

EFFECT OF CLIMATE CHANGE ON COWPEA PRODUCTION IN MWANIA WATERSHED: A CASE OF MACHAKOS COUNTY

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ABSTRACT

Agriculture is one of the sectors that directly depend on climate factors and thus climate variability and climate change have been implicated to have significant impacts on global and regional food production particularly the common staple food crops. The goal of this study was to determine the impact of various climatic factors on the production of cowpeas and thus adopted a descriptive research design. This study was conducted in Mwanja Watershed in Machakos County in Kenya. The study used secondary data from a survey conducted by Kenya Agricultural Research Institute in three watersheds of three counties Machakos, Makueni and Kitui. A total population of 400 cowpeas farmers were interviewed however this used a 10 percent sample size (40 cowpeas farmers) from Mwanja Watershed in Machakos. The data was analysed using both descriptive and inferential statistics. The findings reveal that 95.45% respondents indicated that they cultivated cowpeas for household consumption while 4.55% of the respondents cultivated the crop as a source of income. The farmer's perception on climate change effects on cowpeas production in the region was obtained where 60.38% of the respondents asserted that the amount of rainfall received had reduced, and another 60.38% asserted that the temperatures had increased and it was much hotter, while 11.32% reported new incidences of pest and diseases and 83.02% agreed that the rate of pests and disease incidences had increased. The regression results reveal that cowpeas production and rainfall had a positive and significant relationship while, it was also established that a negative relationship between temperature and cowpeas yields and further the results showed a negative relationship between cowpeas yields and pest and diseases. The study recommends that small scale farmers should be helped to combine into big units (cooperatives) to increase the irrigation efficiency and that crop varieties resistant to extreme temperatures and resistant to pest and diseases attack should be developed as this would improve on cowpeas production which was established to be heavily reliant on availability of rainfall.

Keywords: Rainfall, Temperature Variability, Pests and Diseases, Crop Yield

1.1 INTRODUCTION

Agricultural growth and development is crucial for Kenya's overall economic and social development, Agriculture contributes 24% directly to GDP and 60% of export earnings (Johnston and Mellor 1961, Government of Kenya 2007). Despite this, the sector has been over the last decade. The sector also provides food and creates employment, about 73% of the labour force in in Kenya depends on agricultural production of their livelihood. Despite this, the sector has been experiencing declining growth and has become vulnerable to climatic change which arises out of varied interactions between the environment, natural resources (land, crops, animals and water) and people. These interactions are likely to change the ecological, environmental and agricultural landscape, and therefore influence agricultural production (Apata, Samuel & Adeola, 2009).

Cowpea is widely grown by the resource-poor farmers in the semi-arid parts of Kenya for subsistence and as a source of income (Machiara, 2004). The crop is usually intercropped with cereals such as maize, sorghum, pulses such as beans, pigeon peas and roots and tubers such as cassava and sweet potatoes. It is rich in protein and digestible carbohydrate and its energy content is nearly equal to that of cereal such as maize and sorghum (Mukhtar & Singh, 2004). With Kenya's human population on the increase, pressure for farming land will continue to displace agriculture into marginal lands. Cowpea is tolerant to drought and nutrient deficient soils. It also flourishes where other crops when water-stressed, and therefore continues to photosynthesize during droughts hence is a crop of choice to fight nutritional and food insecurity in the country (Jones *et al.*, 2001) especially in drier regions. Cowpea also thrives well in dry environments with as little as 300 mm of rainfall. The deep root systems of cowpea help stabilize the soil structure and the canopy covers the ground thus preserving moisture. These attributes are particularly important in the drier regions, where moisture is at a premium and the soil is fragile and subject to wind erosion (Jones *et al.*, 2001).

Erratic rainfall patterns and diverse distribution of soils, in the semi-arid areas of Kenya, leads to recurring site- and season- specificity of crop growth environments. Much of the challenge in these areas relates to the inability of farmers or policy makers to anticipate and make proactive adjustments to climate change and variability (Okwach, 2002). Water

plays very crucial roles in agricultural productivity. To begin with rainfall is the most important climate parameter which influences the growth characteristics of crops (Bewket 2009; Befekadu & Berhanu, 2000), water also facilitates the movement of nutrients and is an energy exchanger in crop development. Considering these critical roles, clearly, inadequacy of water supply hampers efficient crop growth, resulting in low productivity. According to von Braun (1991), for instance, a 10% decrease in seasonal rainfall from the long-term average generally translates into a 4.4% decrease in food production. Similarly, according to Bryan *et al.* 2012, a range of climate models suggest median temperature increases of between 3^oC - 4^o C in Africa by the end of the 21st Century, roughly 1.5 times the global mean response. This will likely result in significant yield losses of key staple crops, such as maize, sorghum, millet, groundnut, and cassava, of between 8 % - 22 % by 2050 unless key investments are made to improve agricultural productivity under climate risk (Schlenker and Lobell 2010). Further, rainfall variability and associated droughts have been observed to be major causes of food shortages and famines, in sub-Saharan Africa regions largely practicing smallholder subsistence farmers which rely solely on high unpredictable and sporadic seasonal rainfall (Ndamani & Watanabe 2008 and Ifejika Speranza, et al., 2008).

An increase in global temperature as a result of climate change caused sea levels to rise and changed the amount and pattern of precipitation and an expansion of subtropical deserts. Other effects of the warming include more frequent occurrence of extreme weather events including heat waves, droughts, heavy rainfall, species extinctions due to shifting temperature regimes and changes in crop yields. Changes in temperature patterns have caused dramatic changes in cropping seasons, and the effect of these changes has resulted in wide fluctuations in yield and seed quality of cowpea. Both quality and quantity of cowpea seed are affected by the amount and distribution of rainfall, which is affected by the period of planting (Morakinyo & Ajibade, 1998). Accurate timing of sowing a crop in any particular context is an important agronomic requirement. High yields of good quality seed are obtained when cowpeas are planted so that the crop matures in dry weather. The crop flourishes well in areas where the minimal and maximal temperatures range between 18.2^oC and 27.6^oC, respectively, during the growing season.. When compared to other crop species, cowpea has considerable adaptation to high temperature and drought (Hall

& Ehlers, 1997). Whereas other crops fail due to a shortage of soil moisture, cowpea survives. Hall and Patel,(1985) posit that cowpea dry grain yield as high as 1000 kg ha⁻¹, can be obtained in the drought environment with low humidity and only 181 mm of rainfall. However, if the temperature increases in cool or temperate climates, the relevant regions may become more susceptible to aflatoxins.

1.2 Statement of the Problem

The response of cowpea yield to climate change varies from one agro ecological zone to the other and thus climate change and variability is the topical issue in this paper. It follows therefore that any change in climate may impact the agricultural sector differently. Climate change could have both positive and negative impacts and these could be measured in terms of effects on crop growth, availability of soil water, soil fertility and erosion, incidence of pests and diseases, and rise in sea levels (Butterworth *et al.*, 2009). Adapting crop varieties to local ecological conditions will reduce risk due to climate change; however, varieties improved for cultivation in one region could be adopted for cultivation elsewhere, where they would face the same abiotic and biotic stresses. Some studies have been conducted to assess the impact of climate change on agriculture in developing countries (Gbetibouo & Hassan, 2005, Change, 2007; Cooper *et al.*, 2006). These studies point to the concern for the present and future climate aberrations, weather trends and their implications for agriculture that continue to inspire researchers as well as public and policy-level interests regarding the analysis of climate change in relation to agricultural productivity. This study therefore seeks to contribute to the debate by investigating the effects of climate change on cowpeas production in South Eastern Arid and Semi-Arid lands (ASALs) in Kenya.

1.3 Research Objectives

1.3.1 General Objectives

To examine the effects of climate change on cowpeas production in Mwanja District in Machakos County.

1.3.2 Specific Objectives

- i. To examine the influence of Rainfall variability on cowpeas production in South Eastern ASALs of Kenya
- ii. To establish the effects of Temperature variability on cowpeas production in South Eastern ASALs of Kenya
- iii. To establish the effects of Pests and Diseases on cowpeas production in South Eastern ASALs of Kenya

1.4 Conceptual Framework

The study is conceptualized in figure 1 below explaining the relationship between independent variables and dependent variables or outcomes, it also shows the relationship between the dependent and independent variables.

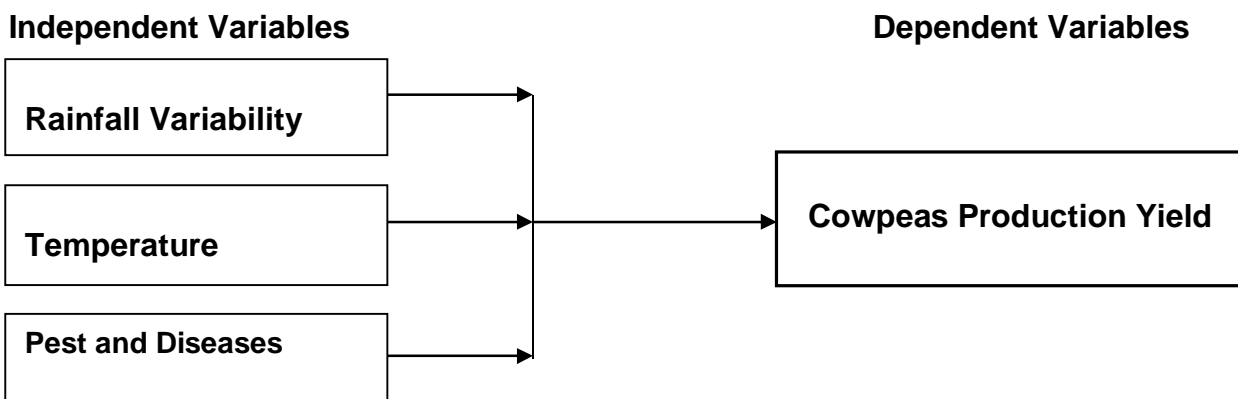


Figure 1 Conceptual Framework

Source: Authors' design

2 METHODOLOGY

The study used secondary data from a broad survey conducted Kenya Agricultural Research Institute (KARI) now known as Kenya Agricultural and Livestock Research Organisation (KALRO) due to ongoing parastatals reforms. The survey was conducted in 2013 June –August in three watersheds of three counties, Machakos Makueni and Kitui.

However this study will focus on Machakos County and Mwanja watershed, Kalama location.

Description of Research Sites

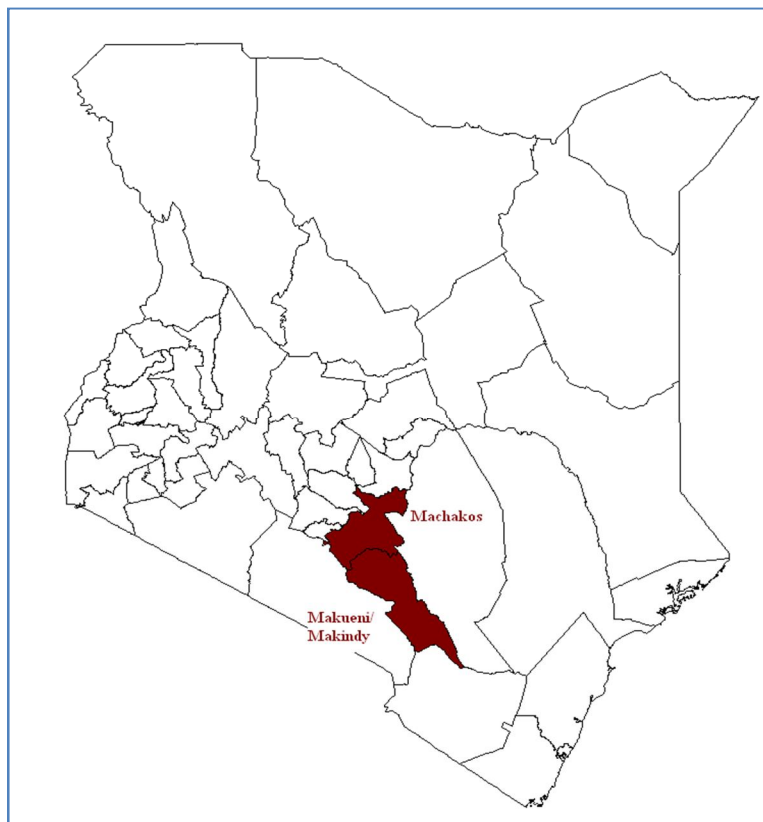


Figure 1: Machakos and Makueni Counties: Source KALRO

Machakos County, covers an area of approximately 6281km² and has a population of 1,098,584 (2009 Census). The terrain is hilly and with an elevation ranging from 1000 – 1600 m.a.s.l. Main agro-ecological zones (AEZs) are categorized as Lower Highlands²⁻³, Upper Midlands²⁻⁶ and Lower Midlands³⁻⁴ (Government of Kenya 2007). Rainfall ranges between 500 – 1200 mm per annum with 66% reliability. Temperature ranges within 20°C – 30°C. Main crop enterprises are maize, beans, pigeon peas, cowpeas and green grams. Livestock enterprises include local zebu, goats, local poultry and improved dairy (in the medium potential areas).

The entire survey consisted of 400 cowpeas growing farmers however, a 10 percent sample size was taken from the population and the data was coded and analyzed using

MS Excel and SPSS (Version 20) Software. Both descriptive and inferential statistic and were obtained.

The study used a descriptive research design to assess knowledge on the effects of climate change on cowpeas farming.

In order to establish the relationship between cowpeas production and Rainfall Variability, Temperature Variability and Pest and Diseases a multiple linear regression model was used and the significance of the model examined using analysis of variance (ANOVA).

The regression model estimated was of the following form:

$$Y = \alpha + \beta_1 RV + \beta_2 TV + \beta_3 PD + \epsilon_{it}$$

Where,

Y= Cowpeas Production

RV= Rainfall Variability

TV= Temperature Variability

PD= Pest and Diseases

α = Constant

β_{1-4} = regression coefficient

ϵ_{it} = error term

3.0 RESULTS AND DISCUSSION

3.1 Farmers perceptions on climatic factors and pest and diseases

3.1.1 Rainfall predictability and variability.

The research findings on the variation on total amount of rainfall per year indicated that 60.38% of the respondents observed that the amount of rainfall received annually in the area had reduced, while 22.64% of the respondents observed that the total amount of rainfall experienced in the area had been the same while 5.66% of the respondents indicated that it had increased.

The findings also reveal the extent to which the farmers perceived rainfall variability in the area and 50.94% of the respondents observed that the rainfall received was more variable while on the other hand 22.64% of the respondents observed that rainfall predictability had stayed the same while 26.42% of the respondents asserted that it had been less variable

Farmer's perception on rainfall predictability indicated that 79.25% of the respondents felt that the rainfall pattern in the area was less predictable and 11.32% of respondents felt that it had stayed the same while another 9.43% of them felt that they had been more predictable. These observations and perceptions by the farmers imply that there is likely to be a decline in the yields of their produce as erratic rainfall affects adversely both plant population and flowering ability, resulting into tremendous reduction of crop yield and total biomass.

3.1.2 Temperature changes

The findings also reveal the extent to which farmers perceived variations in temperatures in the watershed. The results indicated that 60.38% of the respondents observed that the temperatures in the region had increased and it was much hotter while only 28.30% of the respondents on the other had asserted that they temperatures were much cooler. Another, 11.32% of the respondents had the perception that the temperatures had not changed much and had stayed the same.

3.1.3 Pest and diseases

The farmers perception regarding the incidences of pest and diseases in the region indicated that majority of the farmers reported an increased prevalence of pest and disease infections on crops grown in the area. 83.02% respondents interviewed agreed that the rate of pest and disease incidences in the area had increased whereas few of the respondents asserted that they incidences of pest and diseases had stayed the same. On the other hand new incidences of pests and diseases had been reported by some farmers in the area as indicated by 11.32% of the respondents. 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 crops and were more likely to suffer a loss and reduced income from their crops.

3.2 Impact of climatic factors, pest and diseases on cowpeas yield.

Regression analysis was conducted to empirically establish the effects of temperature variability, rainfall variability and the effects of Pests and Diseases on cowpeas production. Regression results in table 1 indicated the goodness of fit of the regression model estimated was satisfactory and that 55.2 % of the variance in cowpeas production is explained by the variances in the temperature variability, rainfall variability and Pests and Diseases. The estimated model was established to be significant as indicated in Table 1 below.

Table 1. Test of significance of the estimated regression model

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	0.648	3	0.036	2.696	0.046
Residual	0.107	49	0.013		
Total	0.755	52			

The table 2 below presents the regression results where the predicted variable, Cowpeas Yield is regressed against the predictor variables; Temperature Variability, Rainfall Variability and the Pests and Disease Incidences. The results indicate that the relationship between Rainfall Variability and Cowpeas Production is positive ($\beta = .066$) and significant ($P = .03$). 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 introduces unfavorable growing conditions into the cropping calendars thereby modifying growing seasons which could subsequently reduce crop productivity as water serves as a carrier of nutrients and energy exchanger in crop development. Considering these critical role, clearly, inadequacy of water supply hampers efficient crop growth, resulting in low productivity. This finding is consistent 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 generally results to a decrease in food production.

The results also show that the relationship between Temperature Variability and Cowpeas Production is negative ($\beta = -.027$) and significant ($P = .04$). This implies that an increase temperature by one unit would result in a 0.027 unit decrease in cowpeas production per hectare. This finding is consistent with those of Richie (1985) who also found out that change in temperature patterns causes wide fluctuations in crop yields

The results further showed that, the relationship between Pests and Disease Incidence and Cowpeas Production is negative ($\beta = -0.052$) and significant ($P = .01$). This implies that an increase in pest and disease incidence would result to a decline in Cowpeas Production

Table 2. Regression results on the impact on climatic factors and pest and diseases on cowpeas yield.

	Coefficients			
	B	Std. Error	t	Sig.
Constant	.019	.118	1.963	.022
Rainfall Variability	.066	.048	2.285	.032
Temperature Variability	-.027	.020	-1.980	.038
Pests and Disease Incidence	-.052	.019	-2.730	.019

4. CONCLUSION AND RECOMMENDATIONS

Based on the study findings the study concludes that rainfall variations have a positive and significant effect on cowpeas yields. 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. Based on these conclusions the study specifically, recommends the following measures be taken in account by farmers and policy makers towards ensuring that cowpea yields are not adversely affected by the climatic factors as well as the increased incidences of pests and diseases.

First, the study recommends that in order 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 rain water into tanks, thus

ensuring that they have substantial amount of water stored up. In 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 through 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. Secondly, 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. Lastly, the study recommends that cowpeas varieties that are resistant to extreme temperatures and also 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.

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