EFFECTS OF CLIMATE CHANGE ON AGRICULTURAL PRODUCTION.

CASE STUDY OF KISUMU DISTRICT, NYANZA PROVINCE IN KENYA.

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BEM/14379/71/DF

A RESEARCH DISSERTATION SUBMITTED TO THE FACULTY OF ENGINEERING AND APPLIED SCIENCE, KAMPALA INTERNATIONAL UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A BACHELOR OF SCIENCE DEGREE IN ENVIRONMENT MANAGEMENT OF KAMPALA INTERNATIONAL UNIVERSITY,

KAMPALA, UGANDA.

AUGUST 2010.

DECLARATION

I, **OMBWA FELIX GUYA,** hereby declare that the work contained in this dissertation entitled, **EFFECTS OF CLIMATE CHANGE ON AGRICULTURAL PRODUCTION** with the exception of the acknowledged references, ideas and concerns is my original work and it has never been submitted for fulfilment of the requirement of a degree award or any other education qualification in any institution of learning.

Signed..... Date..... 4/09/2010

Felix. O. Guya

APPROVAL

This research report entitled, **EFFECTS OF CLIMATE CHANGE ON AGRICULTURAL PRODUCTION** is submitted to Kampala International University, School of Engineering and Applied Sciences with my approval as the Supervisor.

Dr. Twaha Ali Basamba

Signature…… Date…… 4.9.2020

DEDICATION

To my parents Mr. LAWRENCE and Mrs. AGNETA GUYA, I love you all, may God be with you always because he said he will not cast off his people neither forsake his inheritance. And my fiancée, NEREAH OKOTH APELA, who has always been with me to give all the support I needed. May God bless you so much.

ACKNOWLEDGEMENTS

I would like to thank my dad, Lawrence Guya and mum, Agneta Guya for their hard working character that has made everything so smooth for me.

I appreciate so much Dr. Twaha Ali Basamba for his supervision and direction throughout my entire work.

All United Faith Church members, Kampala International University, for being my family and place that taught me morality and kept my faith in Christ growing.

Andrew Otekat, Asilah Ayub and Hatibu Hashim for being so understanding, unselfish and above all for giving me all the support I needed. God bless you all.

Above all, to God in the name of Jesus Christ, who gave me the strength and wisdom to accomplish this work.

ABSTRACT

Kisumu District is an administrative District of Nyanza Province in western Kenya with a population of 504, 359 and a land area of 912 square kilometers. The main industries are subsistence agriculture and fisheries on Lake Victoria. It falls within the coordinates of 0 55" south and 34 55" east. The main type of soils is ferrasols. It experiences a bimodal type of rainfall. The minimum temperature is 15 Celsius while the mean maximum temperature is 36 Celsius. Humidity is relatively high.

The study was both descriptive in design, and it based on primary and secondary data to establish the magnitude of the problem. The primary methods included interview, questionnaire and observation. It gave a chance for ground truthing or counter checking with the secondary data which was obtained from numerous books, newsletters and journals. A sample of 20 farmers and five agricultural extensionists were used to aid in data collection

The major objective of the study was to find out the main effect of climate change on agriculture production, while the specific objectives included identifying causes and effects of climate change among others.

The major findings of the cause of climate change was production of greenhouse gases especially carbon dioxide from human activities which include agricultural production, industrialization, burning of fossil fuels and deforestation.

Recommendations in the study included placing a worldwide cap on carbon dioxide emissions by limiting the use of fossil fuels in industry and transportation, accelerating international agreements to completely phase out CFCs, stopping the loss of tropical forests and encouraging planting of trees over vast areas now suffering from deforestation, among others.

ACRONYMS

NGO – Non Governmental Organizations

CBO - Community Based Organizations

PPM - Parts Per Million

MOA - Ministry of Agriculture

IPCC - Intergovernmental Panel on Climate Change

KNBS - Kenya National Bureau of Statistics

GHGs - Green House Gases.

FAO - Food and Agriculture Organization of the United Nations

KARI - Kenya Agricultural Research Institute

SARD - Sustainable Agriculture and Rural Development

UNCED – United Nations Conference on Environment and Development.

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CHAPTER ONE

1.0 INTRODUCTION

1.1Background

Broadly speaking, many African countries are majorly agricultural economy based meaning that most of these economies are supported by agricultural production. In sub Saharan Africa, which contains 82 % of Africa's population, per capita food production dropped by 30% between 1960 and 1994 and is projected to fall by another 30% during the next 25 years. Some 30 million people in sub Saharan Africa typically suffer from famine and there are even more people to feed. Thousands die each day from malnutrition and other hunger related diseases. Some analysts argue that crop yields in sub Saharan Africa are extremely low primarily because farmers there have not had access to modern industrialized agriculture. Others point out that the situation is not that simple and that several interacting factors are to blame including rapid population growth, global warming and climate change. Sub Saharan Africa is affected by severe soil erosion, nutrient poor soils, lack of water for irrigation, severe and increasing desertification which affects more than one fourth of the region.

Kenya is not an exception in this case because 80% of the Kenyan economy is dependent on agriculture production obtained majorly from the cash crops such as coffee, tea, pyrethrum and sugarcane among others. Kenya is endowed with good soils especially on its highlands and the rift valley region but other areas as well equally practice agriculture and among them is Kisumu District which is one of the 72 districts of Kenya according to the population census of 1999 (KNBS, 1999)

1.2 Statement of the problem

Kisumu District is an area that surrounds the shores of Lake Victoria and the major economic activities taking place in this area are fishing as well as subsistence crop production. Due to the increasing population pressure, which is as a result of poor family planning methods, there has been increased demand for food production in order to sustain the growing population. Due to poor knowledge and out of desperacy, the population has exploited the natural resources that were available to an extent that they are now being depleted. Out of these attempts, continuous degradation has taken place and food production is continuously going down. This has led to erratic rainfall patterns causing frequent and unpredictable droughts particularly in the plains and around the shores of the lake. It has also led to frequent floods in the Kano plains especially in the River Nyando Basin and other rivers such as Nyamasaria and Miriu. On the above two issues, farmers are always advised to construct their homes in raised grounds and clear water channels.

There has always been low farm input use by farmers due to the high costs. This has led to food insecurity. Kisumu District has been identified as one of the major areas with food deficits especially in major food items such as maize and beans. There has also been minimum knowledge on environmental conservation measures as well as agricultural production techniques that can help them both conserve nature and raise their food production levels.

If current trends are not reversed fairly quickly, most of the region is expected to undergo increasingly severe famine, diseases, social chaos and ecological deterioration.

1.3 Objectives

1.3.1 General objective

The general objective of the study was to find out the main effects of climate change on agricultural production in Kisumu District.

1.3.2 Specific objectives

The specific objectives of the study were:

- To identify the causes of climate change,
- To determine the relationship between climate change and agricultural production,
- To identify the effects of reduction in agricultural production,
- To identify the possible solutions to the problem of climate change.

1.4 Research questions

The research questions were as follows:

- What are the main causes of climate change?
- What is the relationship between climate change and agricultural production?
- What are the effects of reduction in agricultural production?
- What are the possible solutions to the problem of climate change?

1.5 Scope of the study.

The study majorly focused on the state of climate change and its effects in agricultural production in Kisumu District of Nyanza Province in Kenya. The study was carried out around the shores of Lake Victoria on the various farms where crop production is taking place. The study targeted food crop farmers around the Lake Victoria region as well as agricultural extension officers in these areas that work with the local farmers. The study also aimed at getting information from the institutions that operate in these areas in the agricultural field. The institutions included; CBOs, NGOs or governmental organizations that work with the communal farmers.

1.6 Significance of the study

The findings of the research were intended to yield a better understanding on the concept of climate change and how to handle the climate change phenomenon so as to be able to maintain the high levels of agricultural production for food security.

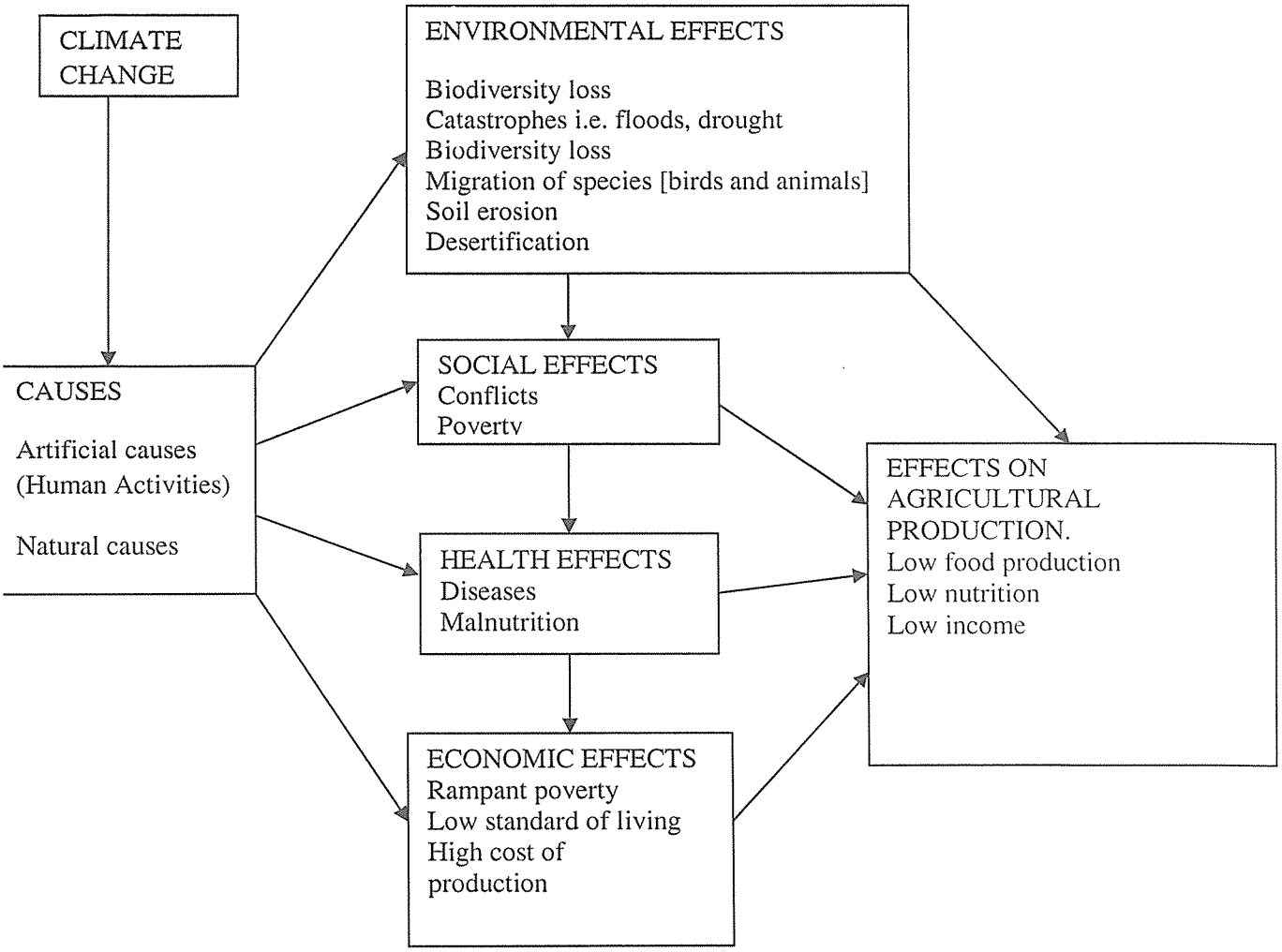
The study gave results which will add more knowledge on the available literature about the state of climate change, its effects and possible solutions.

Future researchers can also use the findings which will be obtained from this research on effects of climate change on agricultural production to advance on further studies and more research to be carried out on the same.

The research was able to bring out clearly the causes, effects and possible solutions to climate change in our society.

This research was also significant for the awarding of the degree in Bachelors of science in Environmental Management of Kampala International University.

1.7 Conceptual Framework



Human activities directly affect the environment and make it lose its ability to meet the demand of all flora and fauna. This causes handicaps in the economy which raises health concerns like malnutrition and diseases. This cements the position of degradation to our environment which has greatly caused climate change.

CHAPTER TWO.

2.0 LITERATURE REVIEW

2.1 Causes of global warming and climate change

Several gases in the atmosphere are transparent to ultraviolet and visible light but absorb infra red radiation. These gases allow sunlight to penetrate the atmosphere and be absorbed by the earth's surface. This sun light energy is re radiated as infra red radiation (heat), which is absorbed by the green house gases in the atmosphere. Because the effect is similar to what happens in the green house where the glass allows heat to enter but retards the loss of heat, these gases are called green house gases, and the warming thought to occur from their increase is called the green house effect. The most important green house gases are the following;

Carbon dioxide (CO2). The most abundant of the green house gases. It occurs as a natural consequence of respiration. However, much larger quantities are put into the atmosphere as a waste product of energy production. Coal, oil, natural gas and biomass are burned to provide heat and electricity for industrial processes, home heating and cooking. Another factor contributing to the increase of carbon dioxide concentration in the atmosphere is deforestation. Trees and other vegetation remove carbon dioxide from the air and use it for photosynthesis. Since trees live for a long time, they effectively tie carbon in their structure. Cutting down trees to convert forested land to other uses release this carbon, and a reduction in the amount of forest lessens its ability to remove carbon dioxide from the atmosphere. The combination of these factors (fossil-fuel burning and deforestation), has resulted in an increase in the concentration of carbon dioxide in the atmosphere (Enger and Smith, 2006)

Chlorofluorocarbons (CFCs) are entirely the result of human activity. They were widely used as refrigerant gases in refrigerators and air conditioners, and as expanders in foam products. Although they are present in the atmosphere in minute quantities, they are extremely efficient as green house gases (about 15,000 times more efficient at retarding heat loss than is carbon dioxide)

Methane, Comes primarily from biological sources, although some enter the atmosphere from fossil-fuel sources. Several kinds of bacteria that are particularly in wetlands and rice fields release methane into the atmosphere. Methane releasing bacteria are also found in large numbers in the guts of termites and various kinds of ruminant animals such as cattle. Control of methane sources is unlikely since the primary sources involve agricultural practices that would be very difficult to change. For example, nations would have to convert rice paddies to other forms of agriculture and drastically reduce the number of animals

use for meat production. Neither is likely to occur, since food production in most parts of the world needs to be increased, not decreased (Enger and Smith, 2006)

Nitrous oxide a minor component of the green house gas picture enters the atmosphere primarily from fossil fuels and fertilizers. It could be reduced by more careful use of nitrogen containing fertilizers. (Enger and Smith, 2006)

2.2 Potential Consequences of Global Warming and Climate Change

Scientists suggest that rising temperatures will lead to increased incidences of severe weather and changes in rainfall patterns that would result in more rain in some areas and drought in others. They suggest that the magnitude and rate of change will differ from region to region. Furthermore, some natural ecosystems or human settlements will be able to withstand or adapt to the changes, while others will not.

Poorer nations are generally more vulnerable to the consequences of global warming these nations tend to be more dependent on the climate sensitive-sectors, such as subsistence agriculture and luck the resources to buffer themselves against the changes that global warming may bring. The IPCC has identified Africa as the continent most vulnerable to the impacts of projected changes because widespread poverty limits adaptation capabilities.

In addition to changes in weather, there are many other potential consequences of warmer temperatures and changes in climate. These include rising sea levels, disruption of the hydrologic cycle, potential health concerns, changing forests and natural areas, and challenges to agriculture and the food supply. (Tyler G Miller, 2000)

Disruption of hydrologic cycle

Among the most fundamental effects of climate change is disruption of the hydrologic cycle. Rising temperatures are expected to result in increased evaporation, which will cause some areas to become drier, while the increased moisture in the air will result in greater rainfall in other areas. This is expected to cause droughts in some areas and flooding in others. In those areas where evaporation increases more than precipitation, soil will become drier, lake levels will drop and rivers will carry less water. Lower river flows and lake levels could impair navigation. Hydroelectric power generation, and water quality, and reduce the supplies of water available for agricultural, residential, and industrial uses.

Some areas may experience increased flooding during winter and spring, as well as lower supplies during summer. In California's Central valley for example, melting snow provides much of the summer water supplies; warmer temperatures would cause snow to melt earlier and thus reduce summer supplies, even if

rainfall increased during the spring. More generally the tendency for rainfall to be more concentrated in large storms as temperatures rise would tend to increase river flooding, without increasing the amount of water available. It is very difficult to predict the effects of changes in the hydrologic cycle, but several concerns have been raised (Enger and Smith,2006).

Navigation: Climate change could impair navigation by affecting average water levels in rivers and lakes, increasing the frequency of both floods (during which navigation is hazardous) and droughts(during which passage is difficult), and necessitating changes in navigational infrastructure. On the other hand, warmer temperatures could extend the ice free season in many parts of the world.

Hydropower: Hydropower depends on the flow of water on rivers. Increases the in amount of water flowing down a river would be beneficial, and decreases would be harmful.

Water supply and demand: in some parts of the world, the most widely discussed potential impact of climate change is the effect on water supply and demand. The potential changes in water supplies would result directly from the changes in runoff and the levels of rivers, lakes and aquifers.

Flood control: While the impacts of sea-level rise and associated coastal flooding have been widely discussed, global climate change could also change the frequency and severity of inland flooding, particularly along rivers.

Environmental quality and recreation: Decreased river flows and higher temperatures could harm the water quality of rivers, bays and lakes. In areas where river flows decrease, pollution concentrations will rise because there will be less water to dilute the pollutants. Increased frequency of severe rainstorms could boost the amount of chemicals that run off from farms, lawns and streets into rivers, lakes and bays.

Political issues: The areas of the world that currently are experiencing problems with water quantity and quality are likely to see these problems become more severe. This is particularly true in the arid and semi-arid regions of the world. Water scarcity in the Middle East and Africa is likely to be aggravated by climate change, which could increase tensions among countries that depend on water supplies originating outside their borders.

Health effects.

Climate change impact human health in variety of ways. The most direct effect of climate change would be the impacts of hotter temperatures. Extremely hot temperatures increase the number of people who die (of various causes) on a given day. For example, people with heart problems are vulnerable because the cardio-vascular system must work harder to keep the body cool during hot weather. Heat exhaustion and **some respiratory problems increase. In august 2003, Europe experienced a prolonged heat wave. France** recorded its highest temperatures on record. Thousands of people (primarily the elderly) died in

France and throughout southern Europe as a result of the heat. Carbon dioxide concentrations of 550 PPM (double preindustrial levels) could cause such heat wave events to occur six times more frequently.
Climate change also aggravates air quality problems. Higher air temperatures increase the concentration of ozone at ground level, which leads to injury of lung tissue and intensifies the effects of airborne pollen and spores that cause respiratory disease, asthma and allergic disorders. Because children and elderly are most vulnerable, they are likely to suffer disproportionately with both warmer temperatures and poorer air quality.
Throughout the world, the prevalence of particular diseases depends largely on local time. Several serious diseases appear only in warm areas. As the Earth becomes warmer, some of these tropical diseases may be able to spread to parts of the world where they do not currently occur. Diseases that are spread by mosquitoes and other insects could become more prevalent if warmer temperatures enabled those insects to become established farther North. Such "Vector borne" diseases include malaria, dengue fever, yellow fever and encephalitis. Some scientists believe that algal blooms could occur more frequently as temperatures rise , particularly in areas with polluted waters, in which case outbreaks of diseases such as cholera that tend to accompany algal blooms could become more frequent. (Enger and Smith, 2006)

2.3 Relationship between climate change and agricultural production.

Climate strongly affects crop yields. A carbon dioxide concentration of 550ppm is likely to increase crop yields in some areas by as much as 30% to 40% but will decrease yields in other places by similar amounts, even for the same crop. A warmer climate would reduce flexibility in crop distribution and increase irrigation demands. Expansion of the ranges of crop pests could also increase vulnerability and result in greater use of pesticides (Tyler G Miller, 2000)
The greatest difficulty for the agricultural community in coping with climate change, however, is not knowing what to expect. Already, farmers lose an average of one in five crops because of unfavorable weather. As the climate shifts, the vagaries of weather will become more pronounced and crop losses are likely to increase. However, farmers are capable of rapidly switching crops and land uses and so the impact may not be as bad as some observers think (Tyler G Miller, 2000)
The episodic warming of the southern Pacific Ocean known as EL NINO is becoming far more common. The El Nino phenomenon influence weather by guiding jet stream and moisture patterns. Thunderstorms and hurricanes have been more frequent and more severe in recent years (Bradshaw and Weaver, 1993)
Agriculture of any kind is strongly influenced by the availability of water. Climate change modifies rainfall, evaporation, run off and soil moisture storage. Changes in total seasonal precipitation or in its pattern of variability are both important. The occurrence of moisture stress during flowering, pollination and grain filling is harmful to most crops. Increased evaporation from the soil and accelerated

transpiration in the plants themselves will cause moisture stress and as a result there will be need to develop crop varieties with greater drought tolerance (Enger and Smith, 2006)

The demand for water for irrigation is projected to rise in a warmer climate, bringing increased competition between agriculture- already the largest consumer of water resources in semi arid regions- and urban as well as industrial users. Falling water tables and the resulting increase in the energy needed to pump water will make the practice of irrigation more expensive (Enger and Smith, 2006)

Higher temperatures are likely to be experienced in the soil, where warmer conditions are likely to speed the natural decomposition of organic matter and to increase the rates of other soil processes that affect fertility. Additional application of fertilizers may be needed to counteract these processes and to take advantage of the potential for enhanced crop growth that can result from increased atmospheric carbon dioxide. This can come at the cost of environmental risk, for additional use of chemicals may impact water and air quality. (Bernard and Richard, 1998)

Nitrogen is made available to plants in a biologically usable form through the action of bacteria in the soil. This process of nitrogen fixation, associated with greater root development, is also predicted to increase in warmer conditions and with higher CO2, if soil moisture is not limiting. Where they occur, drier soil conditions will suppress both root growth and decomposition of organic matter, and will increase vulnerability to wind erosion, especially if winds intensify (Bernard and Richard, 1998)

Conditions are more favorable for the proliferation of insect pests in warmer climates. Longer growing seasons will enable insects such as grasshoppers to complete a great number of reproductive cycles, thus causing greater infestation during the following crop season. Altered wind patterns may change the spread of both wind borne pests and of the bacteria and fungi that are the agents of crop diseases. Crop-pest interactions may shift as the timing of development stages in both hosts and pests is altered

(Tyler G Miller, 2000)

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of the study area.

Kisumu District is an administrative District of Nyanza Province in western Kenya. It has a population of 504, 359 as of 1999 population census by the Kenya National Beaureau of Statistics and has a land area of 912 square kilometers. (MOA 2008) The main industries are subsistence agriculture and fisheries on Lake Victoria. It falls within the coordinates of 0 55," south and 34 55" east. The main type of soils are ferrasols and its fertility ranges from moderate to low with most soils being unable to produce without the use of either organic or inorganic or in most cases both types of fertilizers (MOA,2008)

It experiences a bimodal type of rainfall and the rainfall ranges between 800mm and 2000mm per annum. The short rains occur between August and November while the long rains occur between March and May. Temperatures vary with altitude too. The minimum temperature is 15 Celsius while the mean maximum temperature is 36 Celsius (according to the meteorological department, MOA) Humidity is relatively high with mean evaporation between 1800mm to 2000mm per annum. Most of the areas have underlying murram with poor moisture retention (MOA, 2008)

3.2 Research Design

The research was both a descriptive and empirical type of research. This is because it aimed at getting facts of existing phenomena (climate change) and at the same time it aims at obtaining data based on evidence. It based itself on actual facts which helped in drawing conclusions.

The research used both primary and secondary methods of data collection. Secondary data was obtained from the past literature such as books, magazines and journals. Primary data was to be collected using questionnaires, observations and interviews where necessary, to create an array of balanced opinions and to avoid biased interpretation that would not serve the purpose of the study.

3.3 Sampling Design

There was use of random sampling, use of questionnaires; observations as well as interviews so as to cover a broad section of the target population (farmers and extension officers) preference was given to climate change and its effects.

3.4 Data collection methods and procedures

3.4.1 Questionnaires

Questionnaires were used because this provided for the respondents a chance to objectively give their opinions and it also enabled data to be collected in a wide area. The questionnaire enabled the respondents give information at their own time of convenience which reduced bias and incomplete responses attributed to lack of time and being timid in the presence of the researcher.

3.4.2 Interviews

The research used face to face interviews which provided first-hand experience and personal contact with the interviewees. Interviews also provided high capability for facial validation which was instrumental in gaining insight into the reasons for certain responses from participants. It included verbal discussion with the target farmers, extentionists and any other group of people who could provide relevant information on climate change and its effects in agriculture production.

3.4.3 Observations

Observations were used because this provided a chance to validate responses from the respondents with what is actually on the ground, on a first-hand basis. The researcher also participated on the day to day activities including the observation in the crop fields to be able to see what was visible in the field and the effects of climate change.

3.5 Data Analysis Techniques

Data was sorted and coded manually and qualitative data analysis techniques were used where necessary. Data collected was effectively and efficiently examined, verified and edited for the purpose of satisfying the evidence for answering the research questions. The data collected provided the researcher with evidence in order to obtain answers to the research questions and come up with a concrete and reasonable conclusion on the effects of climate change on agricultural production.

3.6 Limitations of the study

The area under study was too wide for the scheduled time of study (research). This meant that extra effort as well as personnel was needed to be able to complete the work within the short time frame.

The respondents included local farmers who do not understand English language. This, therefore, require extra time for interpretation of the languages from either English to Luo or vice versa.

There are numerous costs that were incurred in this research. They included paying other assistants to help in gathering information, meeting travel expenses, the cost of producing the final research report, among others.

CHAPTER FOUR

4.0 FINDINGS AND DISCUSSIONS.

4.1 INTRODUCTION

Agriculture is highly sensitive to climate variability and weather extremes, such as droughts, floods and severe storms. The forces that shape our climate are also critical to farm productivity. Human activity has already changed the atmospheric characteristics such as temperature, rainfall, levels of carbon dioxide (CO2) and ground level ozone. The scientific community expects such trends to continue. While food production may benefit from a warmer climate, the increased potentials for droughts, floods and heat waves will pose challenges for farmers. Additionally, the enduring changes in climate, water supply and soil moisture could make it less feasible to continue crop production in certain regions.

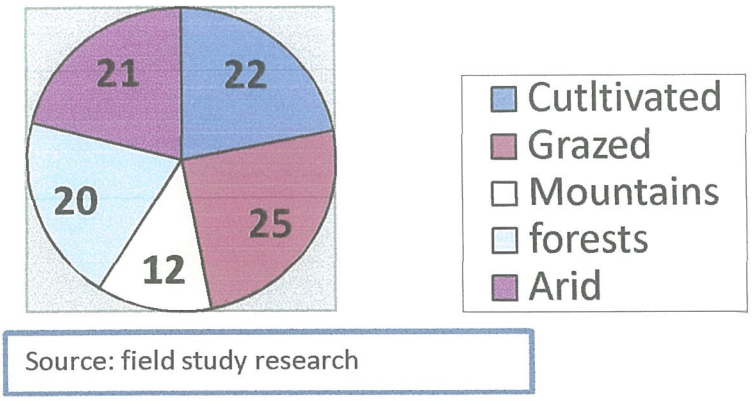


Fig 1: Land Distribution and Activities in Kisumu District

The research showed that 25% of the land is used for rangeland purposes, 22% for cultivation, 21% is under arid areas, 12 % under mountains and 20% is covered by forests which are continuously being encroached into.

It is only the area under cultivation that was majorly used for crop production that feeds the people of Kisumu District.

Table 1 shows the global temperature variations which have affected all parts of the world including Kisumu District and its eventual effects on world agriculture production. This table shows how climate

has been changing for the 100 years. From this, it can be observed that the world temperature has been steadily rising increasing the heat stress otherwise known as global warming. This has negatively affected agriculture production in Kisumu district.

4.2 TABLE 1, Global temperature variations

year	1868	1880	1900	1920	1940	1960	1980	2000
temperature	-0.5	-0.4	-0.2	-0.3	0	-0.1	0.1	0.4

Source: field study research

This has increased frequency of heat stress, droughts and floods negatively affect crop yields and livestock beyond the impacts of mean climate change, creating the possibility for surprises, with impacts that are larger, and occurring earlier, than predicted using changes in mean variables alone. This is especially the case for subsistence sectors especially in Kisumu district. Climate variability and change has also caused the risks of fires, pests and pathogen outbreak, negatively affecting food production as can be vividly seen in Fig 6.

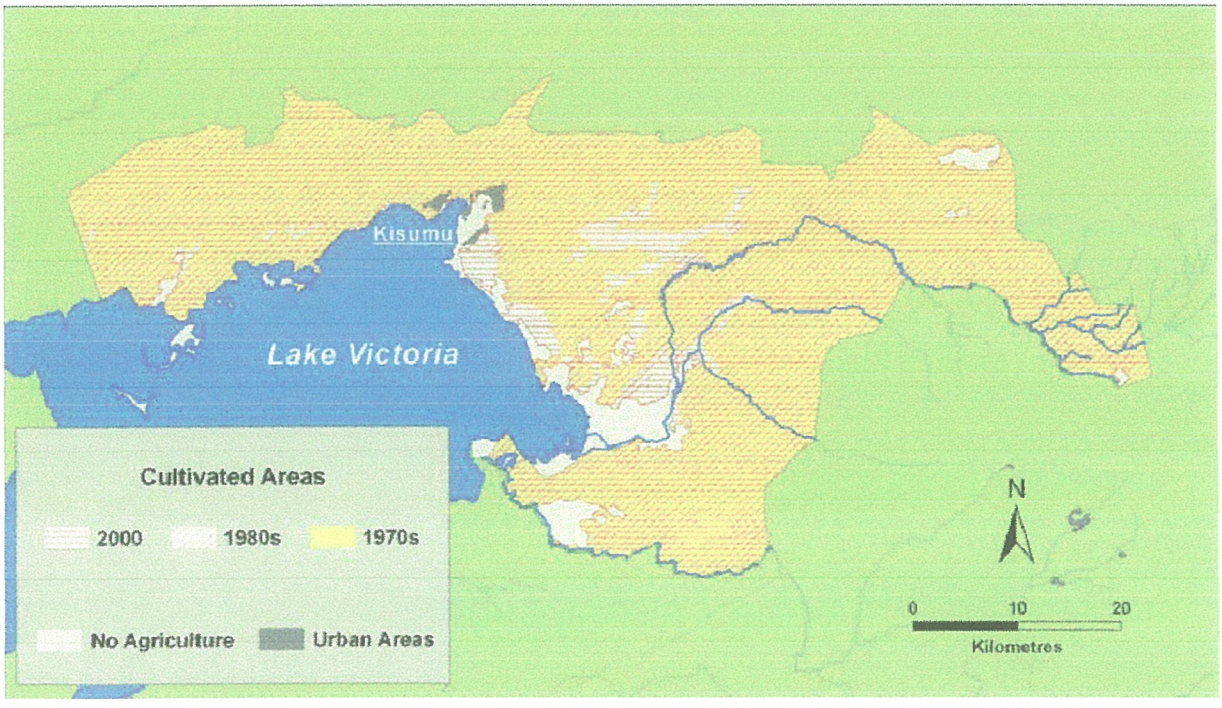


Fig 2: A map of Kisumu district showing cultivated areas between 1970s and 2000

4.2.1 Relationship between climate change and agriculture production

From the study, several factors directly connected climate change and agricultural productivity. The climatic factors included the following:

- Average temperature increase
- Change in rainfall amount and patterns
- Rising atmospheric concentrations of CO2
- Pollution levels such as troposphere ozone
- Change in climatic variability and extreme events

The above factors were later tabulated and the following results were obtained:

	1970	1980	1990	2000	2010
Rainfall amount(mm)	1400	1350	1300	1200	1100
Atmospheric CO2(PPM)	318	325	338	355	370
Pollution levels(PPM)	400	430	441	449	460

Fig 3: climatic factors affecting agricultural production

The agricultural impact study considered the effects of one or two aspects of climate change on particular farming activities, such as corn production among others and the results can be observed in fig 5. Other studies, however, have considered the full set of anticipated shifts and their impact on general agricultural production.

Average temperature: The research indicated that an increase in average temperature lengthened the growing season in regions with a relatively cool spring and fall, like in Kisii areas (south Kisumu) and adversely affected crops in regions where summer heat already limits production, increase soil evaporation rates and increase the chances of severe droughts. This was very evident in the production period of tea grown in this area that has increased from eight to twelve months before the first harvest can be made. This has also been observed of late in the shows of Lake Victoria, which has been greatly affected by prolonged period of production of crops such as sugarcane and rice.

Change in rainfall amount and patterns: the study indicated that changes in rainfall have affected soil erosion rates and soil moisture, both of which are important for crop yields. This has led to precipitation increase, and decrease in most crop outputs, still as observed in table 3. While regional precipitations vary, the numbers of extreme precipitation events have been witnessed in Kisumu north District according to the interviews carried out.

Year	1960	1970	1980	1990	2000	2010
CO2 concentration in PPM	318	325	338	355	370	385

PPM-parts per million

Fig 4: CO2 concentration in Parts per Million

Rising atmospheric concentrations of CO2:The results of the research according to Fig 4 indicated increasing atmospheric CO2 levels, driven by emissions from human activities, such as charcoal burning, bush burnings and even the few industries around Kisumu area, has enhanced the retardation in growth of some crops such as rice and Soya beans. CO2 can be one of a number of limiting factors that, when increased, can enhance this. Other limiting factors included water and nutrient availability.

Pollution levels such as tropospheric ozone: higher ground level ozone limits the growth of crops. Since ozone levels in the lower atmosphere are shaped by both emissions and temperature, climate change was identified to most likely increase ozone concentrations. Such changes have hindered any beneficial yield effects that result from elevated CO2 levels.

Change in climate variability and extreme events: changes in the frequency and severity of heat waves, drought and floods have remained key uncertainties in future climate change. Such changes are anticipated to have potential effects on agriculture. For example, according to the study, the planting season of most cereals, that is, maize, millet and others, is gradually shifting from the month of February to late March, due to very unpredictable rainfall patterns.

4.3 Potential impacts of Climate Change on agriculture production and food supply.

The research found out that Global warming and climate change have several environmental effects that have lead to many socio-economic changes such as poverty and food insecurity. The general increase in temperature is a threat to many living organisms and thus has negatively affected the environment and tourism industry, since most areas that acted as tourist sites are now drying up while others are being cut down o provide either settlements or farming land. A good example was the Lambwe valley in the south of Kisumu.

It seems so obvious that any significant change in climate, on a global scale, impact local agriculture, and therefore affect the world's food supply. The study considered just how farming might be affected in

different regions of Kisumu district, and by how much; and whether the net result may be harmful or beneficial, and to whom. This was found to be very true since grain production has considerably gone down, people are continuously becoming poor, food insecurity going up and peoples living standards going down.

Several uncertainties limited the accuracy of current projections. One related to the degree of the temperature increase and its geographic distribution. Another pertained to the concomitant changes likely to occur in the precipitation patterns that determine the water supply of crops, and to the evaporate demand imposed on crops by the warmer climate. There was a further uncertainty regarding the physiological response of crops to enriched carbon dioxide in the atmosphere. The problem of predicting the future course of agriculture in a changing world was compounded by the fundamental complexity of natural agricultural systems, and of the socio-economic systems governing food supply and demand. This was reflected on by the two diagrams below that showed both total world grain production against the grain production per capita in Kisumu district.

year	**1950**	**1960**	**1970**	**1980**	**1990**	**2000**	**2010**
grain production (in tones)	600	900	1000	1400	1500	1400	1200

Fig 5: Total world grain production of corn

year	**1950**	**1960**	**1970**	**1980**	**1990**	**2000**	**2010**
Per capita production (kgs/person)	240	280	300	330	300	280	250

Source: field study research

Fig 6: Grain production per capita in Kisumu district

The research found out that Climate change presents crop production with prospects for both benefits and drawbacks. To address any of them more clearly we first defined the main interactions that linked a chain of processes together: Food is derived from crops (or from animals that consume crops); crops in turn grow in fields, which exists in farms, which are components of farming communities, which are sectors in nation states, and which ultimately take part in the international food trade system. Understanding the potential impacts of global environmental change on this sequence of interlocking elements was a first step in determining what will happen when anyone of them was changed as a result of possible global warming, and a prerequisite for defining appropriate societal responses. Three main enterprises were put into consideration for this study and the results were as shown in the diagram below:

Enterprises	**Current Production level hectarage & per unit area**		**Potential production hectarage & per unit**		**Remarks**
	Hactarage	Prod./Ha	Ha	Prod./Ha	
Maize	5850	100bags/ha	9000	25 bags	Destroyed by drought
Sorghum	5500	8 bags/ha	6000	18 bags	Destroyed by drought
Finger millet	31	3 bags/ha	100	6 bags	Destroyed by drought

In summary, I looked at the possible biophysical responses of agro-ecosystems to the specific environmental changes that were anticipated as a result of the build up of global green house gases, and then at the range of adaptive actions that might have been taken to ameliorate their effects. The results then indicated that heat stress which eventually turned to drought highly destroyed corn production in Kisumu.

4.4 Anticipated responses of agro-ecosystems

Agriculture of any kind is strongly influenced by the availability of water. Climate change was identified to modify rainfall, evaporation, runoff, and soil moisture storage. Changes in total seasonal precipitation or in its pattern of variability are both important. The occurrence of moisture stress during flowering, pollination, and grain-filling was harmful to most crops and particularly so to corn, soybeans and other crops. Increased evaporation from the soil and accelerated transpiration in the plants themselves caused moisture stress; as a result there was a need to develop crop varieties within greater drought tolerance, which I gave as one of the recommendations.

The demand for water for irrigation especially from areas away from the lake Victoria, such as North Kisumu district, was projected to rise in a warmer climate, bringing increased competition between

agriculture- already the largest consumer of water resources in semi-arid regions- and urban as well as industrial users. Falling water tables, and the resulting increase in the energy needed to pump water was making the practice of irrigation more expensive, particularly when with drier conditions more water was required per acre. This meant that additional investments for dams, reservoirs, canals, wells, pumps, and piping were needed to develop irrigation networks in these locations that are far from the lake for irrigation purposes.
Finally, the study identified that intensified evaporation was increasing the hazard of salt accumulation in the soil. This greatly led to acidity of some soils in Kisumu district which has in turn led to poor crop production.

Extreme meteorological events, such as spells of high temperature, heavy storms, or droughts, in Kisumu District disrupted crop production. The study considered possible changes in the variability as well as in the mean values of climatic variables. Where certain varieties of crops (such as maize, millet among others) were grown near their limits of maximum temperature tolerance, such as sugarcane in central Kisumu, heat spells were particularly detrimental. Similarly, frequent droughts not only reduced water supplies but also increased the amount of water needed of plant transpiration.

Higher air temperatures would also be felt in the soil, where warmer conditions were likely to speed the natural decomposition of organic matter and increased the rates of other soil processes that affected fertility.
Additional application of fertilizer was needed to counteract these processes and to take advantage of the potential for enhanced crop growth that could result from increased atmospheric CO_2.This came and the costs of Environmental risk, for additional use of chemicals impacted water and air quality. The continual cycling of plant nutrients- carbon, nitrogen, phosphorus, potassium, and sulphur- in the soil- plant-atmosphere system also accelerated in warmer conditions, enhancing CO_2 and N_2O. Green gas emissions.

Nitrogen is made available to plants in a biological usable form through action of bacteria in the soil, eg use of organic fertilizers. This process of ***Nitrogen fixation,*** associated with greater root development, was also predicted to increase in warmer conditions and with higher CO_2, if soil moisture was not limiting. Where they occurred, drier soil conditions suppressed both root growth and decomposition of organic matter and increased vulnerability to wind erosion, especially if winds intensified. An expected increase in convictive rainfall- caused by stronger gradients of temperature and pressure and more atmospheric

moisture- resulted in heavier rainfall when and where it does not always occur. Such "extreme precipitation events" caused increased soil erosion.

From the study carried out, conditions were more favorable for the proliferation of insect pest in warmer climates. Longer growing seasons enabled insects such as grasshoppers to complete a great number of reproductive cycles during the warmer climates. This has meant massive attack on crop produce by these pests in Kisumu District that has caused great loses to farmers in this area. Altered wind patterns also changed the spread of both wind borne pests and of the bacteria and the fungi that are the agents of crop disease. Crop pest interactions shifted as the timing of development stages in both hosts and pests altered. Livestock diseases were similarly affected. The possible increases in pest infestations were about greater use of chemical pesticides to control them, a situation that required the further development and application of integrated pest management techniques.

4.4.1 Adaptation modes applied

In Kisumu district, a wide variety of adaptive actions were taken to lessen or overcome adverse effects of climate change on agriculture. At the level of farms, adjustments included the introduction of later – maturing crop varieties or species, switching cropping sequences, sowing earlier, adjusting timing of field operations, conserving soil moisture through appropriate tillage methods, and improving irrigation efficiency. Some options such as switching crop varieties were inexpensive while others, such as introducing irrigation (especially high efficiency, water conserving technologies), involved major investments. Economic adjustments included shifts in regional production centers and adjustments of capital, labor, and land allocations. For example, trade adjustments helped to shift commodity production to regions where comparative advantage improved; in areas where comparative advantage declined labor and capital moved out of agriculture into more productive sectors.

A major adaptive response applied was the breeding of heat – and drought resistant crop varieties by utilizing genetic resources that may be better adapted to new climatic and atmospheric conditions. Collections of such genetic resources was maintained in KARI banks; these were screened to find sources of resistance to changing diseases and insects as well as tolerances to heat and water stress and better compatibility to new agricultural technologies. Crop varieties with a higher *harvest index* (the fraction of total plant matter that is marketable) helped to keep irrigated production efficient under conditions of reduced water supplies or enhanced demands. Genetic manipulation also helped to exploit the beneficial effects of CO_2 enhancement on crop growth and water use.

A recent study by the ministry of agriculture and other organizations in the same area, has emphasized the ability of local farming to adapt to changing conditions, since in the past technological improvements have indeed been developed and put into use when needed. The government has substantial agricultural research capabilities and a wide range of adaptation options that are currently available to farmers in the country. Some of them according to the study included use of high heat and pest resistant varieties, use of disease free seeds, used of chemicals as an integrated method among others, hence in so far as the government is concerned, prospects for agricultural adaptation to climate change appear favorable, assuming water is available.

Considerable investments were needed, however, to utilize soil and water resources more efficiently in a changed climate. Other countries, particularly in the tropics and semi-tropics are not so well provisioned with respect to both the research base and the availability of investment capital.

The potential for adaptation should not lead to complacency. Agricultural adaptation to climatic variation was never perfect, and changes in how farmers operated or in what they produced caused significant disruption for people in rural regions of Kisumu District. Indeed, some adaptive measures were detrimental impacts of their own. For example, where major shifts in crops were made, as from grain to fruit and vegetable production, farmers found themselves more exposed to marketing problems and credit crises brought on by higher capital and operating costs. The considerable social and economic costs that resulted from large scale climatic extremes were exemplified by the consequences of the Nyando river floods of 1993. Nyando is one of the major distributaries of Lake Victoria and is used for irrigation purposes.

While changes in planting schedules or in crop varieties were readily adopted, modifying the types of crops grown did not ensure equal levels of either food production or nutritional quality. Nor did it guarantee equal profits for farmers. Expanded irrigation led to ground water depletion, soil salinization and water logging. Increased demand for water by competing sectors limited the variability of irrigation as an adaptation to climatic change. Expansion of irrigation as a response to climatic change proved to be difficult and costly even under the best circumstances.

Mounting societal pressures to reduce environmental damage from agriculture would likely foster an increase in protective regulatory policies that could further complicate the process of adaptation. Hence, the government through the ministry of agriculture is taking time to implement these policies on the local farmers to ensure effectivity.

Present agricultural institutions and policies in Kenya tend to discourage farm management adaptation strategies, such as altering the mix of crops that are grown. At the policy level, obstacles to change are created by supporting prices of crops that are not well suited to a changing climate, by providing disaster payments when crops fail, and by restricting competition through import quotas. Programs have been modified to expand the flexibility allowed in crop mixes, to remove institutional barriers to the development of water markets, and to improve the basis for crop disaster payments.

Adaptation cannot be taken for granted: improvements in agriculture have always depended upon the investment that is made in agricultural research and infrastructure. It has helped to identify, through research, the specific ways that farmers now adapt to present variations in climate. Questions were asked whether farmers attempted to compensate for a less favorable climate by applying more fertilizer, more machinery or more labor to ensure increased productivity. The results indicated that farmers were adopting all the available options as use of fertilizers, use of both manual labor as well as use of machinery where applicable to help boost production as well as cope with the changing conditions.

4.4.2 Uncertainty, thresholds and surprises

Some farmers believed that climatic change would exert its influence so slowly- a fraction of a degree per decade- that the effects would be barely noticeable in the midst of other technological and economic changes. Others emphasized the need to study the potential for what are called "threshold effects"- i.e. the abrupt and disproportionate shifts in production that may be triggered when critical levels of certain factors are surpassed.

Unexpected consequences or "surprises" as well accompanied the build-up of greenhouse gases. Even if climate changed gradually, it was slowly affecting the range of options available for agriculture in any given region. Under changing climate conditions, farmers' past experience was a less reliable predictor of what is to come. These and other uncertainties were taken into account explicitly in climate change impact study.

4.4.3 Uncertainty

The uncertainty inherent in predictions was a very important feature of climate change. Impact studies and work had begun to develop explicit methods to deal with the concept. Earlier studies had often used "best estimate" scenarios that were based on the mid-points of the predicted range of expected change in temperature, precipitation, or other parameters. Including the entire range from the upper to the lower bounds of predicted effects was a more prudent and realistic approach, which clarified the way uncertainty, can propagate throughout a real system. The results indicated that KARI was doing well in

helping farmers work out the uncertainties by providing the alternatives mentioned earlier to help farmers cope with the changing climatic conditions.

Other uncertainties derived from the fast pace and unpredictable directions of future social, economic, political and technical changes. The world of the coming century will be different in many ways; unforeseeable development in other sectors could change the way in which agriculture responds in climate change. Questions regarding population (i.e. for how many people need the worlds' agricultural system provide?) and technological change (can productivity continue to improve?) are particularly relevant and should be explored with upper and lower bounds of possible projections.

4.4.4 Thresholds

Some effects, such as the flooding of a river or the withering of a crop, came into play only after certain limiting conditions or thresholds had been crossed. The identification of thresholds in climate change impact research involved analyzing the effects of different levels of climate forcing on an agro-ecosystem to identify the critical conditions under which the response of crops would abruptly change.
These critical levels involved either natural or socio-economic factors, and both were considered. For example, in the biophysical domain threshold temperatures were defined for many specific crop processes, notwithstanding the complexity of interactions among temperature, amount and duration of sunlight, nutrients, and water supply.

In socio-economic domain, defining critical levels of warming was even more challenging, due to the intricate interplay of supply, demand and prices and to the characteristic adaptability of agriculture as a managed human system. Here, determining critical levels of warning involved defining relative impacts on producers and consumers in diverse geographic and social groups.

4.4.5 Surprise

An even more challenging task was to estimate the probability of coincidental events that would happen in conjunction with the global warming, spanning the range between low probability catastrophic events (called "surprises") and higher probability gradual changes in climate and associated environmental effects. A seemingly small change in one variable- for example, rainfall-would trigger a major unsuspected change in another; for example, droughts or floods might possibly disrupt the transport of grains. Moreover, one "surprise" would then lead to another in a cascade, since biophysical and social systems are interconnected.

4.5 CAUSES OF GLOBAL WARMING AND CLIMATE CHANGE

Global warming is caused by among other factors increased industrial pollution, the clearing of forests or marshes to make way for farms, settlements and factories, burning of fossil fuels among other factors. Due to global warming, hotter temperatures have changed rainfall patterns, led to invasive insects and new diseases.

Global warming is as a result of both natural and human activities that produce greenhouse gases which accumulate in the atmosphere. These gases form a blanket-like layer which allows in-coming short wave light rays from the sun yet stops the long wave heat rays from escaping back to space. This process leads to increased temperatures in the atmosphere, a called global warming. It has occurred in the past, but scientific research predicts that it will increase as a result of increased emission of green house gases such as methane and carbon dioxide.

From the study, the following were identified to be the major causes of climate change, together with their effects as well as sources:

Water vapor

This was identified as the biggest contributor to the natural 'greenhouse effect' and varies the most in the atmosphere. Cold air can hold little water and so the atmosphere contained very little water vapor. In contrast, air over the tropics has been seen to be very humid and the atmosphere can contain up to 4% water vapor.

It's this 'positive feedback' that makes water vapor important in climate change as a small increase in global temperature would lead to a rise in global water vapor levels thus further enhancing the greenhouse effect. Human activities have little impact on the level of water vapor in the atmosphere.

Carbon Dioxide

Carbon dioxide is probably the most important of the greenhouse gases as it accounts for the largest portion of the 'trace gases' and is currently responsible for 60% 'enhanced greenhouse effect'. It's thought that it has been in the atmosphere for billion of the Earth's 4.6 billion year geological history and in much larger proportions (up to 80%) than today.

Most of the carbon dioxide was removed from the atmosphere as early organism's evolved photosynthesis. This locked away carbon dioxide as carbonate minerals, oil shale and coal, and petroleum in the Earth's crust when the organisms died. This left 0.03% in the atmosphere today.

Atmospheric Carbon dioxide comes from a number of natural sources, mainly the decay of plants, volcanic eruptions and waste product of animal respiration.

It's removed from the atmosphere through photosynthesis in plants and by dissolving in water, especially on the surfaces of the oceans. Carbon dioxide stays in the atmosphere for approximately 100 years.

The amount of carbon dioxide taken out of the atmosphere by plants is almost perfectly balanced with the amount put back into the atmosphere by respiration and decay. Small changes as a result of human activities can have a large impact on this delicate balance.

Burning fossil fuels releases carbon dioxide stored millions of years ago. We use fossil fuels to run vehicles (petrol, diesel and kerosene), heat homes, business and power factories. Deforestation releases the carbon stored in trees and also results into less carbon dioxide removed from the atmosphere.

The concentration of carbon dioxide in the atmosphere has increased more in the northern hemisphere where more fossil fuel burning occurs. Since the Industrial Revolution, the concentration globally has increased by about 40%.

Methane

The importance of methane in the greenhouse effect is its warming effect. Even though it occurs in lower concentrations than carbon dioxide, it produces 21 times as much warming as CO_2. Methane accounts for 20% of the 'enhanced greenhouse effect'.

Methane is generated naturally by bacteria that break down organic matter (in Westland's), it's in the guts of many termites and other animals (ruminants) and in natural gas deposits. Methane remains in the atmosphere for 11-12 years- less time than most other greenhouse gases.

At the present, about two thirds of global methane comes from man-made sources, such as the burning of fossil fuel, landfills, rice cultivation, manure, the accidental release during drilling for natural gas production and transmission or, from cattle ranching.

Since the Industrial Revolution, the level of Methane in the atmosphere has increased by about two and half times.

The rise in Methane started more recently than the rise in carbon dioxide, and the process of removal from the atmosphere is difficult to predict. However, without technological change further increases in concentration are inevitable.

Nitrous oxide

Nitrous oxide (N_2O) has increased by 15% during the last 200 years and is still rising. Sources of the gas include agriculture and burning of biomass; lesser quantities from fossil-fuel burning. N_2O is produced in agriculture via anaerobic de-nitrification processes, which wherever nitrogen (a major component of fertilizers) is highly available in soils. The build up of nitrous oxide is particularly unwelcome; because it's long residence time (114 years) makes the gas a problem in only the atmosphere, where it contributes to warming, but also the stratosphere, where it contributes to the destruction of ozone.

Ozone

Although ozone in the atmosphere is short lived, it is a potent greenhouse gas. Some ozone from the stratosphere (where it is formed) descends into the troposphere, but the greatest source is anthropogenic through the action of sunlight on pollutants. Estimates indicate that the concentration of ozone in the atmosphere has increased by 36% since 1750.

Major sources are automotive traffic and burning forests through deforestation and agricultural wastes.

CFC's and Other Halocarbons

Emissions of halocarbons are entirely anthropogenic. Like nitrous oxide, halocarbons are long lived and contribute to both global warming in the atmosphere and ozone destruction in the stratosphere. Used as refrigerants, solvents, and fire retardants, halocarbons have a much greater capacity (10,000 times) for absorbing infrared radiations than does CO_2.

The rate of production of chlorofluorocarbons (CFC's) has declined since Montreal Accord of 1987, and the concentration of CFC's in the atmosphere leveled off in the late 1990's and is now slowly declining. However these gases are highly stable and will continue to exert their warming effects for many decades.

Together the other anthropogenic GHG's are estimated to trap as much infrared radiation as CO_2 does. Although the troposphere concentrations of some of these gases are rising, it is hoped that they will gradually decline in importance because steps being taken to reduce their levels in the atmosphere, leaving CO_2 as the primary greenhouse gas to cope with in the future. They are summarized in the table below.

Periodic changes in sunlight intensity resulting from 'Milankovitch cycles' which include, the shape of the earth's orbit around the sun elongates and shortens in a 100,000year cycle, the axis of rotation changes its angle tit in a 400,000 year cycle, and over a 26,0000 year period, the axis wobbles like an out of balance spinning top.

Principal Greenhouse Gases

Greenhouse Gas	Pre-1750 concentration (ppm)	Current concentration (ppm)	Contribution to Global Warming	Principal Sources
Carbon Dioxide (CO_2)	280	373.1	60	• Burning of fossil fuels • Deforestation
Methane (CH_4)	0.688	1.73	20	• Produced by bacteria in wetlands, rice fields, and guts of livestock's. • Release of fossil fuels.
Chlorofluorocarbons (CFCs)	0	0.00088	14	• Release from foams, aerosols, refrigerants, and solvents.
Nitrous oxide (N_2O)	0.270	0.317	6	• Burning of fossil fuels • Fertilizers • Deforestation.

4.6 Global Climate Change

The intergovernmental panel on climate change (IPCC) was set up in 1988 to asses' information on climate change and its impact. Its Fourth Assessment Report predicted that global temperatures would rise from anything between 1.1°c to 6.4°c by the end of the century.

Although the issue of the changing climate is very complex and some changes are uncertain, temperatures rises are still expected to affect countries throughout the globe have a knock on effect with precipitation sea level rises.

The research concluded that we can say with high confidence (>90% probability) that the effect of human activities since 1750 has been to warm the planet earth. It also says that it is very likely (>90%) probability, that observed temperature increases since the middle of the twentieth century have been caused by the increase in manmade greenhouse gas concentrations.

The research believes that it is very likely that hot extremes, heat waves, and heavy precipitation events would continue to become more frequent, by the second half of the 21st century.

New data represented by scientists at an international meeting at Copenhagen (March 2009) indicated that the best estimate of the Intergovernmental Panel on Climate Change, made only two years earlier, in relation to rise in water levels was woefully out of date as seen as far conservative.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSION

By the year 2025, 83 per cent of the expected global population of 8.5 billion will be living in developing countries, Kenya being one of them. Yet the capacity of available resources and technologies to satisfy the demands of this growing population for food and other agricultural commodities remains uncertain. Agriculture has to meet this challenge, mainly by increasing production on land already in and by avoiding further encroachment on land that is only suitable for cultivation.

Major adjustments are needed in agricultural and environment policy, both national and international levels, in developed as well as developing countries, to create the conditions for Sustainable Agriculture and Rural Development (SARD). The major objective of SARD is to increase food production in a sustainable way and enhance food security. This will involve education initiatives, utilization of economic incentives, utilization of economic incentives and the development of appropriate and new technologies, thus ensuring stable supplies of nutritionally adequate food, access to those supplies by vulnerable groups and production for markets; employment and income generation to alleviate poverty and natural resource management and environmental protection.

The priority must be on maintaining and improving the capacity of the higher potential agricultural lands to support an expanding population. However, conserving and rehabilitating the natural resources on lower potential lands in order to maintain sustainable man/land ratios is also necessary. The main tools of SARD are policy and agrarian reform, participation, income diversification, land conservation and improved management of inputs.

The study found out that climate change has been very influential in as far as agricultural production is concerned. Since development goes hand in hand with agriculture production, special emphasis should be put on sustainable development in order to strike a balance between what is within the carrying capacity of the limited and finite natural resources and what is not. Development has to safeguard environmental quality since it is the basis of all human life.

5.2 Recommendations

Measures to reduce climate change

There are a range of measures to reduce climate change effects but its always better to prevent it from occurring. In developed countries, mechanical measures such as cloud seeding (artificial rain formation) have been tried out but the climate has not yet gone back to its original state.

Planting trees is one of the major keys to climate regulation in Kisumu District. Trees act as natural sinks for the excess greenhouse gases. In addition trees also modify climate as they enable the hydrological cycle to function through evapo-transpiration. It is through this function of water cycle maintenance that trees protect the watersheds.

Subsistence and commercial farmers can regulate the poor agricultural practices such as bush burning which does not only clear land leaving it exposed to agents of soil erosion, distraction of organisms, but also pollute the air.

Energy saving or cleaner energy technologies can be promoted to save our forest resources from being depleted in the name of wood fuel and charcoal.

Proper urban development, waste management, water catchments protection and protection of fragile ecosystems such as wetlands from encroachers are other measures that can minimize the effects of global warming. Therefore, I strongly recommend the following measures to help counter the problem of climate change, especially in the study area of Kisumu District;

- Place a worldwide cap on carbon dioxide emissions by limiting the use of fossil fuels in industry and transportation.
- Encourage the development of nuclear power, but only if cost effectiveness, reliability, spent fuel and high level waste issues are resolved.
- Accelerate international agreements to completely phase out CFCs.
- Stop the loss of tropical forests and encourage planting of trees over vast areas now suffering from deforestation.
- Make energy conservation rules much more stringent (tighten building codes to require more insulation, use energy-efficient lightning, and so forth) by the central government.
- Reduce the amount of fuels used in transportation by raising mileage standards, encouraging car pooling, stimulating mass transit in urban areas and imposing increasingly stiff carbon taxes on fuels. Invest in and deploy known renewable energy technologies: wind power, solar collectors, solar thermal, geothermal among others.

- Adoption of greener technologies in terms of nuclear energy generation should be encouraged.
- Conventions such as the Kyoto Protocol and other specific statutes dealing with environmental protection should be made legally binding to all signatory states.
- Alternative economic models and options for economic development in developing countries should be adopted in order to avoid the precedent destroy, develop and then mitigate approach currently used.
- The Environmental Impact Assessment process should be fully implemented by governments without whenever industries are being built up.
- Full implementation of environmental law statutes should be practiced by all common sharing resource areas such as Kisumu District.
- Develop disease, pest and heat resistant varieties for areas such as kisumu to ensure constant food production as well as improve the production level.
- Sustainable development should be the pillar of all human concerns and activities.

APPENDIX A

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APPENDIX B

TIME SCHEDULE OF ACTIVITIES

ACTIVITY	PERIOD	OUTPUT
Proposal writing	18/01/2010	Proposal submission for approval
Field customization	Jan 2010	Initial information collection
Developing instruments	Feb 2010	Developing of instruments
Data collection	Feb 2010	Coding and entering of data
Data analysis	March-April 2010	Analyzing and interpretation of data
Preparation of report	May 2010	Submission of dissertation

APPENDIX C

Questionnaire's on assessment of effects of climate change on agricultural production. A case study of Kisumu District.

QUESTIONNAIRE FOR EXTENTION OFFICERS.

Dear Respondent

Ref: Collection of survey data

I am a student of KAMAPLA INTERNATIONAL UNIVERSITY carrying a study on the above topic. You are kindly requested to answer the following questions by providing the most relevant information and to the best of your knowledge on the issues sought by the questions below. The information being sought is purely for academic reasons and will be treated with utmost confidentiality.

Section A

Instructions: tick the appropriate answer

1. Tick your appropriate gender

Male ☐

Female ☐

2. Indicate your education level

Secondary education ☐

College education ☐

University education ☐

3. Which organization do you work for/with?

Please state.[ ]

4. How long have you worked for the organization?

Below-2 years ☐

2 -5 years ☐

Above 5 years ☐

5. Indicate your position in this organization

Managing director ☐

Manager ☐

Supervisor ☐

Field officer ☐

Others (specify).....

6. Which department do you belong to?

Crop department ☐

Animal department ☐

Planning department ☐

Financial department ☐

Others (specify).....

SECTION B

7. What do you understand from the term climate change?

Please explain briefly.....

8. Does it affect your working area?

Yes ☐

Please explain.....

No ☐

Please explain.....

9. What is the relationship between climate change and agriculture production?

Positive ☐

Negative ☐

No relationship ☐

10. What is the state of climate change currently?

Very high ☐

High ☐

Moderate ☐

Very low ☐

Give your own opinions on climate change;.....
.....
.....

THANK YOU FOR YOUR CO-OPERATION

FARMERS QUESTIONAIRE

Dear Respondent

Ref: Collection of survey data

I am a student of KAMAPLA INTERNATIONAL UNIVERSITY carrying a study on the above topic. You are kindly requested to answer the following questions by providing the most relevant information and to the best of your knowledge on the issues sought by the questions below. The information being sought is purely for academic reasons and will be treated with utmost confidentiality.

TICK WHERE APPROPRIATE

1) Gender: MALE ( ) FEMALE ( )

2) EDUCATIONAL LEVEL:

SECONDARY LEVEL ( )

UNIVERSITY LEVEL ( )

OTHERS (specify).....

3) What do you do to earn a living?

Agriculture.....

Fishing.....

Others (specify).....

PART TWO: Impact of climate change on agriculture production.

4) Do you understand what climate change is and its effects?

YES [ ]

NO [ ]

5) How do you think it has affected agricultural production?

Please explain briefly.

6) For how long have you noticed the changes in agriculture production?

Please specify years or months. [ ]

7) Do you receive any assistance from any organizations to tackle the problem?

Yes [ ]

No [ ]

Please specify the organization if any.....

THANK YOU

APPENDIX D

BUDGET ESTIMATIONS

NO.	ACTIVITY	COSTS	
		US Dollars	USHs
1.	STATIONARY	30	60,000
2.	TYPING AND PRINTING	18	35,500
3.	TRANSPORT	25	50,000
4.	MEALS	25	50,000
5.	PHOTOCOPY	8	15,000
6.	INTERNET AND AIRTIME	23	45,000
7.	MISCELLANEOUS	38	75,000
TOTAL		167	330,500