate change as the variation in the earth's global climate or in regional climates over time and involves changes in the variability or average state of the atmosphere over durations ranging from millions of years (IPCC, 2007). The United Nations Framework Convention on Climate Change (UNFCCC) uses term 'climate change' for human-caused change and 'climate variability' for other changes. In last 100 years, ending in 2005, the average global air temperature near the earth's surface has been estimated to increase at the rate of 0.74 +/- 0.18 °C (1.33 +/- 0.32 °F) (IPCC, 2007).

Climate is the average weather experienced over a long period. This includes weather elements such as temperature, wind, humidity, and air pressure and rainfall patterns. Climate change was defined by Intergovernmental Panel on Climate Change (IPCC, 2007). Fourth Assessment Report as "change in the state of the climate that can be identified (such as by using statistical test) by changes in mean and/or variability of its properties, and that persists for anextended period typically decades or longer." Climate includes patterns of temperature, precipitation, humidity, wind and seasons. "Climate change" affects more than just a change in the weather; it refers to seasonal changesover a long period of time (IPCC, 2007). These climate patterns play a fundamental role in shaping natural ecosystems, and the human economies and cultures that depend on them.

2.2.2 Adaptation

IPCC (2001) defined climate change adaptation as an adjustment in nature or human system in response to actual or expected climatic stimulus or either effect, which demonstrates harm or exploits beneficial opportunities. Inter-Agency Report in 2007 also defined climate change adaptation is the ability to respond and adjust to actual or potential impacts of changing climate conditions in ways that moderate harm or take advantage of any positive opportunity that the climate may bring. Adaptation to climate change involvesdeliberated adjustments in natural or human systems and behaviors to reduce the risks to people's lives and livelihoods. All living organisms, including humans, adapt and develop response to changes in climate and habitat (FAO, 2008).Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.

Accordingly, two main types of adaptation areautonomous and planned adaptation. Autonomousadaptation is the reaction of; for example, a farmer changing precipitation patterns, in that she/he changes crops or uses different harvest and planting dates (FAO, 2007). In the context of climate change, adaptation refers to adjustments in human and natural systems to respond to actual or expected climate impacts. Adaptations may vary to their climatic stimuli but also with respect to other and non-climate conditions, sometimes called intervening condition, which serve to influence the sensitivity of systems and the nature of communities' adjustments.

For example, a series of droughts occurred may have similar impacts on crop yields in two areas, but differing economic and institutional arrangements in the two areas may well result in quite different effects on farmers and hence in quite different adaptive responses, both in the short and long terms (Smit *et al.*, 2000). Most ecological and social systems have a measure of in-built adaptation capacity autonomous adaptation but the current rapid rate of climate change will impose new and potentially overwhelming pressures on existing adaptation capacity.

This is particularly true given that the secondary changes induced by climate change are expected to undermine the ability of people and ecosystems to cope with and recover from extreme climate events and other natural hazards (FAO, 2008).

2.2.3 Small-scale Farming

Small-scale farming or artisan farming is any kind of small scale, low technology, commercial or subsistence farming practices, particularly those of ethnic group using traditional techniques such as hand hoes and sickles, hand maize pruning insteadof electricalmachines and hand insecticide spraying by hand pumps instead of diesel motor machines (FAO, 2008). Small-scales farming are characterized by a high degree of importance of farming and associated activities as part of a way of life and of a culture, and by dependence on agriculture resources for traditional livelihoods. Consideration of the geographic origin of farmers, farm workers and their communities, their knowledge and the technologies they use, ownership hand hoes, boots,racks, bicycles, wheelbarrows and other means of production and storage) and farming unit structures, and formal and informal labor relations can also help defining

small-scale farming. Other criteria to take into account may include the type and size of the farming harvests storage or large tanks and its covers and stands.

2.2.4 Impacts

IPCC (2014), the term impact is used primarily to refer to the effects on natural and human systems of extreme weather and climate events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. Impacts are also referred to as consequences and outcomes. The impacts of climate change on geophysical systems, including floods, droughts, and sea-level rise, are a subset of impacts called physical impacts.

2.2.5 Climate-Smart Agriculture (CSA)

Agriculture that sustainably increases productivity, resilience/adaptation, reduces/removes greenhouse gases mitigation, and enhances the achievement of national food security anddevelopment goals.

2.3 Theoretical Literature Review

This research was guided by Adaptive Cycles Theory.It is noted by the theorists that all systems undergo disturbances by climate change. With this understanding, ensuring long-term stability of systems rests upon changes that occur at times of crucial phases of cycles of long-term change (Chapin *et al.,* 2009). Adaptive cycles, therefore, offer a framework for descriptions of the role of disturbances in social and ecological systems. These cycles basically represented are disruption, reorganization,

and renewal of the system Walker *et al.,* 2004. Accordingly Climate is now one of the major phenomena threatening lives and humanity in general since the beginning of industrial revolution. The anthropogenic climate variability is already affecting aquatic ecosystems and the human societies that depend on them(Perry *et al.,* 2009).

Small-scale farmers in the developing countries are more vulnerable to climate variability due to their high reliance on agricultures and poor adaptive capacity. The theory therefore can be adopted to describe adaptive cycles of any social and/or ecological system. The stresses that the most surprising thing about adaptive cycles isperhaps that, the sequence of the phases-release, renewal, growth, and conservation can be used as a way of thinking about many types of social-ecological systems, including lakes, businesses, governments, national economies, and cultures, although the sequence of phases is not always the same." From the management point of view, the most crucial lesson from studies of adaptive cycles establish social-ecological systems to be typically vulnerable thus "likely to change to a new state in response to a stress or disturbance" (Walker and Salt, 2006).

It is further postulated that systems create their own vulnerabilities in the conservation phase where they spend most of their time (ibid.). In this stage managers often strive to bring down constant changes in ecological processes so that minor perturbations are contained to enhance accomplishments of management targets (ibid.). Stressing the importance of effective use of the theory in natural resource management, Chapin *et al.*(2009) noted that" recognition of these changing properties of a system through the lens of adaptive cycle suggests that effective long-term management and policy-

making must be highly flexible and adaptive, looking for windows of opportunity for constructive policy shifts".

2.4 An Overview of the Effects of Climate Changes on Agriculture and Water

Climatic fluctuations have always been affecting agriculture and water and management performance.Theatmosphere and the ocean will continue to warm over the next 50-100years, sea level will continue rise due to thermal expansion of water and melting of glaciers including the melting of icecap of MT. Kilimanjaro, ocean pH will decline (become acidic)as more carbon dioxide is absorbed, and circulation patterns could change at local, regional and globalscales(Bindoff *et al.* 2007 in Munday *at al.,* 2008). The major aquatic habitats in Sub-Sahara Africa (SSA) include the Great Rift Lakes such as Lakes Malawi and Victoria; Man- made Reservoirs such as Lake Kariba; large riverand floodplain such as the Nile and Zambezi Rivers, and coastal habitats such as estuaries, mangrove swampsand deltas (Hlohowskyj*et al.*1996). The diversity of the habitats and the species they support respond differently effects of climate change.

Climate change affects agriculture through changes in average temperatures, rainfall, and climate extremes e.g., heat waves; changes in pests and diseases; changes in atmospheric carbon dioxide and ground-level ozone concentrations; changes in the nutritional quality of some foods; and changes in sea level.

2.5 Crop Development Models

Study effects of global warming on agriculture, models: -as of crop development models, yield prediction, quantities of water or fertilizer consumed, are used. Such

models condense the knowledge e.g. knowledge of Kilema ward people accumulated of the climate, soil, and effects observed of the results of various agricultural practices. Strategies of adaptation to modifications of the environmentfor example simulation of aphid reproduction or septoriacereal fungal disease development.Most developed models are about wheat, maize, rice, groundnuts and soybean.

Increased CO_2have positive physiological effects by increasing the rate of photosynthesis. This is known as" carbon dioxide fertilization". Currently, the amount of carbon dioxide in the atmosphere is 410 parts per million. In comparison, the amount of oxygen is 210,000 ppm. Plants may be starved of carbon dioxide as the enzyme that fixes CO_2, RuBisCo, also fixes oxygen in the process of photorespiration. The effects of an increase in carbon dioxide would be higher on C_3 crops such as wheat than on C_4 crops such as maize, because the former is more susceptible to carbon dioxide shortage. Studies have shown that increased CO_2 leads to fewer stomata developing on plants, which lead to reduced water usage.Climate change may increase the amount of arable land in high-latitude region by reduction of the amount of frozen lands.

Potential effects of global climate change on pests, diseases and weeds:Weeds would undergo the same acceleration of cycle as cultivated crops, and would also benefit from carbonaceous fertilization. Since most weeds are C_3 plants.The effects of climate change on fish stocks it can be classified as physical and biological impacts. Physical change includes sea surface temperature rise, sea level rise. These factors when combined together will have adverse impacts on the already strained resource

(Brander, 2010).The oceans play a significant role in regulating global climate. Inland waters are equally vulnerable and might be impacted strongly by climate change (IPCC, 2007).

Globally, sea level has risen by 10 to 20 cm in the 20th century, largely due to thermal expansion, and by 2100 the global rise in sea level ranging between 9 cm and 88 cm has been predicted, based on the Intergovernmental Panel on Climate Change's full range of 35 climate projection scenarios Church *et al.,* 2001. In coastal areas, sea level rise may alter the salinity of estuarine habitats, inundate wetlands, andreduce or eliminate the abundance of submerged vegetation, adversely affecting those species which rely on these coastal habitats for reproduction and recruitment (Hlohowskyjl *et al.,* 1996).

Climate change increases or decreases water salinity in multiple ways. While tropical oceans are increasingly becoming saltier andthe closer to the poles have become fresher (IPCC, 2001). This highlights that tropical oceans are very likely to suffer more from the potential effects of increasing water salinity relative to waters in higher latitudes. Changes in water salinity have different effects depending on the tolerance level of the organisms and the nature of their ecosystem whether freshwater, marine or estuarine. The salinity of some freshwater ecosystems is predicted to increase as a result of anthropogenic climate change (IPCC, 2001). Such physical changes will negatively impact the population of both plankton and bigger prey fish species by affecting the organisms' ability to osmoregulate (IPCC, 2001).

Oceans are believed to have the capacity to absorb most of the anthropogenic carbon dioxide (CO_2) emissions. Carbon dioxide is also soluble in water and reversibly converts to carbonic acid. As a result of this chemical reactionand world's oceans are acidifying at an alarming rate (Caldeira and Wickett, 2003). While this has a positive impact in slowing down global warming, increased acidity as a result of dissolved CO_2 in seawater has negative impact on ocean ecosystem.

Direct effects include changes in physiological processes such as reduced growth of calcified structures, otolith development, and fertilization success. These may ultimately lead to direct impacts at the whole-organism level, including reduced growth and reproductive output, increased predation and mortality, alteration in feeding rates and behavior, reduction in immune competence and reduced thermal tolerance. Indirect effects include alteration in predator or prey abundance, effects on biological habitats such as coral reefs, and changes in nutrient recycling, (Cooley, 2011).

2.6 Empirical Literature Review

This section describes the potential impact of climate change on farming activities. The livelihoods of 520 million people in the world directly depend on fisheries and aquaculture (FAO, 2009). Most of the growth has been in small-scale farming in development world. It is likely that poor people will turn to common-pool resources in future as a result of the negative impacts of climate change on fisheries, agriculture and other productive sectors.

Glacier retreats and disappearance e.g. that of Mt. Kilimanjaro will have different quantitative impacts. A reduction in runoff will affect the ability to irrigate crops and will reduce summer stream flows necessary to keep dams and reservoirs replenished as rivers of Himo and Mue in Kilemaward which feeds Pangani basin and “Nyumba ya Mungu”dam of which have very low water in summer times.

Ozone and UV-B: in excess of ultraviolet radiation B can directly affect plant *physiology* and cause massive amounts of mutations, and indirectly through changed *pollinator* behavior.

ENSO(El Niño Southern Oscillation)effects on agriculture: as will affect monsoon patterns more intensely in the future as climate change warms up the ocean's water. Crops that lie on the equatorial belt or under the tropical Walker circulation, such as rice, will be affected by varying monsoon patterns and more unpredictable weather. Scheduled planting and harvesting based on weather patterns will become less effective.Livestock and livestock-related activities such as deforestation and increasingly fuel-intensive farming practices are responsible for over 18% of human-made greenhouse gas emissions, including: 9% of global carbon dioxide emissions,35–40% of global methane emissions chiefly due to enteric fermentation and manure,64% of global nitrous oxide emissions chiefly due to *fertilizer* use.Livestock activities also contribute disproportionately to land-use effects, since crops such as *corn* and *alfalfa* are cultivated in order to feed the animals.

2.7 Impact of Agriculture on Climate Change

According to the *Intergovernmental Panel on Climate Change*, the three main causes of the increase in greenhouse gases observed over the past 250 years have been fossil fuels, land use, and agriculture.

Plant diseases and climate change: Climate change may alter the developmental stages of pathogens that can affect crops. The biggest consequence of climate change on the dispersal of pathogens is that the geographical distribution of hosts and pathogens could shift, which would result in more crop losses.

2.8 The US Global Change Research Program (2009)

Many crops will benefit from increased atmospheric CO_2 concentrations and low levels of warming, but higher levels of warming will negatively affect growth and yields. *Extreme events* will likely reduce crop yields.*Weeds*, *diseases* and *insectpests* benefit from warming, and will require more attention in regards to *pest* and *weed control*.

Increasing CO_2 concentrations will reduce the land's ability to supply adequate livestock feed. Increased heat, disease, and weather extremes will likely reduce livestock productivity.

2.9 Mitigation and Adaptation in Developing Countries

The Intergovernmental Panel on Climate Change (IPCC) has reported that agriculture is responsible for over a quarter of total global greenhouse gas emissions. Given that agriculture’s share in global gross domestic product (GDP) is about 4 percent, these figures suggest that agriculture is highly greenhouse gas intensive. Innovative

agricultural practices with new knowledge and technologies can play a role in climate change mitigation and adaptation at national and Kilema ward.

This adaptation and mitigation potential is nowhere more pronounced than in developing countries where agricultural productivity remains low; poverty, vulnerability and food insecurity remain high; and the direct effects of climate change are expected to be especially harsh. Creating the necessary agricultural technologies knowledge and harnessing them to enable developing countries to adapt their agricultural systems to changing climate will require innovations in policy and institutions to address the indicators and adaptation of climate change in Kilema ward. In this context, institutions and policies about knowledge, indicators and adaptations are important at multiple scales.

Travis Lybbert and Daniel Sumner suggest six policy principles: (1) The best policy and institutional responses will enhance information and knowledge flows, incentives and flexibility. (2) Policies and institutions that promote economic development and reduce poverty will often improve agricultural adaptation and may also pave the way for more effective climate change mitigation and indicators through agriculture. (3) Business as usual among the world's poor is not adequate. (4) Existing technology options for adaptation must be made more available and accessible without overlooking complementary capacity and investments especially for Kilemaward whereby most of colonial men made streams are dry. (5) Adaptation and mitigation in ***agriculture*** will require local knowledgeresponses, but effective policy responses must also reflect global impacts and inter-linkages. (6) *Trade* will play a critical role

in both mitigation and adaptation, but will itself be shaped importantly by climate change knowledge.

The Agricultural Model Inter-comparison and Improvement Project (AgMIP) is used to evaluate agricultural models and inter-compare their ability to predict climate impacts. In sub-Saharan Africa and South Asia, South America and East Asia, AgMIP regional research teams (RRTs) are conducting integrated assessments to improveknowledge, understanding of agricultural impacts of climate change (including biophysical and economic impacts). Other AgMIP initiatives include global gridded modeling, data and information technology (IT) tool development, simulation of crop pests and diseases, site-based crop-climate sensitivity studies, and aggregation and scaling.A significant gap in observational coverage and that theproblem is more acute for some regions, mainly the higher elevations along the Mt. Kilimanjaro.

This range constitutes a major determinant of indicators in climate systems for adaptation ofthe Kilema ward and high-elevation data is important forthe detection and assessment of climate change and itsimpacts on glaciers, snow cover, and run-off of Mt. Kilimanjaro.Recommendationsonhow to cross the gap between planning and implementingadaptation by using indigenous and national knowledge, indicators of climate change options are highlighted necessity.

Adaptation Funds under the Kyoto Protocol, innovative financing options are needed to close the gap between costs of adaptation and available indigenous resources. Now, it is important to bridge the gap betweenadaption assessment and planning and adaptionimplementation, and to build on knowledge from capacity buildingprojects.

2.10 Research Gap

Climate change has effects on agriculture through a variety of channels, including ocean warming and acidification as well as a range of effects on freshwater systems due to shifting rainfall patterns, increased evaporation levels, more frequent and severe floods, droughts, soil erosions, land slumping and other mechanisms (Badjeck, *et al.* 2009). These geophysical changes in turn, have diverse ecological effects, for example, by interfering with the growth, distribution, reproduction and survival of crops, crustaceans, and other terrestrial fauna and flora biodiversity. Ocean warming is leading to increase in coral bleaching events, and coastal infrastructure directly through increased frequency and intensity of tropical storms, droughts and floods as well as sea-level rise, coastal erosion and other geophysical processes. These changes have significant social and economic implications for fisheries and agricultural communities.

Climate change affects trade, economies, and jobs. Vulnerability mapping, as it is called, alerts people to climate-change hot spots where action adaptation is urgently needed. Many studies on climate change and coping strategies have been done but not in Kilema Ward in Kilimanjaro where this study addressed the role of Indigenous Knowledge Systems (IKS) on adaptation to climate change.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

In this chapter, methods used to collect and analyze data are presented. The sections covered include the study area, research design, sampling procedure, population and sample size. The chapter also covers types of data, data collection methods, tools, data processing and data analysis.

3.2 The Study Area

This study was carried out in four villagesin Maua, Mjashi, Masaera and Pofo villages located in Kilema ward in Kilimanjaro region. These villages were chosen because, in Kilema ward, the main source of livelihood is farming and therefore any changes in the land farms occasioned by climate change and variability are likely to have an impact on the small scale farmers'livelihood. According to Department of agriculture (2002), 90% of the inhabitants were practicing small farming activities.

Another reason is that the frequent natural disasters(e.g. Soil erosion,droughts, crop pests of tomatoessunflowers coffee, lemons, bananas, finger millets and sweets potatoes which used to flourish highly in the past but now veryslowly growing are common phenomena in the study area. Moreover, the farmers of the study areas are well experienced on natural disasters of having no enough crops, no clean and safe water. However, they are occasioned by lacking climate change adaptation strategies. Adaptation includes rearing pigs, cows, sheep, goats, rabbits, chickens and ducks, small scales traders, carpentries, masonries and irrigation farming.

3.3 Research Design and Methods

The study adopted both descriptive and explanatory research designs as well as qualitative and quantitative mixed methods. This study allows for the description of a given phenomenon related to research objectives. The design allowedtesting the relationships. Together with that, an explanatory study enables the study to formally seek answers to problems by answering the question “why” as opposed to questions such as “what” “where”, “when” which are answered by a descriptive approach. Finally, this combination of designs enabled the study to describe relationship(s) among variable. Further, the study used both quantitative and qualitative methods for its data.

3.4 Sampling Procedure, Population and Sample Size

3.4.1 Sampling Procedure

Sampling is a process of drawing a sample from a larger population. It is a process of obtaining the number of elements nearby which one would wish to make inferences. Systematic random sampling was used in this study in order to enable valid inferences from a representative sample in relation to its respective population. Sample frame of the list of registered small-scale farmers in Maua, Mjashi, Masaera and Pofo villages was obtained from the chairmen in Kilema ward. Sampling involved taking every 4^{th} name on the list from each location of which the starting point was selected randomly.

Random sampling removes biases on the research and thus provides a good representation of the target population.A sample of 58 respondentsonly was successful selected out of 100 registered farmers who were selected.

3.4.2 Population and Sample Size

Population is the target group to be studied in a particular study while a sample is a small partof it –that is the subset of the target population. The population, therefore, is a total collection of elements about which one wishes to get information. Samples are used in research as representative of the whole population because of cost in terms of time, materials and financial resources.

The total population in this study comprised of 58 small scale farmers/registered in Masaera, Maua, Pofo and Mjashi farmer'svillage'sand officers from the fourvillages. Therefore, due to time and financial constraints, 58 respondents were selected to administer the questionnaire and interviewed. This sample size number is approximately 58% of the total population.

3.5 Sources of Data

3.5.1 Primary Data

Primary data was collected using several procedures. Observations were made on various economic activities carried out in the area and information recorded on a record sheet. A structured questionnaire was self-administered to the small scale farmers; both closed-ended and open-ended questions were asked. The closed-ended questions were used to solicit information from respondents on matters such as socio-economic characteristic, economic activities, seasonal variations in crop rotations and harvests, farming adaptation and duration, farming techniques, and equipment. Open-ended questions were used to capture details on opinions such as small-scale farmer's assessment knowledge of the effect of climate and climate variability and the description of livelihood changes. Before the final version of the questionnaire was

administered, a pilot survey was conducted. This was done in order to pre-test the questionnaire to ensure that the questions included were clear, understandable and yieldedthe required and relevant information. Following the pilot study, various changes were made to add or and omit information from the questionnaires. Interview guides were used to gather information from one official from agriculture departments and one official from Meteorological Departments. The interview guides assisted in gathering data on various issues such as knowledgeof variability of weather elements, adaptation techniques, and indicators of climate changes, farming techniques, and other economic activities.

3.5.2 Secondary Data

Secondary data is information, which has been collected and compiled for another purpose. This method was used to collect data from various office documents such as reports, files, articles, journals and others available related sources from districts, wards and village levels. Also, other information was collected through the websites and internet search engines. The use of secondary data broadens the database from which scientific generalizations can be made (Kothari, 1990).

3.6 Data Collection Methods

Data are facts, figures, and other relevant materials, past and present that serve as bases for the study and analysis. In this study, primary data was collected using different methods including questionnaires,interviews, direct observation, and Focus Group Discussions (FGD). Tools and techniques used included a semi- structured questionnaire, and a checklist and the Secondary data were collected through documentary reviews, (Kothari, 1990).

3.6.1 Questionnaires

The questionnaire (Appendix I) was used as the main tool for data collection. This consisted of both closed and open-ended questions, seeking clarification during the interviews. According to Kidder *et al.* (1986), the questionnaire gives respondents greater feelings of anonymity, which in turn encourages openness to the questions and minimizes interview bias. A collection of accurate and reliable data and other necessary information from the field is not an easy task. It must be done properly since the success of the questionnaires depends on the reliability of data. Data were collectedfrom primary source by the researcher himself as questionnaires s were held with the knowledge on climate change impacts, adaptationand indicators of climate change to small-scale farmers. A brief introduction to the objectives of the study was given to each of the selected farmers. Before going to make actual meeting the key informants were assured that all information would be kept confidential. At the time of the meeting, each question was explained clearly and asked systematically as for their sound understanding.

3.6.2 Interviews

The interview was adopted as a method for data collection partly due to its cost effectiveness and its strength of capturing empirical data in both informal and formal settings (Kothari, 1990). The interview guide (Appendix 1 and 2) consisted of both open and closed ended questions. An interview was conducted with key informants such as local leaders, district farmers' officers, Community Forest officers (NGO) and Metrological Officers and Veterinary officers. The questions were designed to solicit information relating to actual and expected returns on respondents. The study area

characteristics and their relations to impacts and adaption of climate change impacts were considered. The questions that were asked to all respondents were identical in order to solicit homogeneous information.

3.6.3 FocusGroup Discussion

Focus Group Discussion (FGD) is a form of structured group discussion involving people with knowledge and interest in a particular topic and a facilitator. Focus groups provide an opportunity to discussion thoroughly on the desired topics (Kothari, 1990).The advantage of this method (Appendix II) according to May (1993) is that it allows the interaction with a range of key informants and allows the researcher to focus on group norms and dynamics around the issue being investigated. Moreover, focus group discussions are useful in verifying and clarifying information and in filling in gaps of information caused by inadequate information gathered from the interviews and observations. So, for the sake of this study, FGD was carried out by the researcher to groups of 5- 10 members **c**omposed by male and female selected randomly by village leaders.The essence of FGD wasto understand people's knowledge, attitude, skills and feelings towards climate change effects, adaptation strategies and indicators of climate change in Kilema ward by small scale farmers. Two discussions werecarried out using focus group discussion moderators who oriented and instructed to follow rules of carrying out FGD. The Focus Group Discussion was guided by a checklist prepared in advance (Appendix II).

3.6.4 Direct Observation

Observation is essential in making a correlation of the questionnaire response to the actual phenomenal on the ground (Kothari, 1990). Observation makes it possible to

study the behavior of farmers and the farming environment. Furthermore, verbal reports can also be validated and compared with actual behavior through observation.

In this study apart from interviews and discussions, direct observations were used to evaluate the knowledge of climate change and adaptation measures, designs and types of farming gears. Furthermore, observation helped to study some facial expressions, gestures, and other behaviors during interviews which portrayed the hidden or doubtful responses during interactions between observer and respondent particularly on the sensitive issue of income, beliefs, and attitudes towards knowledgeon climate change, acceptance and adaptation. Moreover, the camera was used to capture some events and structures of interest to this study. The information gathered using observation was used to counter-check information provided by respondents and focus group participants.

3.6.5 Documentary Literature Review

Literature review as a systematic search of published work to find out what is already known about the intended research topic was captured well. With this method numerous published and unpublished materials regarding the research topic were reviewed. The literature used in this study was searched from scholarly journals, websites search engines, and brochures. A literature review in this study served many important purposes, which included establishing the research gap the needed for the research, broadening the horizon of the researcher, and preventing the researcher from conducting research that already existed. Aitchson (1998) supports the view that a literature review allows the researcher to find out what has been done in terms of the problem being investigated to ensure that duplication does not occur. Documents

reviewed in this study include physical and ecological impacts of knowledge onclimate change related to terrestrial as well as inland agriculture and animal husbandry (Barage, 2010). More secondary data was gathered from assessment and mapping studies and other relevant reports on indicators of climate change impacts and the adaptation strategies.

3.6.7 Data Analysis, Interpretation and Presentation

Data analysis means the computation of certain measures along with searching for establishing the patterns of relationships that existedwithin the data group (Kothari, 1990). In this study data that was collected using questionnaires were cleaned, coded and analyzed using SPSS version 20 software packages& MS Excel, 2007. Descriptive statistics giving frequencies and percentages were presented in various forms particularly by using Tables, graphs, charts and percentages. Interviews and FGD data was analyzed using content analysis and presented based on pre-determined themes, categories and pattern, mainly presented in the narratives.

3.7 Validity and Reliability

In general, validity is an indication of how sound your research is. To enhance the validity of this research, before the final version of the questionnaire was administered, a pilot survey was conducted. This was done in order to pre-test the questionnaire to ensure that the questions included were clear, understandable and would yield relevant information. Following the pilot study, various changes were made to add or/and omit information from the questionnaires. Also, to ensure that the instruments were effective, understandable and better output, the questionnaire was translated into Kiswahili for ease understanding by the local community

representatives, that is the farmers and the officers included in this study. Reliability is the degree to which an assessment tool produces stable and consistent results. To ensure that the findings reflected the true options of respondents as well as the situational knowledgeof climate change from informant's vulnerability and adaptation measures used, the research questionnaires were tested before being applied in this study. Both strategies ensured good validity and reliability of this research.

CHAPTER FOUR

RESULTS AND DISSCUSSIONS

4.1 Introduction

This chapter combined the results and the discussions together for easy the presentations of the findings to be clearly understood. Other researchers from similar climatic conditions have been cited for similarities or differences among the cross studies.

4.2 Socio-demographic Characteristics of the Respondents

The demographic characteristics of the respondents included gender, age, marital status, education level, the source of income and the number of people living in the household. The studies found that majority of the respondents 86.2% were male and the female were 13.8% (Table 4.1). The reasons of interviewing more men than women is thatmore men are involved in farming activities while women engage in post-harvest activities such as crop processing and storage, cutting grasses for housed animals(e.g. cow, goats, rabbits, pigs,sheep including chickens and ducks), cooking and crops trade in local village markets. Males are also workingas motorcycles drivers, repairing of irrigationcanals andtransporters oftomatoes, mangoes, bananas, avocados and maize to the markets.

In age wise, the study revealed that 30.7% of the respondents were aged between 31 - 40 years (Table 4.1), 21.8% were aged between 41 - 50 years, and 19.5% of the respondents were aged 50 and aboveyears of age, and 18.4% were aged between 21-30 years old while 9.6% of respondents were aged below 21 years old. This implies that majority of the farmers are under the age of 21- 50 years. This age group is generally the most economically productive since they have the energy to undertake

tedious activities like farming, irrigation and are responsible for taking care of the housed animals andthe children, young and old members of their families.

Table 4.1: Demographic Characteristics of the Respondents

Characteristics	Respondents	Percent
Gender		
Male	50	86.2
Female	8	13.8
Total	**58**	**100**
Age categories		
Below 21	4	9.6
21 – 30 years	10	18.4
31 – 40 years	20	30.7
41 – 50 years	13	21.8
50+ years	11	19.5
Total	**58**	**100**
Education level		
Incomplete primary education	22	37.4
Primary education	24	41.9
Secondary education	8	13.5
Advanced level /middle colleges	4	7.2
Total	**58**	**100**
Marital status		
Single	16	16.8
Married	71	77.6
Divorces	3	3.1
Widower	2	2.5
Total	**58**	**100**

Source: Field Survey, 2018

There was a marked difference in the education level of the respondents as most of the respondents 41.9% had attained primary education, 13.5% attained secondary education and 7.2% of respondents had advanced secondary education (A – level) and middle college education while 37.4% of respondents had an incomplete primary

education. This finding is similar to the study of Lwenya *et al.* (2009) who found that both men and women in each country (Kenya, Uganda, and Tanzania) tended to be poorly-educated, with a high proportion being primary school drop outs.

The lack of education limits their chances of finding alternative employment outside farming and irrigation. Poorly educated males are more likely to be employed as mere farming workers. Regarding the marital status of the respondents, 77.6% of farmers interviewed were married, 16.8% single, while 2.5% widowed and 3.1% were divorced/separated (Table 4.1).

The study found thatagriculture and irrigation were the main source of income besides domesticating cows, pigs, sheep, rabbits, goats as demonstrated by most of the respondents (87.4%), followed by other activities such as chickens rearing(5.5%), while 7.1% of the respondents engagedin small trading of crops, local brews and doing technical works as masonry, carpentry, sewing and welding for extra incomes (Table 4.2). Out of the farmers who have a source of income, 65.6% earn over 50,000 Tanzania shillings a month while 24.8% earn the income ranging between 45,000 and 50,000 Tanzania shillings; 7.5% were earning over 35,000 up to 40,000 Tanzania shillings. Only 2.1% was earning below 30,000 – 35,000 Tanzania shillings per month (Table 4.2). Concerning household size, the majority of the households 64.1% of the respondents' lives with 5 to 10 peoples in their house, 22.8% live with less than 5 peoples per house while 13.1% of the respondents live with more than 10 people in the same household (Table 4.2).

Characteristics	**Respondents**	**Percentages**
Sources of income		

Agriculture and irrigations	51	87.4
Manual work like animals and chickens rearing.	4	7.1
Masonry, carpentry and motorcycle passengers' transportations, sawing and welding	3	5.5
Total	**58**	**100**
Income per months		
30,000 – 35,000	1	2.1%
35,000 – 40,000	6	7.5%
45,000 – 50,000	13	24.8%
Above 50,000	38	65.6%
Total	**58**	**100%**
Number of people living in house hold		
Below 5	12	20.5%
5 - 10	43	75.7%
above10	3	3.8%
Total	**58**	**100%**

Table 4.2:Sources of Income and Earnings Per Month

Source:Field survey, 2018

4.3 Effects of Knowledge on Climate Change on Farming Activities

4.3.1 Effects ofKnowledge on Climate Change on Crops Harvests

There are several climatic knowledge variables, which influence climate change. According to the study area, drought, rainfall variations, fluctuation of temperature, soil erosion,shortage of water for irrigation and clean water for drinking, reoccurrence of crop pests(e.g. birds, white flies and plant fungus e.g. aphid and septoria)are common climatic problem pests and vectors frequently occurring in Kilema ward. According to small-scale farmers, these climatic variables have an impact on their farming activities.

According to the questionnaires, 45.7% of small-scale farmers mentioned that rainfall variation change causes disastrous problems during seed sawing and often rot seeds and farmers are unable to spend more time and money for farming. About 34.8% of respondent indicated that temperature change impact crops growth as high

temperature increase dryness of crops thus low harvests. This result confirmed to Jarraud (2011) that, the 2010 data confirm the Earth's significant long-term warming trend. The ten warmest years on record have all occurred since 1998." Over the ten years from 2001 up to 2010, global temperatures have averaged 0.46°C above the 1961 to1990 average, and are the highest ever recorded for a 10-year period since the beginning of instrumental climate records.These changes of temperature have an impact on cropsharvests and availability.

However, 90% of the respondent showed that the availability of crops harvests during droughts periodis very low. Rainfall would influence crops available or cropsharvests at any given time. The results from this study showed a mixed impact of high rainfall on the crops harvests. However, 34.8% of the respondents reported low to very low crop harvests during high rainfall season due to soil erosion, 65.2% reported high to very high crops harvests due to smart agriculture (e.g. planting trees, use of terraces for preventing soil erosion in elevated highlands, etc.). This may be explained by the fact that although during high rainfall there is an increase in cropsyield but the dangers posed by high rainfall (e.g. flooding of rivers, land slumping and sliding) deter some farmers from venturing into the farms for a long period. Thus, those who take the risks record higher yields while those who stay away or venture into the farms for a short while due to soil erosion, floods, land slumping, injuries or loss of seeds during high rainfall record low crops harvests.

For the case of temperatures, the result of the study revealed thatthe majority, 80.4% of respondents reported low crops harvests during high temperature, however, 19.6% of respondents revealed that crops harvests is high particular during moderate

temperature.Soil erosions often impact crop harvests. From the study results majority 91.3% of the respondents observed that soil erosion reduce crops harvests. This is true based on the fact that as it had been presented that duration of soilerosion is shortened by quicklyremoving the top soils which are fertile or leading to no harvests at all. At the same time, tractors and hand hoes maybe unable to farm on naked, rocky soils due to erosion or landslides. Some species of crops e.g. sorghums, finger millets,bananas, tomatoes, and maizedonot grow on eroded land and affecting harvests. The situation is the same during flood conditions as 93.5% of the respondents reported low crop harvests.

4.3.2 Knowledge on Effects of Climate Change on Farmer's Health

This study found that climate change has an impact on small-scale farmers' life. Farmers faced various kinds of problems such as sickness, injuries,famine, and diarrhea due dirty water and deaths. According to the questionnaires administered, 77.2% of respondents were the victim with sudden rainfall pattern who fall sick due to body injuries as a result of high rainfall when their houses, farms, trees,pigs shelters are swept away by soil erosion, land slumping and sliding. About 22.8% of the respondents' mention that have low impacts on the lives of the small scale farmers, regard to moderate and low rainfall.

Other results from this study show that temperature variations have high impacts on the small scale farmers. Generally, during high temperature 73% of the respondents fall sicknesses from hot conditions feela headache and fever, while 37% were not affected by climate change. This observation is supported by FAO (2008),which reported that temperature changes are likely to impact cold water species negatively

and warm water species positively.In sunny and dry periods, 72.8% and 51.1% of the respondents respectively, mentioned that no impacts on farmer's health because of this period most of the farmers do not engage infarming activities due to the shortage of water for irrigation and the risks involved. In these periods some farmers engaged in little irrigation Agricultural activities, harvesting of mangoes, bananas and avocado fruits.The contradiction is involved during the drought period, 51.1% of small scale farmers said that the impacts on farmers health are low compared to 49.95% said the impacts is high.

4.3.3 Knowledge on Effects of Climate Change to Get Water

According to the findings,all respondents observed that during drought, water availability have high impacts to small scale farmers.Low river water conditions provide the small scale farmers with unfavorable conditions to get water into the streams for longer period of time.

Changes in rainfall pattern have different impacts on the duration of farming or distance of arming. Rainfall pattern changes may either prolong or shorten distance/ duration of farming. The results from this study show that during high rainfall, 98.9% of the respondents observed that there is short time of farming and only1.1% observed that farming takes normal time. The situation is different during moderate and low rainfall. Respondents were asked to indicate whether changes in temperature patterns have impacts on the duration of farming or not. The results showed that high temperature has an impact on farming duration as pointed out by 50% of the respondents. The same 50%of respondents reported that during high temperatures farmers do not go for farming. Strong wind and flooding had a negative effect on

farming distances and harvesting. The majority of the small-scale farmers (90%) observed that farming duration is shortened and others indicate that there is no farming at allbecause soil erosion, land slumping, sliding and floods in rivers make the farmers stay indoors.

4.3.4 Knowledge on Effects of Climate Change in Farming Techniques

Farming techniques change according to the environment of farming areas. The study showed that farming techniques are affected by climate change. The findings revealed thatduring the drought 92.4% of the respondents showed that they use irrigation techniques while 7.6% said that, during heavy rainfallsfarmers must use other techniques of farming like terraces and SMART agriculture, because of soil erosion.

The study also showed that farming techniques change a lot during high temperatures where 55.4% of respondents use the other techniques (i.e. mulching and agro-forestry) as opposed to the usual farming methods. The situation is, however, different during moderate and low rainfall seasons, 44.6% respondents reported using the usual farming method.

During the high temperature, 76.1% of the respondents reported that climate change has effects on farming techniques and sometimefarmers are forced to use other methods of farming while 23.9% reported using the usual methods of farming. A change in farming technique during high temperature is attributed by low farming yield. High temperatures are normally experienced during drought. During strong winds and heavy rain falls 70.7% of the respondents mentioned using other farming techniques because the usual farming techniques are affected by climate change so

that, the preferred farming methods during strong wind and heavy rainfalls are causing soil erosion, land slumping, sliding, falling of banana trees, trees and pighouses are swept away to the rivers. About 51.1% of the respondents reported that, during flooding the impacts on the crops harvestsis high and farmers preferred to use terraces techniques of farming compared to 48.9% of respondents who said that effectsof flooding in low lands make the soil fertile and wet for crops during summers,and involved the change of farming techniques.

According to the findings of this study, 89.1% of the respondents reported that farms in the lowlandsare submerged or destroyedduring high rainfall. Only 10.9% of respondents reported that there were low impacts on farms types as slightly elevated farms during high rainfall. On temperature changes, this study revealed that temperature variations have no effect on farming equipment e.g. tractors and hand hoes. Wind as an aspect of climate variability affects the falling of banana and avocado trees.All respondents indicated that strong winds either destroy crops and fruit trees. No one of respondents reported that strong winds have no effects on the banana trees. The situation is the same during flood. All respondents report that flood has impactsto the farms.

4.3.5 Knowledge on Effects of Climate Change on Availability of Water

Climate change may affect water availability for irrigation and domestic uses. Both water for irrigation abundance and availability affect the harvests per unit effort in summer and thus for prices, the revenues from that efforts especially from tomatoes, cabbage, spinach, carrots and summer maize. Study showed 58.7% of respondents revealed that the revenues are higher during the heavy winter rainfalls because more

irrigation waters are available in summer. Compared to 41.3% showed that this period revenues are low because every farmer has plenty of crops.

Table 4.3:Average of Water Level in Rivers and Streams

Months	Water levels in rivers	Water level in furrows	Enough water for irrigations
January	low	low	Not available
February	low	low	Not available
March	high	high	available
April	high	high	available
May	high	high	available
June	high	high	available
July	high	high	available
August	high	high	available
September	high	high	available
October	low	low	Not available
November	low	low	Not available
December	low	low	Not available

Source: Field survey, 2018

During rainfall season the study showed that 54.3% of the respondents mentioned increased water for irrigation because rainfall influence water availability or crops harvests; 45.7% of the respondents said, this time, is characterized by abundance of vegetables and revenues due to the irrigation agriculture. For the case of Temperature, the study showed that 51.1% mentioned that temperature is characterized by low revenues because of drying of crops. 48.9% of small-scale farmers mentioned that the revenue is normal because they are close to source of irrigation water.In wind and flood season 58.7% and 70.7% respondents respectively, revealed that revenue is low due to dangers of falling of banana and avocado trees compared to 41.3% and 28.3% respectively who mentioned that the revenues in these period is high because more food is available in flat lands. So due to the above

viewed, increased trend of crops harvests is observed in the period between March4 to September. And between May to July crops ripe because the rain season start to decline in July. While between Octobers to February the rain water is not available. Table 4.3 presentsthe low and high water for irrigation in the study areas.

4.4 Knowledge Perceptions of Small Scale Farmers on the Climate Change

Interviews with key informants revealed that local people perceive that climate change has a direct influence on their farming activities. It was noted that most of the respondents perceivethat heavy rainfall reduced crops harvests due to extensive soil erosions. Other climatic elements mentioned as indicators of climate change were temperature, drought, soil erosion, malnutrition, school dropouts, maternal/child death, melting of glaciers of Mt. Kilimanjaroand wind. These variables have the effect on the amount of harvests.

The study revealed that there are a growing feeling and perception among the farmers that climate change and variability is occurring. Most of the respondents in the study areas acknowledged that there has been a change in climatic conditions. The study noted that respondents perceived changes in climate by focusing on the major climatic variables which have big impacts on their livelihood such as rainfall inconsistency and unpredictability over years increased the incidence of droughts, the wind, flood and increased temperature.Focus group discussions on the small-scale farmers in the study area reveal that climate is continuously changing and it is getting worse over time. Changes have been associated with a change in rainfall patterns with rainfall coming late in the season or not adequate. Other events which were associated with change in

climate are increased incidents of drought, the wind and extreme temperatures. These changes have an effect on the crops harvests.

In all the study villages it was acknowledged that rainfall pattern has changed over time for the past 30 years becoming more unreliable as well as showing a decreasing trend and amount, the key informants in all the study villages reported that rainfall has become uncertain. In the past they used to have two rain seasons namely long rains (masika or mvua za mwaka) starting from February andending late June, with peak rains in March/April; and short rains (vuli) starting from September to November.

The relationship between crops availability and rainfall is that the key informants in study area report that farming activity is effected by rainfall factor. Accordingly, small-scale farmers in studying area reported that if rainfall is adequate then they obtain a lot of crop harvests. This is due to high percolation of rain water deposited to the un eroded soil surface runoffs. Nutrients andfertilizers are injected into the soils from different sources ofindustries, rivers andlands which can influence the crops distribution and abundance. Also, rainfall plays an important role in growth and flourishing of animal fodders whichinfluence rearing of domestic animals. The rainfall makesthe grasses, crops and trees very greenish, so this time is easy to cut grasses for storage which are not available during summer(i.e.October to February each year).

Perceptions on changes in rainfall have been of concern to farmers in Kilema ward. About 88% of the respondents'knowledge indicates that seasonal rainfall patterns have decreased over the years, while 5.5% of the respondents revealed that rainfall increased and 6.5%of respondents indicated no changes noticed (Table 4.4). The

majority of the respondents (70%) accepted that decreasing of rainfall leads to the disturbance on farming condition. Farmers revealed strong rainfallsalways appear between Aprilto July each year. The heavy rainfalls make reappearance of green grasses all around Kilema ward thus plenty of available fodders.

As far temperature in concerned,94.82% of the respondents revealed that temperaturehasincreased over the year and 5.18% of the respondents mentioned that temperature decreased in recently years (Table 4.4). Respondents indicated that temperature hasbecome high particular during the months of October to December in each year.

On the perception of small-scale farmers on increased or decreased of drought,94.6% of small-scale farmers revealed that drought has increased and only 5.4% of the respondents reported that they have not noticed any change. The increase in drought has contributed to the low crop harvests.Other variables assessed when to determining the perception of climatechange on small-scale farmers was the flood as one of the important climatic variables. According to the respondents, 66.3% mentioned that flood causes disastrous problems as soil erosion in farming activity. However the farmers explained that floods were mainly associated with increased soil slumping, loss of pig’s houses and house properties.

Most farmers reported that flood contributed to decreased income from farming compared to moderate rainfall because farming duration is shortened, this is largely due to the threat of flooding on safety in the river waters as farmers are drowned and killed. So farmers fear the floods and kept away from farming. Floods are becoming more frequent allegedly due to erratic rainfall which is the outcome of climate change.

Table 4.4: Knowledge Perceptions of Communities and Small Scale Farmers

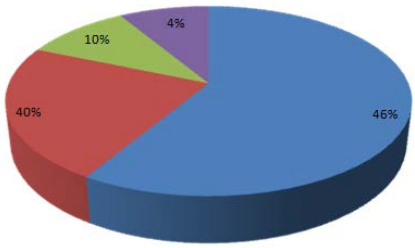
Descriptions	Frequencies	Percentages
Knowledge climate change awareness		
Aware	27	46.7
Not aware	31	53.3
Total	58	100
Knowledge temperature change		
Increasing temperature	55	94.82
Decreasing temperature	3	5.18
Total	**58**	**100**
Knowledge on rainfall variation		
Increasing rainfall	3	5.5
Decreasing rainfall	51	88
No observation	4	6.5
Total	**58**	**100**
Drought variation		
Increasing drought	55	94.6
Decreasing drought	0	0
No observation	3	5.4
Total	**58**	**100**
Wind pattern variation		
Increasing of wind especially in high altitudes making banana trees to fall	51	88
Decreasing of wind	3	5.5
No observation	4	6.5
Total	**58**	**100**
Knowledge on flood variation		
Increasing flood	6	10.9
Decreasing flood	13	22.8
No observation	39	67.2
Total	**58**	**100**
Social indicators of climate change		
Low life expectancy	3	5.17
Low adult literacy	2	3.4
Scarcity of freshwater access	23	39.7
High infant mortality	1	1.7
Low secondary school enrolment	18	31.03
Inequality in income, in access to fresh water	10	17
Inequality health care and gender inequalities.	1	1.7
Total	**58**	**100**
Physical Indicators of Climate Change in Kilema Ward.		
Poor harvests of vegetable crops (e.g. tomatoes)	11	18.96
Disappearance of lemon fruits in lower areas	8	13.79
Disappearance of finger millet growth	6	10.34
Disappearance of oranges trees growth	10	17.58
Appearance of coffee berry disease	9	15.51
Disappearance of medicine plants	2	3.44
Disappearance of wild fruits	4	6.89
Disappearance of yams	5	8.62
Disappearance of some banana species	3	5.17
Total	**58**	**100**

Source: Field survey, 2018

The farmer's awareness on climate change was assessed. The study revealed that 53.3% of the total respondentswere not aware ofthe climate change, while 46.7% of total respondents claimed that they are aware ofthe climate change. In other words, the majority of the respondents in the study area were not aware ofthe climate change because they have not experienced any changes in crops harvests due to closeness to water for irrigation.A similar study conducted by Olayinka *et al.* (2013) revealed that most people indicated that awareness of the various causes and impacts of climate change is known to many farmers, Table 4.4.

4.5 Knowledge on Technological Determinants of Climate Change Adaptations

The data indicated that, 46% of the respondents commented that keeping high bride variety of animal was the determinants for livestock production in the study area (Figure 4.5). While 40% percent of the respondents explained that availability of medicine affect livestock production in the study area. Whereas 10% of the respondents explained that eradications of pestsincreased productionof crops and 4% said that the use of genetically modified crops (GMO) increased harvests.



Key/legend

Availability of high bride animals	46%
Availability of medicine	40%
Eradications of pests	10%
Use of GMO	4%

Figure 4.1: Knowledge on Technological Determinants of Climate Change Adaptations

Source: Field survey, 2018

Generally, the findings indicated that there wereknowledge of adaptations on the relationshipwith climate change of environmental determinants, social-economic determinants and technological determinants for agricultural production in the study area. However the study results indicate that socio-economic determinants count greater proportion on farming and livestock production. This implied that socio-economic determinants are the greater determinants for agricultural production in the study area. One of respondents said that:

> *"In our society agricultural production depends on different factors such as environmental factors, technological factors and socio-economic factors. Environmental factors include rainfall, pests and diseases. These factors influence agricultural production in the study area. While technological factors include improved highbred seeds and livestock, irrigation and harvesting tools. However both environmental factors and technological factors are determined by socio-economic factors; such as skills and education, age, gender and capital income".*

These findings are congruent to the statement that agricultural production technologies include biological and chemical technologies. Specifically, these technologies include chemical fertilizers, selected seeds or High Yielding Varieties, irrigation and soil quality enhancing technologies. Farmers use these technologies in order to enhance the production and productivity of the land. It is also indicated that, for poor farmers, adoption of technology places new demands on their limited resource base (Kamruzzaman & Takeya, 2008). Meanwhile Bahiigwa *et al.*(2005) puts that the comprehensive agricultural support policies by government or donors such as fertilizer subsidies, credit subsidies, fixed prices, floor prices and public irrigation schemes, were the main features of agricultural productivity Faltermeier and Abdulai (2009) in their side explained that improved seed is an important component of agricultural productivity, food security and sustainable economic growth.

Regardless of the scale of agriculture, seed quality, particularly its genetic attributes, determines the level of crop productivity in the presence of other crop production inputs. An estimated 50% of the global increase in yields over the past fifty years has been derived from genetic progress and seed quality, in addition to agronomy improvement and phytosanitary product uses (Faltermeier and Abdulai, 2009). Above all agricultural credit is described as banking finance for primary production, processing and trade of agricultural products, and the production and distribution of inputs (Faltermeier and Abdulai, 2009). Poor farmers have very little chance to borrow from the formal sector because they rarely have collateral acceptable to banks.

4.6 Knowledge of Coping and Adaptive Strategies to the Impact of Climate Change on Farming Activities

The results of this study revealed that 94.6% of the respondents observed that variability in weather and climate has affected livelihoods of farmers as opposed to 5.4% of respondents who have not noticed any difference in their livelihood despite weather and climate variability. Changes in rainfall pattern, the occurrence of rivers flooding, changes in wind pattern, changes in temperature, changes in streams water levels, increased flooding event, malnutrition, school dropout, maternal/child deaths and drought among others, have impacts on crops availability and harvests. Climatic and weather changes have a direct effect on the crop growing ecology, crops harvesting, safety and efficiency of farming infrastructure. These effects impact on crop species composition, production, affect yield, health, and life of small-scale farmers, loss and damage to livelihood assets (Badjeck *et al.*, 2009). Therefore, the small scale farmers have to seek adaptation and mitigation strategies in order to sustain their livelihood.

The respondents were asked to state how climate variability has impacted on their livelihood. The results in Table 4.5 revealed that 98.27% of the respondents observed that they have lost income from farming, 96.55% of respondents experienced reduction in access to food due to loss of revenue from farming, while 91.37% had either their farming equipment's destroyed or lost in the land slumping and soil erosion, 86.20% had to risk of malnutrition and under-nutrition by family due to reducing access to crops harvests for a source of protein and cereals (Table 4.5). 81.03% had to move away from home for some time in search of good irrigation water sites; 71.41% had to abandon farming at some time for other economic activities; 52.2% had encountered some form of conflict with other users over irrigations areas in competing for the resources.

Table 4.5: Knowledge on Impacts of Weather and Climate Variability on Farmers' Livelihoods

Impact of weather and climate change	Frequency	Percentages (%)
Loss of income from farming	57	98.27
Abandoning farming to other economic activities	42	72.41
Damaging/destroying farming equipment or lost in land slumping	53	91.37
Going away to the rivers and trenches in search of irrigation water sites	47	81.03
Loss of membership in irrigation farms to more capable, cooperative farmers	05	8.62
Conflict with other small scale farmers over irrigation area and time	48	82.76
Reduced access to food due to loss of revenue from farming in droughts.	56	96.55
Risk of malnutrition and under-nutrition by family due to reduced access to crops harvests for a source of protein and cereal foods.	50	86.20
Loss of medicinal plants in Kilema ward in Kilimanjaro (e.g. KIMAROLO in Chagga -combretum molle)	57	98.27
Respondents can find causes of climate changes	43	74.13
Temperatures increasing	55	94.82
Falling of banana trees due to winds and dryness	45	77.7
Crops dried by high temperatures	42	72.41
Deforestation increasing	37	63.79
Rainfall decreasing	57	98.27
Shortage of foods	56	96.55
Shortage of safe drinking water	54	93.10
River's water contaminated with black ashes due to honey eaters mountain fires	58	100

Source: Field survey, 2018

Other impacts of weather and climate change mentioned by the respondents included lack of security, loss of crops that Submerged in the floods and soil erosion and reduced economic income. Katrina, Eriksen, and Kelly (2002) also alludes to the fact that the direct impact of climate variability on farmer-folk livelihood include damaged infrastructure, damaged crops and seeds, increased danger at the land slumping and soil erosion sites, loss/gain of irrigation trenches and wind falling of banana trees.

When the respondents were asked whether they solely depend on farming, 98.27% of the respondents said that, unlike in the past, they supplement farming activity with other economic activities like fruit businesses, irrigation and masonry, operating sawing and welding machines. However, irrigation during droughts of vegetable farms which was the main supplementing economic activity was not quite viable in the area due to the loss of fertility and low river waters and also its vulnerability to the impact of weather and climate variability.

The respondents were also asked to state if they knew farmers who have completely abandoned farming due to effects of climate variability in their location. About 72.8% of the respondents knew some small-scale farmers who have abandoned farming due to the reduction in water for irrigation. The farmers who abandoned farming to other economic activities resorted to rearing pigs and chickens(34.47%), small scale business (20.68%), and modern irrigation water pumps for vegetables 10.33%, building the old furrows with cement (8.62%), planting trees around water sources (6.88%), making small gardens and planting young trees for selling (12.05%) The Government employments about (3.47% and 6.88 % respectively), (5.6%) selling grasses as fodders (Table 4.6).

Table 4.6: Coping and Adaptive Strategies to Climate Change

Coping and adaptive strategies apart from farming	Frequencies	Percentages
Animals rearing (e.g. pigs, cow, goats, sheep, rabbits, chicken and bucks)	20	34.47
Small scale business (masonry, meat selling and welding) and agro- forestry farming	12	20.68
Making small gardens and planting young trees for selling and crop rotation	7	12.05
Farming and irrigations during summer and droughts by using water pumps, mulching and trenches	6	10.33
Planting trees around farms and water sources	4	6.88
Selling grasses as fodders	3	5.6
Protecting people from cutting trees and fire woods from protected rain forests of Mt. Kilimanjaro and paid by Government	2	3.47
Building the old furrows with cements and culverts and paid by local councils.	4	6.88
Total	**58**	**100**

Source: Field survey, 2018

The respondents were then asked to comment on the outcome of abandoning farming and engage in other livelihood strategic activities (Table 4.7). Their responses were overwhelmingly that it has drastically reduced the incomes. The general view was that weather and climate variability has impacted negatively on the livelihood of the farmers and majority had opted for other alternative sources of income for their socio-economic needs.

However, the number of farmer folk and farming tractors, hoes and fertilizers considerably as a result of the increase improved furrow and pumping irrigations. Some farmers registered a declining trend of harvests per acre due to over farming thus loss of fertility. A similar study conducted by Lokina (2000), revealed that trends

in the crops harvests in Tanzania have been characterized by fluctuations since 1970. The annual crops harvests have been detrimental due to climate change. As a result of this, harvests have a declining trend year after years in Kilema ward, Kilimanjaro Region, Tanzania as it has been revealed by this study.

Table 4.7:Adaptive Strategies to Climate Change used by Indigenous People

STRATEGIC ACTIVITIES	NUMBER	PERCENTAGES
Use of CSA	12	20.68
A-forestation	6	10.34
Making of terraces	3	5.17
Harvest of rain water	1	1.72
Making of plant grass terraces	2	3.45
Mulching	15	25.86
Rearing domestic animals	40	68.94
Water irrigation	4	6.18
Planting of drought resistance crops	2	3.45
Making of small businesses	22	37.93
Motorcycle transportation of passengers and small cargoes	2	3.45
Practice of agro-forestry agriculture	17	29.31
Practice soil management	12	20.68
Practice improved water management	23	39.67
Practice crop management	29	50
Practice livestock management	35	60.34
Practice crop rotation	41	70.68
Practice weather forecasting	26	44.83
Digging trenches along banana trees to preserve rain water for longer irrigation	20	34.48

increased (**Source**: Field survey, 2018)

4.7 Summary of the Findings

The factors which were examined included Indigenous Knowledge Systems (IKS) of how changes in temperature, rainfall and wind, drought and flood affects farming crop harvests, farmer's health, farming duration, choice of farming techniques. Others were selection of farming equipments and fertilizers, boosters, herbicides, pesticides and

livelihoods of the small scale farmer's revenues. The result from this study revealed that IKS on droughts and rainfall has positive impacts of crops availability or crops harvests. Respondents showed that the availability of crops during drought period is very low and rainfall influence crops availability or crops harvests in any given time. These were explained from the fact that although during high rainfall there is an increase in crops yield, but the dangers posed by high rainfall deter some farmers from venturing into the farms for a long period due to dangers of soil erosion, abrupt flooding of rivers, streams, trenches, land sliding and slumping. During high temperature, and strong wind in the high altitudes the study revealed that banana trees are fallen down thus banana availability is low. This is based on the fact that as it has been presented that duration of farming is shortened or there is no farming or harvesting at all. At the same time irrigation trenches and furrows are destroyed during strong rainfalls as water returns to rivers thus leading to low irrigation water as a result farmers don't get enough water and so short time is taken during irrigation.

The study revealed further that small scale farmers were affected by sudden rainfall flooding and they fall sick due to body injuries when soil erosion and land slumping sweep away the fertile soils and seeds by rain water and cold weather condition.Also IKS of temperature variations has high impacts on the small scale farmers. Generally, during high temperatures, 73% of the respondents said that the crops dried from hot conditions. Other respondents declared headache, weaknesses and fatigue as another impact of climatic change scenarios.

On the duration of farming, the results revealed that during strong rainfalls, erosion, land sliding andslumping resulted a few crops or no crop harvesting at all in a

particular places affected. During droughts and rainfall, cropping duration last for few weeks due to the gap of sowing, growing, harvesting and storage. However, during drought the small scale farmers take a longer duration in farming due to lack of seeds, lack of rains, money and rotting of crops and lack of water for irrigation. The study found that according to most respondents, strong winds, erosions and high amount of rainfall reduces the amount of crops harvests. While moderate and low temperatures variations have no effects on the amounts of crops harvests as they are normal. But it is also imperative to note that majority of the respondents reported that drought affected the amount of crops harvests.

The study further showed that cropping techniques change a lot due to climate change which cause temperature and rainfall variability. For example, the study revealed that during highrainfall there is severe erosion, strong winds in the higher altitudes, drought, high temperatures and so most farmers prefer adaptation to use agro-forestry, crop – rotations, irrigations, use of fertilizers, planting of trees, rainwater harvesting, animal and chicken rearing as well as small business adaptations. Climate smart agriculture e.g. Agro-forest, Soil Management, Improved Water Management, Crop management and Livestock management are also used as adaptation strategies.

The findings of this study as presented in chapter four showed that impact of climate change due to rainfall and temperaturevariability has influence on the equipments used for farming. Majority of the respondents reported that strong winds (67.6%) and high rainfall (78.2%) destroy farming equipments, crops and harvests, while soil erosion and uphill landslide lead to submerging of crops, grasses, trees, rocks and falling of banana trees. About 77.7% reportedhigh rainfall and 73.9% reported strong

winds respectively. The study further revealed that effects of climate change due to temperature and rainfall variability had an impact on the livelihood of the small scale farmers. Most of them according to the findings of this study had lost their daily incomes noted by 98.9%, and 97.8% had reduced access to food due to loss of revenue from farming especially from coffee due to Coffee Berry Disease (CBD). About 90.2% respondents had lost farming equipments in the high elevations farms as coffee hand grinding machines, hand hoes, machetes and sickles for cutting grasses. About 80.4% stayed longer period away from home looking water for irrigation and even others 70.7% at some point of time had abandoned farming for other economic activities. The small scale farmers who had abandoned farming had resorted to adapt to pigs and chickens rearing (37%), small scale business (31.5%), motorcycles passengers transporting 12%, mangoes, bananas, jackfruits and avocadoes traders (15%) and other activities such as meat selling (4.3%). Due to CBD and dropping of coffee prices; some people have turned to other crops. Generally, adaptation strategies to build resilience for agricultural production systems and food security for small scale farmers using Indigenous Knowledge Systems (IKS) were utilized in this study.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study examined the knowledge impacts of climate change on small-scale farmers in Kilema ward in Kilimanjaro region. The objectives of the study were to assess the Indigenous Knowledge Systems (IKS) on climate change in the study area of Kilema ward in Kilimanjaro Region, climate change impacts on the small-scale farmers and coping strategies/adaptation measures for their sustainable livelihoods. The study was guided by adaptive cycle theory, since it relates to how the farmers use IKS to adapt to climate change.After the study findings, discussions and the summary, several conclusions can be put forward according to the specific objectives of this study:

Specific objective one revealed the IKS on the awareness on the indicators of climate change scenarios in the study area was about 47% and those who were not aware was about 53%. The indicators of climate change included the increase of temperatures which was reported by about 93% of the respondents and rainfall decrease by 88%; increasing drought 95%; falling of Banana trees due to blowing wind in high altitudes was 88% and scarcity of fresh water access was about 40%.

Specific objective two dealt with the impacts of climate change in the study area which revealed 98% have lost their income from farming; About 98% indigenous medicinal plants – *Combretum molle*L. (KIMAROLO) had been lost; About 97% had shortage/reduce access to food due to loss of revenue from farming in droughts; About 91% farming equipments were destroyed due to land slumping; About 81% went to

intermittent rivers and trenches to search for irrigation water and about 72% abandoned farming and went to other economic activities.

The results of specific objective three which established the climate change mitigation measures or rather the climate change adaptive/coping strategies revealed about 35% were adapting to the climate change by rearing animals such as cow, goats, sheep, pigs, chicken, ducks and rabbits. About 21% started small scale businesses like masonry, welding, agro-forestry farming, selling meat and shops. About 12% started small gardens for planting trees seedlings for selling to earn some income and 10% resorted to irrigation by using pumps during droughts and used trenches as well as mulching to conserve soil moisture contents to curb climate change scenarios.

To sum up,climate change as well as temperature and rainfall variability has affected farming, animals rearing and livelihood activities in Kilema ward in Kilimanjaro region. This had direct impacts on the farmers' folk themselves such as loss of lives, loss of pigs, and loss of trees by land slumping, seeds by soil erosionand livelihoods.There had been increased impacts on healthdue to thedestruction of irrigation streams by destroying the banks, reduced crop harvests.Change in farming techniques impacts on costs of seeds, pestsfumigationse.g. rats, weeds, birds and insects and impacts at farming revenues. Some of the farmer-folk have been forced to seek alternative sources of livelihood such as animal rearing, small businesses and motorcycles passengers transporting, but some of these activities are not sustainable due to prevailing economic conditions and size of the investment. Therefore, there is the need to enhance resilience and adoption of sustainable mitigation and agricultural adaptation strategies. This conclusion is supported by The ISCC (2010), which states

that due to climate change, the crops harvests continues to decline. The small scale farmer-folkssuffer in poverty and disruption of their well-being such as health, education, and other social lives. The challenge is in the mitigation and adaptation strategies that are sustainable for agriculture productions.

5.2 Recommendations

This study recommends imparting knowledge to the small scale farmers on the use of CSA technologies since only 21% practice this technique in order to move to commercial farming. It is also recommends train them to do A-forestation and practice good farming practices. Moreover, it recommends to Local Government Authorities (LGAs) to raise awareness on rain water harvest to the farmers. It is recommended to the small scale farmers to join in groups which can enable them to secure loans for improving their farming and businesses from banks and SACCOS and to own their selling's to good markets locally and internationally.

Based on the findings of this study, the following recommendations are made:

- The findings showed that knowledge on climate change has affected the farming folk in terms of loss of lives, injuries and loss of types pigs houses,equipments,seeds by soil erosions, loss of beans pollinations due heavy rain falls. It is thus recommended that the government and other stakeholders in the farming industry should assist the farmer-folk to acquire modern types of pigs houses, modern streams for irrigations by building the furrows which are cemented to reduce loss of waterthat will reduce the risks of having less water for irrigationsand improve their crops harvests.

- The findings of this study also revealed that climate change has led to shorter farming duration and less crops harvests over the years. It is therefore recommended that the farmers should be empowered to diversify their livelihood activities to areas such as extensive farming to enhance their resilience. Also, farmers should be provided with loans for tractors which will enable them to farm more extensively in big farmswhere there aremore harvests.

- The government and other agencies should conduct climate-change risk and social impact assessments when evaluating mitigation and adaptation alternatives and include analyses of distributional impacts of such alternatives as giving them funds for trees CO_2planting sinks.

- Farmers should form cooperatives which can enable them to save money and buy tractors and used some of the money for the capacity building. Also calling crops extension experts to train on how to farm for more productions, sale and keep records of their sells.

5.3 Recommendations for Further Research

This study was limited to four villages; it could also be replicated to other regions where agriculture is one of the economic activities of the communities to compare the findings. This study revealed that knowledge onclimate change has a significant effect on farming and livelihood activities,thus there is a need to conduct a study on risk reduction as adaptation mechanisms aimed at enabling integrated and broader national planning to improve farming and climate change adaptation strategies.

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APPENDICES

Appendix I:Questionnaire for Small Scale Farmers

Dear Sir/Madam:

This questionnaire is for gathering information on the effects of knowledge of climate change variability on farming activities in Kilema ward. The major aim is to identify the effects of knowledge in Rainfall and Temperature time changes. Also knowledge ofindicators of soil erosions, indicators of high temperatures, indicators of droughts,land slumping, low waters in river streams, furrows. Indicators of plant diseases and adaptation strategies in small scale farmers' in Kilema ward. The answer you will give will go along way into improving the situation posed by effects of climate changes (variability). Please respond as honestly as you can to all the questions. Feel free to make further comments you may want to. The answers you give will be treated with utmost confidentiality. You do not have to write your name anywhere in the questionnaire.

Part A: Socio-Economic Characteristics

1. Questionnaire number……
2. Date of interview……
3. Name of thevillage ……..
4. What is your sex? (Please tick one)

Male ( )

Female ( )

5. What is your age group? (Please tick one)

Below 21 years ( )

21-30 years ( )

31-40 years ( )

41-50 years ( )

Above 50 years ( )

6. What is your marital status? (Please tick one)

Single ( )

Married ( )

Divorced ( )

Widowed ( )

Separated ( )

7. What is the highest level of your education? (Please tick one)

Never attended formal education ( )

Primary school ( )

Secondary school ( )

Advanced Secondary School ( )

Tertiary/middle college ( )

University ( )

Other specify _____

8. What is your other source of income apart from farming? (Please tick one)

Irrigation and agriculture (farmer) ( )

Carpentry ( )

Livestock keeper ( )

masonry ( )

Other specify _____

9. What is your income per month? (Please tick one)

Below 20,000 ( )

25,000-35,000 ( )

45,001-55,000 ( )

65,000-95,000 ( )

Over 150,000 ( )

10. How many people live in your household? (Please tick one)

Below 5 ( )

5-10 ( )

Over 10 ( )

Part B: Knowledge onImpact of climate variability on small scale farmers

11. Do you know about climate change?

Yes ( )

No ( )

If yes? What is climate change?

12. Which climatic variable(s) do you think is/are most important?

Flood ( )

Drought ( )

Rainfall variation ( )

Temperature fluctuation ( )

Soil erosion/land slumping ( )

13. Is there any relation between climate change and crop harvests?

Yes ( )

No ( )

If yes, how?

14. Did you notice any abnormality of climate change in farming practices?

Yes ( )

No ( )

If yes, what abnormalities? …….

15. Has variability of climate such as low waters streams, high rainfall, soil erosion, drought, flooding, and high temperatures had any effect on your farming activities (Please tick one)

Yes ( )

No ( )

If yes, how? …….

16. Has variability of climate change such as soil erosion, drought, flooding, and decrease of river water levels had any effect on the small scale farmers? (Please tick one)

Yes

No

If yes, how?.....

17. What are the effects of climate change variability on farmer folk (Tick the appropriate box)

Climate change variability	Loss of life as a result of famine and diarrhea	Sickness of small scale farmers due to body injuries	Loss of seeds due to soil erosions	Low level river waters	Loss of finger millet and coffee	Use of pesticides and funds	No effect
Soil erosion							
Land slumping							
Low stream water							
High Rain fall							
Moderate rain fall							
Low rain fall							
Drought							
Deforestations							
High Temperature							
Low temperature							
Moderate Temperature							
Reappearances of pests							
Mt. Kilimanjaro glaciers retreats							
Loss of soil fertility							

18**. What are the effects of weather and climate variability on farming duration? (Tick the appropriate box).**

Climate change variability	Short time	Longer time	Normal time	No crops harvests at all
Soil erosion				
Low stream water				
Droughts				
High rain fall				
Moderate rain fall				
Low rain fall				
Drought				
Land slumping				
High temperature				
Low temperature				

Part C: Impact of climate change on temperature and rainfall variability on crops harvests

19. Indicate the impact of the following knowledgeof climate change for Temp & raifallvariability on crops harvests around study area.

Climate change on Temp. & Rainfall variability	Very low	Low	Moderate/ normal	High
Soil erosion				
Crops pests				
deforestation				
High rain fall				
Moderate rain fall				
Low rain fall				
Droughts				
Low water streams				
High temperature				
Low temperature				
Moderate temperature				

Part D: Impact knowledgeof weather and climate (change) variability on farming techniques.

20. Have variability in climate such as soil erosions, drought, flooding, and reduction in river water levels had any effect on your farming techniques (Please tick one)

Yes

No

If yes, how? ……..

21. Indicate the impact of the following variability of climate change on farming techniques around Kilema ward area (Tick the appropriate box)

Climate change variability	Use of usual farming method (putting fertilizer, smart agriculture, animal manure)	Put mulching and terraces	Black water contaminated with ashes	Use other techniques (irrigation, a forestation, agro-forestry,)	Funds for planti ng trees	Disappeara nce of fruits species
Soil erosions						
Crop pests						
deforestations						
High rain fall						
Moderate rain fall						
Low rain fall						
Drought						
Mountain fires						
High temperature						
Low temperature						
Moderate temperature						

22. What are the effects of climate change variability on your farming equipments (i.e. tractors, irrigation trenches, hand hoes or matchet, sickles and mattock forclearing grasses) (Tick the appropriate box)

Climate change variability	Tractors can't cultivate	seeds eroded	Hand hoes broken	Water not safe	Irrigation trenches without water	Destroying instruments	No effect
Mountain fire Contaminate water with black ashes							
Soil erosion remove fertile, top soils							
Low river waters not available in trenches							
High rain fall cause landslides							

Moderate rain fall for good crops harvests							
Low rain fall with no crops							
Drought with no harvests							
Land slumping breaks tractors and hoes in houses							
High temperature dries crops							
Low temperature make crops less growing							
Moderate temperature leads to good harvests							

Part E: Effect of climate change variability on livelihood

23. Have variability in climate change such as soil erosions, drought, mountain fires, and reduction in river/streams water levels etc. had any effect on your livelihood as a farmer (Please tick one)

Yes ( )

No ( )

24. What impacts has climate change variability had on your livelihood? (Please tick all that apply)

□ Loss of income from farming

□ Had to abandon farming at some point for other economic activities

□ Seeds destroyed by soil erosions or rotted thus reducing my revenues

□ Had to be away from home for sometime in search of enough irrigation waters

□ Loss of borrowed money from SACCOScooperatives as seeds didn't grow

□ Conflict with other irrigation folkover irrigation time and areas

□ Reduced access to food due to loss of revenue from farming

□ Risk of malnutrition and under-nutrition by family due to reduced access to crops for a source of protein and energy.

□ Others specify _____

25 (a). Do you know any farmer who has abandoned farms due to the effects of climate change variability on farming activity in your location of Kilema ward(Please tick one)

Yes ( )

No ( )

(b). If yes, what are their coping and adaptive strategies? (Please tick all that apply)

Stream water Irrigations……..……. ( )

Small scale business …….. ( )

Motorcycle transportations of passengers…… ( )

SMART agricultures and using fertilizers……..……. ( )

Fruits transportations and selling …….. ( )

Use of pesticides……. . ( )

Agro-forestry…… ( )

Dry resilient seeds…….....( )

Animal /birds rearing (e.g. pigs, chickens, cow, bucks, sheep and goats)……()

Mulching …….()

Other specify _____

26. Comment on how this has impacted on their livelihood.

_____

_____

27. Some social indicators of climate change are: - (Please tick all that apply)

(a) Low life expectancy ( ),

(b) Low adult literacy ( )

(c)Scarcity of freshwater access. ( )

(d)High infant mortality, ( )

(e) Low secondary school enrolment ( )

(f) High Levels of inequality inincome, in access to fresh water, healthcare and gender inequalities. ( )

(28) Knowledge on climate variability effects through ways such as changes - (Please tick all that apply)

(a) In rainfall pattern ( )

(b) Occurrence of droughts ( )

(c) Changes in rain pattern ( )

(d) Changes in temperature ( )

(e) Changes in river water levels ( )

(f) Increased flooding event around water banks and drought among others ( )

(29)Knowledge on Glacier retreatsand disappearance (e.g. That of Mt. Kilimanjaro) will have different quantitative impacts. (Please tick all that apply)

(a) A reduction in runoff will affect the ability to irrigate crops ( )

(b) Will reduce summer stream flows necessary to keep dams (Nyumba ya Mungu) and reservoirs replenished ( )

(c)Reduce water levels in rivers Himo and Mue inKilema ward which feeds Pangani basin and Nyumba ya Mungu dam of which have very low water in summer times. ( )

(d) Most of the water springs are reduced. ( )

(30)Which crops are mostly affected by pests? (E.g. Aphids) (Please tick all that apply)

(a) Tomatoes ( )

(b) Sunflowers ( )

(C)Coffee ( )

(d)Lemons ( )

(e) Bananas ( )

(e)Finger millets ( )

(f) Sweets potatoes( )

(31According to climate change knowledge, six policy principles have been suggested :- (Please tick all that apply)

(a) The best policy will enhance information and knowledge flows, incentives and flexibility. ()

(b) Policies that reducepoverty will improve agricultural adaptation ( )

(c) Business as usual among the world’s poor is not adequate. ( )

(d) Existing technology options for adaptation must be made more available and accessible especially for Kilema ward whereby most of colonial man made trenches are dry. ( )

(e) Adaptation and mitigation in agriculture will require local knowledge responses ( )

(f) Trade will play a critical role in both mitigation and adaptation

( )

(32)According to climate change knowledgeeducations are undermined b: - (Please tick all that apply)

(a)Loss of livelihood assets ( )

(b) Natural disasters (climate change) reduce opportunities for full time education ()

(c)More children(especially girls) are likely to be taken out of school to help fetch water, earn an income or care for ill family members. ( )

(d) Malnourishment and illness reduces school attendance and the ability of children to learn when they are in class ( )

(e) Displacement and migration can reduce access to education. ( )

(33)

DESIRED INTERVETION/KNOWLEDGE TO CLIMATE CHANGE		
What knowledge needed to prevent soil erosion, land- slumping, low river water and link to meteorological and agricultural institutions (rank one as most important)		
Desired Intervention Knowledge	YES	
	1	2
Information on climate change		
Improved practices of planting trees		
Enhanced Government support rearing plant gardens for a forestations and thus CO2 sinks		
Training in SMART agriculture and improved maintainace of colonial irrigation man made streams		
Improved practices of local trenches digging for irrigations		
Construction of piped water at homes		
Building small dams or pools as a source of piped water		

(34) **Social Economic Impact Knowledge Due to Low River Waters (Rank One - as Most Important, Two -Moderate, Three – (3) - Low)**

IMPACTS	YES		
	1	2	3
No irrigation agriculture			
Poor hand washing			
No safe water for drinking			
Socio-economic developments exacerbate the effects of climate change on ecosystems and humanity (IPCC, 2007).			
Boko et al. (2007) indicate that endemic poverty, poor governance, limited access to capital and global markets, are factors that may undermine community's ability to adapt to climate change			
Developing countries like Tanzania are most vulnerable to extreme climatic events and rainfall variability due to high dependence on rain fed agriculture and natural resources for their livelihoods.			
Complex disasters, ecosystem degradation, are factors that may undermine community's ability to adapt to climate change.			
Conflictson water for irrigation and urbanization are factors that may undermine community's ability to adapt to climate change.			

Thank you very much for your cooperation and may God bless you

Appendix II:Interview Guide for Official from Agriculture Department

Dear Sir/Madam,

This questionnaire is to help in gathering information on theknowledge effects of climate change variability on farming activities and farmers' coping and adaptive strategies in Kilema ward Level. The major aim is to identify the knowledge effects of changes in climate change in farming activities and adaptation strategies in Small Scale farmers. Moreover the indicators of climate change will be analyzed .as well as adaptation strategies. . The answer you will give will go along way into improving the situation posed by effects of climate variability and adaptation strategies. Please respond as honestly as you can to all the questions. Feel free to make further comments you may want to. The answers you give will be treated with utmost confidentiality. You do not have to write your name anywhere in the Questionnaire. Comments on the following in relation to climate change variability and farming in your area of jurisdiction.

Do you know about climate change? .....

Which climatic variable do you think is most important?

Mountain fires ( )

Drought. ( )

Rainfall variation ( )

Temperature fluctuation ( )

Soil erosions( )

Land sliding( )

Low level of river waters( )

Dryness of streams ( )

Reappearances of plants pests ()

And why ……

Is there any relation between climate change and farming activities?

Yes ( )

No ( )

If Yes, How? …….

What is the impact on crops harvests due to climate change over the recent past .....

.....

Do you know farming methods adopted by small scale farmers?

Yes ( )

No ( )

If yes, mention ……..

Is there any awareness being made on climate change to small scale farmers?

Yes ( )

No ( )

If yes, what kind of institutional provided of awareness ……

Comment on the climate change conditions experienced in the area onfarming activities of the recent past.

……

……

……

Appendix III:Interview Guide for Meteorological Department Officials

Dear Sir/Madam,

This questionnaire is to help in gathering information on the knowledge effects of climate change variability on farming activities and farmers' coping and adaptive strategies in small scale farmers in Kilema ward. The major aim is to identify the effects of changes in Rainfall, Temperature, river water level, mountain fires and Wind in Farming Activities in Kilema ward. The answer you will give will go along way into improving the situation posed by effects of climate variability. Please respond as honestly as you can to all the Questions. Feel free to make further comments you may want to. The answers you give will be treated with utmost confidentiality. You do not have to write your name anywhere in the Questionnaire.

What is climate change?

What are the differences between climate change and variability?

……

……

What are variable or weather elements considered in determining climate change.

……

……

What are impacts of climate change on farming?

.....……

……

Comment on the weather conditions experienced in the area over the recent past

……

……

……

……

Do the changes in weather conditions have any impact on the farms/ forests?

……

……

What can be done to control climate change?

……

……

Appendix IV:Observation Guide on the field study

Village Name ……

Villages farms soil erosions ……..

Farming equipmentsused by farmers. (Modern, local or improvement)……

Farming utensilsused (modern, local or improvement)…….

Farming practices……

Living standard (houses:-iron, grasses roofed)……

Environmental degradation……..

Exploitation of natural resources…….

A forestation/plant trees…….

Destruction and improvement of community forestry and naturalMt. Kilimanjaro rain forests……..

Child labor(number of below aged (18yrs) engaged in farming activities.

……..

Income generation activities……..

Drought……

Family planning. (number of Childs @family and age from questionnaire)…….

Water levels in rivers (i.e. Mue and Whona rivers), trenches, springs, Nyumba ya Mungu dam (fed by rivers) and Lake Jipe (fed by rivers from Mt. Kilimanjaro)…….

Appendix V:Focus Group Discussion Guide to get in-depth Views by Probing

Date……..…….……

Village name …….

Number of Participants…….……male…….…….…..Female…….

What is climate change?

What are the main causes of climate change in this area?

What are the mainknowledge impacts of climate change in this area?

Did you notice any abnormality of climate change in farming practices?.....

What areabnormality were founded during farming practices?.....

Do you think the stakeholders have done enough to address the problem?.....

What are the effects of weather and climate variability on farming duration?.....

What initiatives you know that have been taken by respective Government and NGOs, leaders in addressing the problem knowledge of climate change impacts? .,,,,,,,,,,,,

Are they adequate?.....

What are the main knowledgeadaptation measures used by farmers to cope with climate change impacts?.....

Please recommend what steps to be taken to address the problem of climate change impacts and adaptation strategies……..

What obstacles can face small scale farmers on climate change

adaptation?.....

Deaths and illness due to soil slumping, trees falling on houses, heat-waves, floods, droughts ,hurricanes, landslides and low river water causing low crops harvests and vector born diseases (i.e. climate change); –as children and pregnant women are particularly susceptible to vector-borne diseases; which are they?.....

15. Low GDP per capita,– widespread, endemic poverty– weak institutions– low levels of education– low levels of primary health care, little consideration of women and gender balance in policy planning markets, infrastructure and technology are mainly found in Africa due to?.....

THANK YOU AND GOD BLESS YOU ALL.