RELATIONSHIP BETWEEN FARMERS PERCEPTION ON CLIMATE CHANGE AND COWPEA (*VIGNA UNGUICULATA*) IN MWANIA WATERSHED, MACHAKOS COUNTY, KENYA

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2015

Relationship between farmers perception on climate change and cowpea (*vigna unguiculata*) in Mwania watershed, Machakos County, Kenya

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Research project submitted in partial fulfillment of the requirements for the award of Masters Degree In Research Methods, Department Of Horticulture, Faculty Of Agriculture, Jomo Kenyatta University of Agriculture And Technology

2015

DECLARATION

I hereby declare that this research project is my original work and has not been submitted to any academic institution for credit.

Signed…………………………………Date……………………………__

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This project is submitted with our approval as university appointed supervisors

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DEDICATION

I dedicate this work to my son Chester Kipchumba, dear husband Sammy, dad Kigen, mum Ann, Aunty, Hellen, brothers and sisters , Kiprop, Tanui, Chumba, Kurui, Ruto, Jerop and Jemu for their support, and patience for their outstanding faith in me and their encouragement which obviously then made this course possible.

ACKNOWLEDGEMENTS

Gratitude goes to my Supervisors Dr. Edward Mamati and Dr. Edward Bikketi for their guidance, and assistance in ensuring that this project comes to completion.

Special thanks go to Kenya Agricultural and Livestock Research Organization (KALRO) for allowing me the data.

I would like equally to thank Dr. Murenga, Dr. Lelei, Dr. Esilaba, Dr. Kizito, Mr. Ruto, Mr. Wafula and Mr. Thunanira for their continuous guidance and constant ideas.

My gratitude also goes to my dad, mum, grandma, aunty, brothers and sisters for their prayers and moral support in one way or the other during the study. Overall I would like to thank the Almighty lord who has provided all the resources and a conducive atmosphere in the course of my studies. May his name be honored and glorified forever.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

LIST OF ABBREVIATIONS AND ACRONYMS

ASAL	Arid and Semi-arid Lands
DFID	Department for International Development
FAO	Food and Agriculture Organization
GDP	Gross domestic product
GOK	Government of Kenya
IPCC	International panel on climate change
KALRO	Kenya Agricultural and Livestock Research Organization
SSA	Sub-Saharan Africa (SSA),
UNEP	United Nations Environmental programme

LIST OF FIGURES

ABSTRACT

Smallholder agricultural production in Kenya is largely dependent on climatic factors, and thus, climate change and variability will continue to have significant impacts on national food production. As is evident this is already presenting a major challenge for resource-poor farmers depending mainly on rain-fed agriculture especially in the Arid and Semi-arid Lands (ASAL). This study sought to contribute to climate change and crop production research in the dry lands by investigating the effects of various climatic factors on the cultivation of cowpea in Mwania watershed. A descriptive research design was adopted. Data on climatic parameters as well as the cowpeas production were obtained from Kenya Agricultural and Livestock Research Organization (KALRO). Data obtained were examined using descriptive and inferential statistics. The results revealed that 95.45% of the sampled farmers indicated that the purposes of cultivating cowpeas were for household food security while 4.55% of the respondents grew the crop as a source of income. The farmers' perception of climate change and effects on cowpeas production in the region were analysed. 60.38% of the respondents observed that the amount of rainfall received had reduced, and another 60.38% noted that the temperatures had increased and that it was much hotter while 11.32% reported new incidences of pests and diseases while 83.02% agreed that the rate of pests and diseases rates had increased. The regression results revealed that cowpeas production and rainfall had a positive and significant relationship while it was also established that a negative correlation existed between temperature and cowpeas yields. Further, the results showed a negative correlation between cowpeas yields and pest and diseases. The study recommends that farmers should prepare for variations in rainfall by harvesting rainwater into tanks, thus ensuring that they have a substantial amount of water stored up to be in a better position to mitigate the effects of rainfall variations. It also recommends that agricultural research institutions should develop drought resistant cowpeas as this would help curb the reduction of yields because of changes in rainfall amounts. It further also recommends that cowpeas varieties that are resistant to extreme temperatures and varieties that are resistant to pest and diseases attack should be developed as this will help avert the adverse impacts of climatic factors as well as the negative effects pest and diseases have on cowpeas yields.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Sub-Saharan Africa (SSA), a region that had been identified by researchers as particularly vulnerable to the consequences of global climate change by mid-1990s is already experiencing the climate change phenomena (IPCC, 2001). Extreme weather variability associated with climate change is affecting water supplies and food production in many countries. Agricultural production is predominantly rain-fed and hence fundamentally dependent on the vagaries of weather (Slingo et al., 2005). Climate change is also disrupting economic steadiness by affecting the supply and demand balance of agricultural commodities, profitability, trade and prices of products (World Bank, 2011; IPCC, 2007; DFID, 2004; Mendelsohn et al., 2001). There is a general concern that climate variation is expected to present more personalities more regularly and for extended periods of threats to their food security and livelihoods arising from extreme weather events (IPCC, 2007). This is owed to the fact that a large percentage of the population in SSA is heavily reliant on agriculture as the primary source of food and income (Thompson et al., 2010; IFPRI, 2007). Projections indicate that crop yields in SSA will decline by 10-50% by 2050 due to warming and drying occasioned by climate change (Nhemachena, 2009; Thornton et al., 2009; Kurukulasuriya et al., 2006; Jones and Thornton, 2003; Scholes and Biggs, 2004). Smallholder farmers in SSA are particularly vulnerable to climate change owing to widespread poverty and weak economic and technological development that limits their adaptive capacities (Shah et al., 2008). More households are likely to be trapped in chronic poverty and chronic food insecurity because of climate change impacts on agricultural production (Barrett, 2010; Barnett et al., 2008).

Agriculture is of great importance to most Sub-Saharan African economies, supporting between 70 and 80 percent of employment and providing an average of 30 percent of gross domestic product (GDP) and at least 40 percent of export (Commission for Africa, 2005). In Kenya, over 80% of the populations, especially living in rural areas, derive their livelihoods mainly from agricultural related activities, and 75 percent of its population earns its living from rainfed agriculture. (UNEP and GOK, 2010). Due to these causes, the Government of Kenya (GoK) has continued to give agriculture a high priority as a valuable tool for promoting national development. The production of the farming sector is defined by crop product, which depends on a great number of circumstances. Most notable is the endowment of the nation regarding soils and climatic factors, for example, rainfall, temperature and incidences of pests and diseases. Kenya has a diverse environment, and ecological heights with altitude ranging from sea level to above 5000 mm in the highlands and the mean annually rain range from smaller than 250 mm in ASAL to 2000 mm in great potential areas (Kabubo & Karanja, 2007).

The declining farming productivity in the country is alarming and a true challenge to a jurisdiction with a community of nearly 40 million to support. Worse still is the anticipated adverse influence of global warming on cultivation in the future. Weather change shows a significant warning to farming crop production ventures of cereals and pulses in the semi-arid areas that will continue to be more vulnerable to climate change (Ayanwuyi, Kuponiyi, Ogunlade & Oyetoro, 2010).

The spectre of climate change, together with other global environmental changes such as water unavailability, reduced land cover, altered nitrogen availability and cycling that are all strongly influenced by human activities, has increased concerns about achieving food and nutrition security, especially among the poor people (Gregory et al., 2005). In recent times, there have been interests in the debate about agricultural production and global demand to feed the rising population and changing dietary preferences (Tilman et al. 2001). Population increase is expected to degrade further the environment both through a further destruction of native vegetation and intensification of agriculture, thereby destabilizing the food system upon which food security is based (Tilman, 2001).

1.1.1 Cow pea Production

Cowpea bean also known as ‘macassar’ bean or ‘rope’ bean, is one of the dryland legumes grown in Kenya. This plant is grown worldwide with an estimated cultivation area of about 12.5 million hectares yearly and an annual global production of over 3 million metric tons (Egho, 2011). Cowpea drought tolerance, moderately early maturity and nitrogen fixation characteristics fit very well to the tropical soils where moisture and low soil fertility is the major limiting factor in crop production (Hall, 2004). An ideal temperature range for cowpea bean cultivation is from 20 to 30 ◦C, and rainfall requirements are small, about 300mm annually. However, high temperatures and water deficiency during the flowering stage lead to a reduction in grain yield and an increase in respiration, reducing the net photosynthesis. Mean yield of this crop in rain-fed systems ranges from 300 - 700 kg/ha.

Cowpea or the (Vigna unguiculata (L) Walp) is one of the extremely valued species of African legumes (Keller, 2004). It is an ideal food plant, and its application as a green vegetable is necessary in many African nations, for example, Kenya, Tanzania and Nigeria. Its ability to withstand drought, short growing periods and multi-purpose use make the crop a very attractive choice for farmers in marginal, drought-prone regions with low precipitation and less advanced irrigation methods (Hallensleben et al., 2009). In many areas, cowpea has been produced largely for its protein-rich grains, popularly eaten with cereal foods. The cultivation of cowpea as a leafy vegetable, however, seems to have increased markedly in many fields in recent years as farmers shift to more drought tolerant vegetable crops in light of renewed droughts facing many parts of Africa (Saidi et al., 2007)

Cowpea is a valuable crop, providing food and feed for households and livestock and is an income-generating commodity for farmers and traders, and is also used as a cover crop (Oyerinde, Chuwang & Oyerinde, 2013). But despite the quality of cowpea, its production is beset with limitations such as drought, flooding, salinity stress, extreme temperature all of which are expected to worsen with climate change (Alabi, Odebiyi and Jackai, 2003).

1.1.2 Cow Pea Growing in Kenya

Cowpea is widely grown by the resource-poor farmers in the semi-arid parts of Kenya for subsistence and income-generation (Macharia, 2004). Cowpea is intercropped with cereals such as maize and sorghum, perennial legumes such as pigeon peas and root crops such as cassava and sweet potatoes (GoK, 2002). Its grain is rich in protein and is a palatable carbohydrate with an energy content which is nearly equal to that of cereals such as wheat, rice, barley, sorghum, among others (Mukhtar & Singh, 2004).Cowpea is tolerant to drought and nutrient-deficient soils. It also stays greener than other crops when water-stressed, and has the ability to continue to photosynthesize during droughts hence the crop of choice to fight nutritional and food insecurity in the country (Jones et al., 2001).

The deep root systems of cowpea help stabilize the soil structure and the canopy covers the ground thus preserving moisture. These traits are particularly important in the semi-arid regions, where moisture is at a premium and the soil is fragile and subject to wind erosion (Jones et al., 2001).

1.1.3 Effects of climate change on cowpea production

Critical factors that directly link climate change and agricultural productivity include, average temperature increase; change in rainfall amounts and patterns; rising atmospheric concentrations of CO2; pollution levels on the tropospheric ozone layer and climate variability/ change with the associated severe events such as drought and flooding (Semenov, 2009). Lobell, (2008) posits that higher temperature, water evaporation from the ground and delayed and irregular rainfall can have effects on cowpeas farming outputs at any stage from cultivation to final harvest. Similarly changing weather patterns and extreme weather events, such as floods or droughts, can have negative consequences for cowpeas production (Ziervogel et al., 2008; Tadross, et al., 2005).

Climate change has adverse effects on cowpea (Lobell, 2008) production such as triggering the increase in incidences and occurrences of pests and diseases, wilting, reduced seed formation and late emergence of seed respectively, retarded growth and late maturing of the crop (Semenov, 2009). The altered and unpredictable weather patterns can also increase crop vulnerability to pests, infections and the effects of extreme climate issues such as high heats, droughts and torrential rains (Alabi, Odebiyi & Jackai, 2003). Indeed, insect pests, a wide range of bacterial diseases, fungal and viral diseases are a further causative factor for yields losses experienced by cowpea growers (Gregory et al. 2005). Sequential extremes, such as drynesses followed by intense flooding rains, are catastrophic in themselves and are combined with ecological effects such as the expansion of the ranges of pathogens, diseases, and pests that affect human populations and cowpeas production (Rosenzweig, Iglesias, Yang, Epstein, & Chivian, 2001).

Erratic rainfall affects both plant community and flowering ability adversely, resulting in a tremendous reduction of grain yield and total biomass in general (Timko & Singh 2008). Temperature rise may shorten the period of the growing period for these crops and, in the absence of compensatory management responses, decrease yields (Porter & Gawith 1999) and change the area of agriculture by rendering unsuitable some currently farmed areas and suitable, others not currently cultivated.

1.2 Statement of the Problem

Cowpea production is a major component of smallholder farming in the semi-arid regions of Kenya as it forms the major staple food for most communities (BraimohVlek, 2006). According to Mukhtar and Singh (2004) the cowpea yields per unit of land have declined over the years. This decline partly attributed to climate change. Climate change further presents an additional burden, which for farmers as it translates into production risks associated with crop yields, due to the probability of extreme events, the uncertainty of the timing of field operations, and of investments in new technologies (Machiara, 2004). According to Nelson ,Resegrant Palazzo Gray…and Msangi, (2010) an increase in temperature of 1-2^{o}C could lead to a decrease in crop yields by 10-15 percent. Similarly changes in rainfall and persistent droughts in the ASALs will result in changes in the length of growing seasons (Gregory et al. 2005).

According to International Panel on Climate Change IPCC (2001) projections indicate that with the continuing trend in climate change and variability, the impacts on dry land agriculture especially legumes such as cowpea will be adversely affected in areas where many small holder farmers largely or totally rely on rain-fed agriculture and have few options (Alabi, Odebiyi & Jackai, 2003). The overall adverse weather events of projected climate change will likely include; severe socioeconomic impacts such as shortages of food, water, energy, as well as long-term food insecurity.

Several studies have been conducted to assess the impact of climate change on agriculture in developing countries (Gbetibouo & Hassan, 2005; Ayanwuyi & Akintonde, 2012; Agbola & Ojeleye, 2007; Kabubo & Karanja 2007). However, the focus of this study has largely been on the impact of climate change on general food production and the mitigation measures that could be taken to address climate change. International Panel on Climate Change IPCC (2007) noted that the concern for the present and future climate aberrations, weather trends and their implications for agriculture continue to motivate scientists as well as public and policy-level interests regarding the analysis of climate change in relation to agricultural productivity. However, there is limited literature on the effect of climatic changes on dry land-based crops such as cowpeas production in Kenya. Hence this study seeks to investigate the effects of climate change parameters on cowpeas production in South Eastern ASAL's.

1.3 Objectives

1.3.1 Overall Research Objectives

To investigate farmers' perception on climate change parameters effects on cowpea production in Mwania watershed in Machakos County.

1.3.2 Specific Objectives

i. To determine the influence of Rainfall variability on cowpea production in Mwania watershed.

ii. To establish the effects of Temperature variability on cowpea production in Mwania watershed.

iii. To establish the effects of Pests and Diseases on cowpea production in Mwania watershed.

1.4 Hypotheses

H_1. Rainfall variability does not affect cowpea production in Mwania watershed.

H_2. Temperature variability does not affect cowpea production in Mwania watershed.

H_3. Pests and diseases affect cowpea production in Mwania watershed.

1.5 Justification of the Study

Drastic climatic changes in precipitation patterns and rise in temperatures will present unfavorable growing situations which in turn attract pests and diseases into the cropping calendars and thereby altering growing periods which could consequently reduce crop yield. Climate change has significant effects on cowpeas production with higher sensitivity to a future improvement in heat than rain and production systems which are most resilient to climate variability need to be identified and adopt to mitigate the effect of environment variation on crop production (Ayanwuyi & Akintonde, 2012). For instance, Cowpea Yields vary between 50 and 300 kg/ha in farmers' fields in marked difference to over 2000 kg ha obtainable on research stations and by large-scale commercial enterprises in good cropping systems (Bationo et al., 2000). Cowpea Yields are unusually low in fields intercropped due to low soil productivity, low planting quantities, shading by other crops, and insects and disease attacks and also as a result of climate variability in the areas where the crops are grown (Singh & Tarawali, 1997).

The study is a contribution to farmers' understanding of the effects of climate variation on dry land agriculture and seeks to identify strategies to mitigate the impact of climatic variations so as to increase crop productivity. The study will be significant to the government and other partners such as research firms and institutions because they will be able to understand the effects of climate variation on the agricultural activities in the country. Additionally, it will be able to coordinate and seek ways to strengthen the mitigating actions and encourage farmers through regulations and policies to undertake appropriate strategies to reduce the effects of climate change. The study will also be of importance to farmers as they will better plan the planting seasons so that they do so promptly and thus benefiting from the scarce rainfall received in the area.

1.6 Scope of the Study

The study focused on investigating the farmer's perception of effects of climate change parameters on cowpea production in Kenya with particular reference to cowpeas farming in Machakos County. The target population consisted of cowpeas farmers from Mwania watershed in Machakos County. The primary emphasis was on farmers' perception of the effects of rainfall variability, temperature variability, pests, and diseases on cowpea production.

1.7 Limitations of the study

Data collection was limited by a striking shortage of necessary data except for random rainfall data, as there were essentially no long-term weather records for either district. This meant that even the current climate could not be reliably characterized, placing constraints on the accuracy, with which the future can be projected. Targeted climate change projections for the study region were inadequate, for the same reasons. However, the study also relied on secondary data obtained from Kenya Agricultural and Livestock Research Organization (KALRO), and a recommendation made on how to go about improving the site-specific validity of data collection efforts.

CHAPTER TWO
LITERATURE REVIEW

2.1 Cowpea Production

The variability in the medium yield of cowpea in the different producing regions is an authentic reflection of the soil and climatic conditions required for cowpea production (Ayanwuyi & Akintonde, 2012). Cowpea yield is likely to respond to climate change in a rather context-specific way (Ziervogel, 2008).It follows accordingly that any change in climate may affect the agricultural division in particular. Climate change will have both positive and negative impacts, and these can be measured regarding impacts on crop maturity, availability of soil water, soil fertility and erosion, incidences of pests and diseases, and sea level rise (Semenov, 2009).

The area under cowpea is estimated at 1800 hectares excluding the crop in home gardens (Kimiti et al., 2009). About 85% of the total area under the cowpea is in arid and semi-arid lands (ASALs) of Eastern province and 15% in the Coast, Western, and Central regions (Kimiti et al., 2009). Despite its importance in the dry areas of Eastern Kenya, its potential, growth and yield are constrained by several abiotic and biotic factors. Among these are low soil fertility, inadequate farm inputs, noxious weeds, pest and diseases and lack of seeds during planting times. This has decreased in the yield potential of 1500 to 239 kg/ha (Kimiti et al., 2009).

2.2 Rainfall variability

Crop production is largely reliant on seasonal precipitation. Although the approach of irrigation is not new, its investment is still low while unreliable rainfall and variability tend to be the dominant constraint on livelihood strategies in smallholder rain-fed agriculture, particularly in drier environments (Zimmerman & Carter, 2003). The situation is further compounded by a heterogeneous distribution of soils, in the semi-arid areas of Kenya, lead to repeating site-and season-specificity of crop growth environments (RoK, 2006). Much of the challenge in these areas relates to the limited information and communication resulting in the ability of farmers or policy makers to anticipate and make proactive adjustments to climate variability (Okwach, 2002).

Rainfall is the most important climate parameter that influences the growth characteristics of crops (Bewket 2009; Befekadu & Berhanu, 2000). Water serves as a medium for nutrients and energy exchanger in crop development. Considering this critical role, clearly, the inadequacy of water hampers adequate crop growth, resulting in low productivity. According to von Braun (1991), for example, a 10% decrease in seasonal rainfall from the long-term average translates into a 4.4% decline in food production. Rain variability and associated droughts have been observed to be major causes of food shortages and famines (Wood, 1977) in sub-Saharan countries of Africa mainly undertaken by smallholder subsistence farmers who rely solely on high irregular and sporadic seasonal rainfall (Ndamani, 2008). The production of cowpeas is affected by the amount and distribution of rainfall. Further, the production is also affected by the period of planting (Morakinyo & Ajibade, 1998).

2.3 Temperature Variability

Global temperature increases a result of climate change caused sea levels to rise and changed the amount, pattern of precipitation and an expansion of subtropical deserts (Befekadu & Berhanu, 2000). Other consequences of the warming include the most frequent occurrence of extreme climate events including heat surges, droughts, heavy rain, species extinctions due to shifting temperature regimes and changes in crop yields (FAO, 2005).

Changes in temperature models have caused dramatic differences in cropping seasons, and the result of these changes has occurred in wide fluctuations in produce and seed quality of cowpea (Kabubo & Karanja 2007). When contrasted to other crop varieties, cowpea has considerable adaptation to high temperature and drought (Hall et al. 2002, Hall 2004). Whereas other plants decline due to a shortage of soil moisture, cowpea survives (Hall and Patel, 1985). However, the drastic rise in temperatures will introduce unfavorable growing conditions into the cropping calendars thereby changing growing periods which could subsequently reduce crop productivity (Ajetomobi & Abiodun, 2010).

2.4 Cowpea Pests and Diseases

There has been a lot of attention on the impact that climate change scenarios in exacerbating on the prevalence of pests and diseases on crop production, including mycotoxigenic fungal infection and contamination with mycotoxins (Paterson and Lima, 2010). If the temperature rises in cool or temperate climates, the relevant regions may become more susceptible to aflatoxins. Insect pests contribute to the major biotic stresses in cowpea growing regions in both developing and developed countries (Dauost et al. 1985).

The major insect pests in East Africa include; aphids, weevils and a multiple of sucking bugs and leaf-eating beetles Fusarium wilt (Fusarium oxysporum), Asochyta blight (Asochyta phaseolorum), Brown blotch (Colletotrichum capsici or Colletotrichum truncatum), Brown rust (Uromyces spp.). Aphids are the primary causing vectors for significant yield losses.Thrips infestation, especially during seedling stage, often results in total crop failure (Ezueh 1981; Price et al. 1983; Ta'Ama 1983). These pests and diseases cause damage to the cowpea plant either by destroying its leaves, stems, and roots and as a result adversely reduce the productivity of the crop (Schwarrtz, Steadman, Hall, and Forster, 2005).

The parasitic weed (string) also poses a significant threat to cowpea production. Striga spp. Is hemi-parasitic plants that parasitize the root systems of their hosts. The genus Striga, family Orobanchacecae, comprises about 41 species that are found in the African region and sections of Asia; Africa is the presumed zone of origin (Wolf et al., 1991). By parasitizing crop species, they can cause substantial yield losses and are therefore considered agricultural pests. The literature cites three species as having a significant impact on agriculture in tropical and subtropical areas. These are S. hermonthica (Del.) Benth. S. asiatica (L.) Kuntze and S. gesneroide (Willd.) Vatke. The first two classes parasitize cereal crops and wild pastures while the third parasitizes broad-leaved plants including the crop species cowpea (Vigna lunguiculata (L.).) and tobacco (Nicotiana tabacum L.) (Mohamed et al., 2001). S. hermontheca is an obligate outcross, occurs only on the African continent, and has the greatest agricultural impact of all Striga spp (Mohamed et al., 2001). Two striga species and its distribution in Africa have been reported. Striga gesneriodes is mostly found in Sudan and West Africa, while Alectra vogelii is found in Guinea, Sudan, West and Central Africa and part of Eastern and Southern Africa (Timko and Singh 2008). Alectra vogelii is more widely distributed than Striga gesneriodes and is an obligate root-parasitic flowering plant of the family Scrophulariaceae which is one of the major concerns in lowering cowpea yields (Boukar, 2004).

2.5 Conceptual Framework

The study adopts a conceptual framework explaining the relationship between independent variables and dependent variables or outcomes. The figure 2.1 below shows the relationship between the dependent and independent variables

Independent Variables **Dependent**

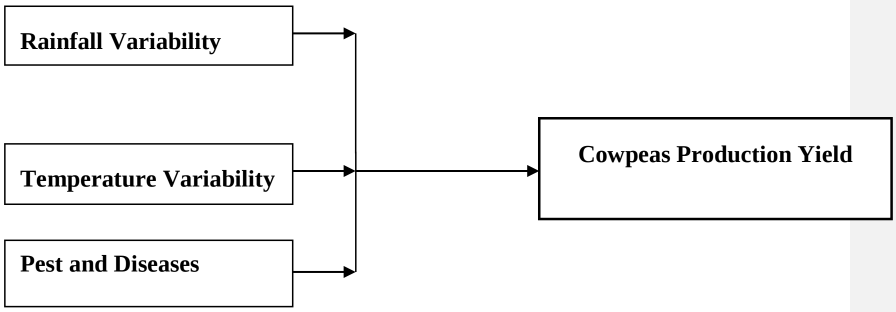

Figure 2.1: Conceptual Framework

2.5.1 Rainfall Variability

Rainfall variance is one of the most significant factors determining variability in agricultural production. This has severe consequences for individuals and societies, causing crop failures (Hammer 2000; Allan 2000; Meinke et al. 2003). Podesta et al. (2002) show that an understanding of rainfall variability is essential for appropriate agricultural risk management. Rainfall variable was measured on a five-point scale where individuals in the study were asked to indicate the extent to which rainfall in the watershed is a more predictable, stayed the same and finally, less predictable.

2.5.2 Temperature Variability

The impact of weather and environmental effects on plant growth is complex. Plant development, growth and ultimately yield are dependent on temperature, solar radiation, precipitation, transpiration, frequency of extreme rainfall and temperature events, increased CO2 concentrations, soil fertility, species type as well as pests, disease and weed prevalence (IPCC, 2007). The temperature variability in this study was measured on a scale where the respondents were asked to indicate whether the temperatures were much hotter, had stayed the same or had been the same.

2.5.3 Pest and Diseases

Pests and diseases can attack crops and have a severe impact on the economic output of a farm. Heavy infestation of pests and diseases of crops leads to a complete destruction of the plant and, as a result, this leads to an adverse impact on the yield of the harvest. In the study the Incidences of crop pests and diseases was measured on a scale where farmer was asked to indicate the incidences of pests and diseases and whether they had increased, stay the same or decreased.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Study Area

Machakos County in the larger eastern parts of Kenya covers an area of nearly 6281km^2 and has 1,098,584 people (2009 Census). The terrain is hilly and with a high elevation ranging from as high as 1000–1600 m.a.s.l. According to the Government of Kenya (2007), the major agro-ecological zones (AEZs) in the region are categorized as the Lower Highlands$_{2\text{-}3}$, Upper Midlands $_{2\text{-}6}$ as well as Lower Midlands $_{3\text{-}4}$. The precipitation is in the region of 500 – 1200 mm yearly and with 66% reliability. Additionally, the temperature ranges from within 20ºC – 30ºC. The Mwania watershed located within Machakos County has the main crop enterprises such as corn, cowpeas, beans, pigeon peas, as well as green grams. Similarly, the livestock varieties include the local zebu, domestic goats, domestic poultry as well as the improved dairy species (in the medium potential regions). The economy is mainly based on rain-fed crop production for subsistence in spite of the frequent droughts that often lead to devastating suffering and occasionally to mass migration problems. Low rainfall levels and high evaporation rates characterize a large area of Machakos. The normal annual rainfall ranges from1800mm on the eastern coast to less than 400mm in the center of the semi- arid region. Annual average heat varies from 16.8 to 33.8 ◦C, and evaporation rates can surpass 10mm. The predominant vegetation type in the semi-arid regions is tropical thorn forest, and the soil is fairly diversified, formed mainly by litho soils, rego soils, lato soils and sandy soils.

3.2 Research design

The research design is a plan that guides the studies in the process of collecting, analyzing and interpreting observations. In essence, the research design is the study's blueprint for the methods and instruments used to gather information and to evaluate it, to respond to the research questions and hypotheses of the study (Eriksson and Kovalainen, 2008). The study applied a descriptive study design to assess knowledge on the effects of climate change parameters on cowpea farming. Lavrakas (2008) describes a descriptive survey research approach as a systematic research technique for collecting data from a representative sample of respondents using instruments composed of closed-ended and open-ended questions, observations, and interviews. It is one of the broadly used non-experimental research plans across disciplines to collect the significant content of survey information from a representative sample of individuals sampled from the targeted population. Given the above definitions, descriptions and strengths, the descriptive survey is the most appropriate design for this study.

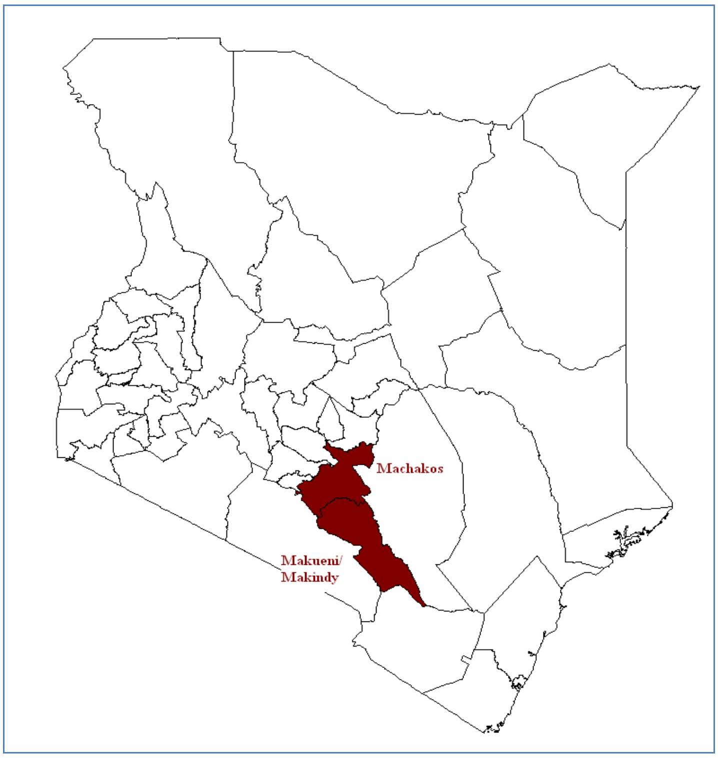

Figure 3.1 Machakos and Makueni Counties

3.3 Target Population

According to Castillo, a research population is a well-defined group of personalities or recipients known to have related characteristics and usually have a universal, binding component or feature. The target population was drawn from Mwania districts of Machakos County and consisted of farmers who were involved in growing cowpeas and the target population consisted of 67 farmers.

3.4 Sampling Design.

Because the target population was homogenous, a simple random sampling was used as this technique is likely to reduce the level of biassed by ensuring a fair selection of the sample. From the target population of 67 respondents, a sample of 55 respondents was selected from Mwania watershed in the secondary data from Kenya Agricultural and Livestock Research Organization(KALRO).

3.5 Data Sources collection procedure.

This study used secondary data from a broad survey conducted by Kenya Agricultural and Livestock Research Organization (KAIRO-KATUMANI). Additionally, information was obtained from Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) in the structure of the project "Enhancing Climate Change Adaptation in Agriculture and Water Research Project, which was funded by Infectious Disease Research Institute (IDRI) in Canada. The survey was conducted in 2013 June –August in three watersheds of three counties, Machakos, Makueni and Kitui. The data was acquired from focus group discussions, and household interviews using structured questionnaires to gather data relating to farmers perception of climate change, adaptation practices commonly employed and scoring of these strategies on the basis of a given criteria. The target group consisted of farmers who were involved in farming cowpeas. However, this study focused on Mwania watershed, in Machakos County, Kalama location.

3.6 Data Analysis

The dataset was analyzed quantitatively using the statistical package for social scientists (SPSS V20) for both descriptive and inferential statistics. Before any analyses, data was scrutinized and cleaned through checking for errors and completeness, editing and coding to ensure that there are no outliers that they ascribe to the requirement of normality as well as the non-existence of Multicollinearity. Outliers are observations, which are uniquely or distinctly different from the majority of the sample responses (Hair et al., 2010). Outliers affect normality of data distribution, and it was therefore considered imperative to examine the data set for the existence of such outliers before they were subjected to parametric analysis. To check for normality, the study used skewness and kurtosis statistic to verify the distribution of the variables and as recommended by Myoung (2008); the rule of thumb that a variable is reasonably close to normal if its skewness and kurtosis have values between -1.0 and + 1.0. Further, the Kolmogorov-Smirnov (K-S) and Shapiro-Wilks (S-W) tests of normality were applied to determine the level of significance of the differences from a normal distribution (Hair et al., 2010). According to Field, (2009), if the test is not significant (P>.05) then it means that the observed pattern is not different from the expected normal distribution and, therefore, average.

Data was further tested for compliance with the assumption of no Multicollinearity among the independent variables. Multicollinearity exists when there is a great correlation between two or more independent variables in a regression model (Field, 2009). With high collinearity, it's hard to find the distinct effect of individual independent variables (predictors) on the dependent variable since it increases the standard error which affects the size of regression coefficients and limits the size of multiple correlations (Field, 2009). Multicollinearity in the study was tested using Variance Inflation Factor (VIF).

After the statistical assumptions had been ascertained, the study performed a multivariate regression analysis to establish the impacts of climate change on cowpeas farming. The data was thus analyzed using multiple linear regression models as presented below;

$$Y=\alpha + \beta_1 RV + \beta_2 TV + \beta_3 PD + \varepsilon it$$

Where, Y= Cowpeas Production, RV= Rainfall Variability, TV= Temperature Variability, PD= Pest and Diseases, α = Constant, β_{1-4} = regression coefficient, εit = error term.

The presentation of data is in form of tables, charts and graphs only where it provides successful interpretation of the findings.

CHAPTER FOUR

RESEARCH FINDINGS AND DISCUSSIONS

4.1 Demographic Profile of Respondents

The profiles of respondents on the three characteristics gender, marital status and the education level are summarized in Table 4.1 below.

Table 4.1: Informants Demographic Profile

Characteristic	Group	Percentage
Gender	Male	74.24%
	Female	25.76%
Marital Status	Married	78.46%
	Single	3.08%
	Divorced	1.54%
	Widowed	16.92%
Education Level	No Education	13.64%
	Primary Education	48.48%
	Secondary Education	31.82%
	College Education	6.06%

Individual respondents constituted (74.24%) male and (25.76%) female. This implied that most of the cowpea farmers in the area were men who could be because agriculture activities require much energy in which the female counterpart could not provide. It was established that 78.46% of the respondents were married, 16.92% were widowed, the 3.08% were single, and 1.54% were divorced. Most farmers were married indicating that they should be responsible and have the ability to adopt appropriate climatic changes adaption measures. The results also showed that 48.5% of the cowpeas farmers surveyed had a primary education 31.8% had secondary education, 13.6% had no education while 6.1% had a college education. This implied that bulk of the farmers were literate though with different background of education. The farmer's literacy level is expected to guide them to adopt the best and appropriate climatic difference measure to encourage cowpea production in the area.

4.2 Cowpeas Production Purposes

Among the surveyed individuals 95.45% of them indicated that the purposes of cultivating cowpeas were purely for food consumption purposes and on the other had 4.55% of the respondents grew the crop as a source of income as indicated in Figure 4.1 below. This implies that the primary motivation of cowpeas production in the area was mainly driven by the consumption purposes rather than as a source of income.

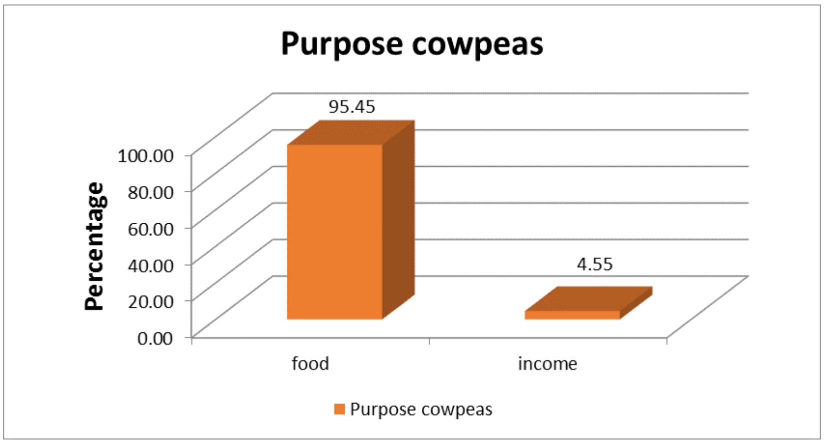

Figure 4.1: Cowpeas Production Purpose

4.3 Testing for Statistical Assumptions

Compliance with data to multivariate statistical assumptions ensures model robustness (Hair et al., 2010). Therefore, it was imperative to test for statistical assumptions before application of multivariate analysis to avoid potential violations which would distort and bias results. First the study examined whether the data had outliers and after that had considered the assumptions of normality and Multicollinearity was tested to explore and describe data distribution.

4.3.1 Outliers

Outliers are observations which are uniquely or distinctly different from the majority of the sample responses (Hair et al., 2010). They may be either high or low (extraordinary or extreme) values on the variable or may be unique or distinct in their combination of values across variables. Outliers are usually more problematic than beneficial in data analysis. In particular, they are not representative of the population and negatively affect the statistical tests (Hair et al., 2010). Most prominent is that outliers bias the mean and inflate the standard deviation (Field, 2009).

In summary, outliers affect normality of data distribution, and it will therefore be imperative to examine the data set for the existence of such outliers before being subjected to parametric analysis. The study adopted the box-plots to establish whether the data had any outliers. The examination revealed that the data had not outliers as indicated by the Whisker-Box Plots in Appendix (ii).

4.3.2 Test for Normality of Data

Normality relates to the shape of the distribution, which is symmetrical and pointy with a mean of zero and standard deviation of 1 (Field, 2009). It should be noted that non-compliance of a set of data to the normal distribution makes all subsequent statistical tests such as F and t-statistics invalid (Hair et al., 2010). Hence, normality is a compulsory test for multivariate analysis and testing for it using both univariates, and multivariate analysis is highly recommended. To check for normality, the study used skewness and kurtosis statistic as well as the Kolmogorov-Smirnov (K-S) and Shapiro-Wilks (S-W) tests to check the distribution of the variables and as recommended by Myoung (2008). As a rule, of thumb, in statistics, a variable is reasonably close to normal if its skewness and kurtosis have values between -1.0 and + 1.0 (Hair et al., 2010).

As the results indicate in Table 4.2 below the observations of the variables had skewness and kurtosis coefficients between the ±1 rule of thumb as asserted by Hair et al. (2010) and from this it was thus concluded that the data was normally distributed. Further to the Kolmogorov-Smirnov and Shapiro-Wilk tests the results indicated that the coefficients of the K-S and S-W tests are insignificant which as suggested by Field, (2009). If the test is not significant ($P>.05$) then it means that the observed distribution is not different from the expected normal distribution and, therefore, was considered normal.

Table 4.2: Statistical Test for Normality

			Kolmogorov-Smirnov			Shapiro-Wilk		
	Skewness	Kurtosis	Statistic	df	Sig.	Statistic	df	Sig.
Yield	0.392	-0.95	0.155	53	0.30	0.929	53	0.42
Rainfall	0.456	-0.196	0.165	53	0.18	0.904	53	0.06
Temperature	0.692	-1.405	0.38	53	0.08	0.668	53	0.13
Pests and Diseases	0.291	0.648	0.489	53	0.58	0.443	53	0.21

4.3.3 Test for Multicollinearity

Multicollinearity occurs when a high correlation between two or more independent variables in a regression model exists (Field, 2009). With high collinearity, it is difficult to find the distinct effect of individual independent variables (predictors) on the dependent variable since it increases the standard error which affects the size of regression coefficients and limits the size of multiple correlations (Field, 2009).

Data was further tested for compliance with the assumption of no Multicollinearity among the independent variables. To test for this phenomenon, the study adopted the Variance Inflation Factors (VIF) and as indicated by Hair et al. (2010) if the VIF is more than 10 (VIF $\geq$ 10) then it indicates that there is Multicollinearity. As observed from the results in Table 4.3 below the Variance Inflation Factors for the Variables are all less than 10, and thus, all the variables do not suffer from Multicollinearity and can, therefore, be subjected to parametric analysis.

Table 4.3: VIF Test for Multicollinearity

Variables	**Collinearity Statistics**	
	Tolerance	**VIF**
Rainfall	0.889	1.125
Temperature	0.824	1.213
Pests and Diseases	0.759	1.317

4.4 Data Analysis and Presentation

The data analysis involved the use of descriptive statistics that included the distribution while inferential statistics involved the use of correlation coefficients matrix, as well as the regression, estimates analysis.

4.4.1 Descriptive Statistics on Climate Variability, Pest and Diseases Indicators

The results presented in Table 4.4 shows the descriptive statistics based on the responses of the cowpeas farmers from Mwania Water Shed in Machakos.

Table 4.4: Climate Variability, Pest and Diseases Indicators

Variable	Constructs	Group	Percentage
Rainfall	Amount of Rainfall	Increased a lot	5.66%
		Increased	0.00%
		Stayed the same	22.64%
		Decreased	60.38%
		Decreased a lot	11.32%
	Rainfall variability	More Variable	50.94%
		Stayed the same	26.42%
		Less variable	22.64%
	Rainfall predictability	More Predictable	9.43%
		Stayed The same	11.32%
		Less predictable	79.25%
Temperatures		Much Hotter	60.38%
		Stayed The same	11.32%
		Cooler	28.30%
Incidences of crop pests and diseases		Increased	83.02%
		Stayed Same	5.66%
		Decreased	0.00%
		New Pests/Diseases	11.32%

As indicated in Table 4.4 above the 60.38% of the farmers reported that the amount of rainfall received annually in the area had reduced, 22.64% indicated that the total amount of rainfall experienced in the area had been the same while 5.66% showed that it had increased. The results further showed that 50.94% asserted that the perceived rainfall variability in the area was more variable, 22.64% indicating that rainfall variability had stayed the same while 26.42% declared that it had been less variable. Finally, on rainfall predictability 79.25% of the respondents felt that the rainfall pattern in the area was less predictable, 11.32% of respondents felt that it had stayed the same while another 9.43% of them felt that they had been more predictable. The implication of this perception by the farmers is a decline in the yields of their produce as erratic rainfall affects adversely both plant population and flowering ability, resulting in a tremendous reduction in crop yield and total biomass.

The results in Table 4.4 further show the farmer's responses concerning the temperatures experienced in the region. The results indicated that 60.38% asserted that the temperatures in the area had increased and was much hotter, 28.30% stated that their temperatures were much cooler whereas 11.32% indicated that the temperatures had not changed much.

Finally, the farmer's responses about the incidences of pests and diseases in cowpeas cultivation were captured. The results as indicated in Table 4.4 showed that 83.02% of the farmers reported an increased prevalence of pest and disease infections on crops grown in the area. 11.32% reported that there had been new incidences of pest and diseases while 5.66% of them reported that the prevalence of pests and diseases had stayed the same over time. This, therefore, implies that with the increase in pests and diseases in the area, farmers were more likely to have reduced crop yields due to the catastrophic effects of the pest and disease infestation on plants and were more likely to suffer a loss and reduced income from their crops.

4.4.2 Effect of Climate Variability, Pest and Diseases on Cowpeas Yield

To examine the impact of climate variability (rainfall changes and temperature variability) and the influence of pests and diseases on the yield of Cowpeas in Mwania Watershed in Machakos County, the study adopted both the correlation and regression analysis. This was performed after all the multivariate statistical assumptions had been ascertained as discussed in Section 4.4. The results presented in Table 4.5 below shows the results of correlation analysis. This correlation coefficient usually ranges between ± 1 and it thus measures the degree to which two variables are linearly related. The higher the magnitude of the correlation coefficient the greater the level of association between two variables. The results in the table indicate the relationship between the predictor (temperatures, rainfall and pest and diseases) and the predicted variable (Cowpeas Yield).

Table 4.5: Correlation Coefficient Matrix

		Yield	Rainfall	Temperature	
Yield	Pearson Correlation	1.00			
Rainfall	Pearson Correlation	0.540	1.00		
	Sig. (2-tailed)	0.040			
Temperature	Pearson Correlation	-0.430	0.181	1.00	
	Sig. (2-tailed)	0.019	0.194		
Pests Diseases	Pearson Correlation	-0.670	0.330	0.417	1.00
	Sig. (2-tailed)	0.045	0.016	0.002	

Table 4.5 indicates that the correlation coefficient between Rainfall and Cowpeas Yield is positive (r=0.540) and significant (p-value=0.040) at 5% significance level and this, therefore, implies that an increase (or decrease) in Rainfall would result in an increase (or decrease) Cowpeas Yield. The results further show that the correlation between Temperature and Cowpeas Yield is negative (r=-0.430) and significant (p-value=0.019) at 5% significance level. Similarly, this indicates that an increase (or decrease) in Temperature would result in a decrease (or increase) in Cowpeas Yield. Finally, the correlation between Pests and Diseases and Cowpeas Yield was found to be positive (r=-0.670) and found significant (p-value=0.045) at 5% significance level. This implies that an increase (or decrease) in Pests and Diseases incidences would result in a decrease (or increase) in Cowpeas Yield.

Given that the correlation analysis had established the nature of the relationship between the variables the study also conducted multiple linear regression analysis. This was meant to indicate the quantum of variability in Cowpeas yield explained by the climate variability and prevalence of pests and diseases. The analysis is based on cross-sectional data collected at Mwania Watershed at a point in time by KALRO. The results of multivariate regression analysis results are as presented in Table 4.6 below.

Table 4.6: Multivariate Regression Analysis

Variable	**Coefficients**			
	β	**Std. Error**	**t**	**Sig.**
Constant	0.019	0.118	1.963	0.022
Rainfall Variability	0.066	0.048	2.285	0.032
Temperature Variability	-0.027	0.020	-1.980	0.038
Pests and Disease Incidence	-0.052	0.019	-2.730	0.009

The results in table 4.6 above indicates that the relationship between Rainfall Variability and Cowpeas Production is active (β=0.066) and significant (p-value=0.032) at 5%. This implies that an increase in rainfall by a unit would increase cowpeas production by 0.066 units per hectare. This finding indicates that drastic changes in rainfall patterns introduce unfavorable growing conditions into the planting calendars thereby modifying planting seasons which could subsequently reduce crop productivity as water serves as a carrier of nutrients and energy exchanger in plant development. Considering this important role, apparently, the inadequacy of water supply hampers efficient crop growth, resulting in low productivity. Secondly, the results also indicate that the relationship between Temperature Variability and Cowpeas Production is negative (β=-0.027) and significant (p-value=0.038) at 5%. This implies that an increase in temperature by one unit would result in a 0.027 unit decrease in cowpeas production per hectare. Finally, the results indicated that the relationship between Pests and Disease Incidence and Cowpeas Production is negative (β=-0.052) and significant (p-value =0.009) at 5%. This implies that an increase in pest and disease incidence would result in a decline in Cowpeas Production.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS.

5.1 The Summary of Findings

5.1.1 The Effect of Rainfall Variations on Cowpeas Production Yields

The study judgments indicate that majority of the respondents interviewed reported that the amount of rainfall received per annum had reduced, and the rainfall pattern was less predictable in the region and was erratic in nature. Given that rainfall is an essential element in the production of cowpeas the less predictability of rainfall patterns are likely to impact adversely on cowpeas production in the region. More specifically, the findings indicate a positive relationship between cowpeas production and rainfall and thus this result implies that an increase in the rainfall amounts received would lead to a rise in cowpeas yield while a decline of rainfall would lead to a reduction in the cowpeas yields.

5.1.2 The Effect of Temperature Variations on Cowpeas Production Yields

The findings from the study also indicate that temperatures in the region were much hotter an indication of increased variations in temperatures experienced in the area. The variation is the temperatures and in most cases extreme temperatures would result in decreased yields. More specifically, the findings from the regression analysis indicate a negative relationship between temperature and cowpeas yields. In essence, this implies that an increase in temperatures would result in decreased cowpeas yields.

5.1.3 The Effect of Pest and Disease Incidence on Cowpeas Production Yields

The findings of the study further indicate that farmers reported increased incidences of pests and diseases, and also new cases of parasites and some household reported conditions. An increase in pest and disease infestation has an adverse impact on the crops yields. Specifically, the results of regression analysis indicate that there existed a negative relationship between cowpeas yields and pest and diseases.

5.2 Conclusions

Based on the study findings the study concludes that rainfall variations have a positive and significant effect on cowpeas yields. The implication of this finding is that erratic and less predictable rains, therefore, results in a decline in yields. This finding is constant with the findings of Bewket (2009) and Befekadu and Berhanu (2000) who asserted that rainfall is the most important climate parameter which influences the growth characteristics of crops, and thus considering its critical role, clearly the inadequacy of water supply hampers efficient crop growth, resulting in low productivity. Similarly, Braun (1991) also indicated that a decrease in seasonal rainfall from the long-term average results in a reduction in food production.

Secondly, the study concludes that temperature variations have a negative and significant effect on cowpeas yields. This implies that a continuous increase in the temperatures would lead to decreased productivity of crops and thus translating to reduced crops yields. This finding is consistent with those of Richie (1985) who also found out that change in temperature patterns causes wide fluctuations in crop yields.

5.3 Recommendations

Based on the above conclusions the study specifically, recommends the following measures be taken into account by farmers and policy makers in ensuring that cowpea yields are not adversely affected by the climatic factors examined in the study as well as the increased incidences of pests and diseases.

First, the study recommends that to be in a better position to mitigate the effects of rainfall variations experienced farmers should prepare for variations in rainfall as well as the less predictability of rainfall experienced by harvesting rainwater into tanks, thus ensuring that they have a substantial amount of water stored up. In the case of drought or variations of rainfall they can supplement the sporadic rains received with irrigation, however, the extent to which irrigation can be carried out in this way is low it would be desirable that small-scale farmers should be helped to combine into big units (cooperatives) to increase the irrigation efficiency.

The study also recommends that agricultural research institutions should develop drought resistant cowpeas as this would help curb the reduction of yields as a result of variations in rainfall amounts.

Given that the study also found a negative and significant effect on temperature and pest and disease on cowpeas production, the study also recommends that cowpeas varieties that are resistant to extreme temperatures and also varieties that are resistant to pest and diseases attack should be developed. This will help avert the adverse impacts of climatic factors as well as the negative effects pest and diseases, have on cowpeas yields.

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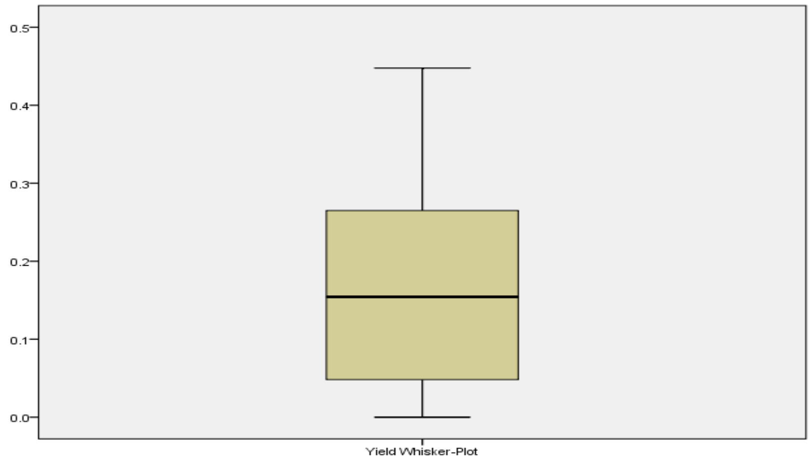
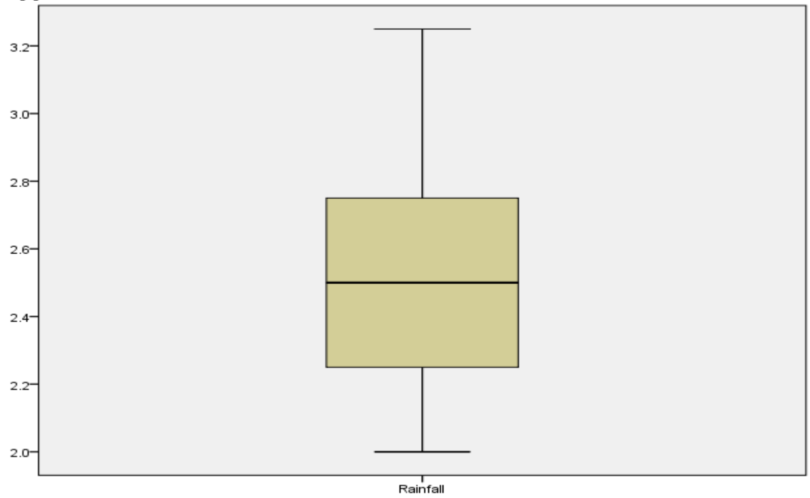
APPENDICES

TEST FOR OUTLIERS (Whisker-Plots)

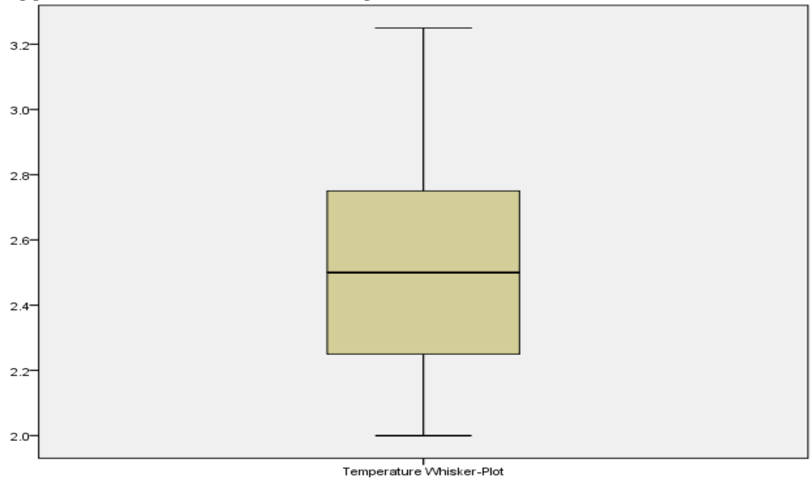
Appendix I: Whisker-Plot for Cowpeas Yield



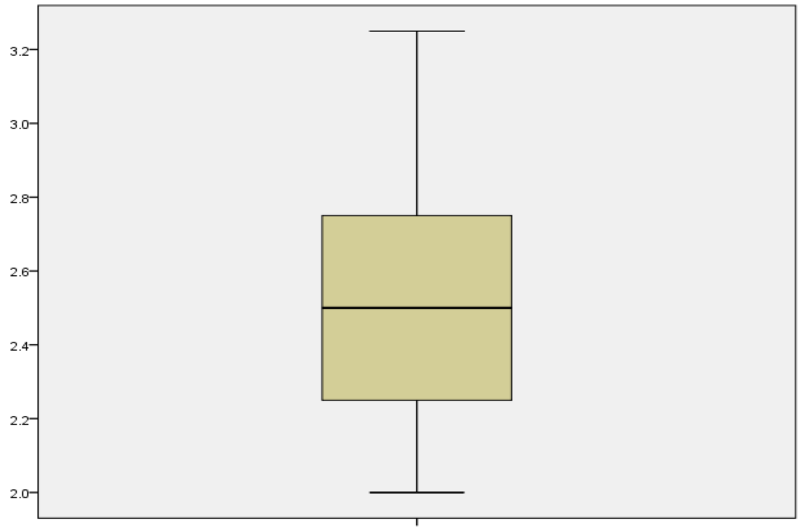
Appendix II Whisker-Plot of Rainfall



Appendix III: Whisker-Plot of Temperature



Appendix IV: Whisker-Plot of Pest and Diseases Incidences



Appendix V Scatter Plot of Residuals