

Adaptation Mechanisms and Coping Strategies to the Effects of Climate Variability on Maize Yield with Focus on Matungulu West, Machakos County Kenya

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Abstract : Climate variability is a phenomenal challenge to the citizens of the globe. It is noticeable from many documented studies that climate variability is taking place at an alarming rate. The globe has been experiencing an increase in temperature of approximately $\approx 0.2^{\circ}\text{C}$ after every ten years for the last three decades. It is also established that rainfall increased significantly from 1900 to the 1950 then dropped from 1970 to present. The total sum of such extremes is a terribly affected livelihood in particular those living below the dollar. However, farmers in Matungulu West, in Machakos County Kenya have established their own measures and strategies to address the effects posed by climate variability. That informed the main objective of this study which was To determine adaptation measures and coping strategies being practiced by households in Matungulu West in Machakos County Kenya in addressing climate variability. A structured questionnaire which was developed and pre-tested was used to interview 380 randomly selected household heads to elicit information. Findings of the study indicate that most (52.2%) of the farmers have reduced or spread risks by replanting with early maturing maize, (26.4%) staggering planting dates, (2.9%) changing crops when replanting, (6.6%) grazing of failed parcels of land and (11.9%) carrying out varietal selection of stress resistant to suit the prevailing conditions. It was established further that (64.8%) of the respondents preferred early sowing as an adaptation option while (1.4%) indicated that they were practicing irrigation farming to combat climate variability. This study made a conclusion that there is a broad range of contrasting diversification strategies employed between different types of households headed by either females or males with the ownership or lack of ownership of cattle being a key factor that cuts across household types and which provided considerable additional flexibility.

Key words: Climate variability, yield, Rainfall, Temperature.

INTRODUCTION

Climate change is attributed to anthropogenic causes and this is exemplified by enhanced heat-absorbing GHG emissions that modify the atmospheric composition and natural climate variability observed over analogous period of time (IPCC, 2012). Climate variability is therefore deviations in the average state and other statistics of the climate on all sequential and spatial scales further than that of individual weather events over a specified time period. This inconsistency may be as a result of natural internal processes within the climate system or by variation to human provoked activities or natural processes (Schnoor, 2010). Several works have demonstrated how climate change and variability alters hydrologic cycles and watershed regimes, negatively impacting ecosystems, water resources forests, sustainable agriculture and the environment (Alexander *et al.*, 2008). The global surface temperature has increased by $\approx 0.2^{\circ}\text{C}$ per decade in the last 30 years (Hansen *et al.*, 2006). It is estimated that the global temperature has increased by 0.72°C since 1950 (Hartmann *et al.*, 2013). Whenever there is an increase in temperature, then there is also a probability that the hydrological cycle components like erratic rainfall, soil moisture and rise in water vapor will be affected.

According to Dinar and Mendelsohn (2009), there is sufficient evidence to suggest that climate variability will affect agriculture. Therefore, this phenomenon has a profound negative effect on the natural resource base and consequently on agriculture which happens to dependent on the climate. Drought stress for instance damages the grain yield when it occurs at reproductive stage of crop's life cycle. During stem elongation, the development and growth of leaves and stem is so rapid that it requires sufficient amount of water, the

water stress at that stage can reduce the height of plant and also affects the leaf of plant. The most crucial time of water stress in maize crop is 10-15 days before and after flowering. At this stage if the water deficit occurs then the grain yield decrease 2-3 times more than the water deficit in another growing stage.

Moreover, studies have shown that an estimated 80% of the maize crop experiences sporadic yield reduction due to drought stress. Mahalingam, (2014) study shows that drought at flowering and grain filling period may cause losses of 40-90%. This is a clear indication that climate change influences maize yield to a greater extent in countries like Kenya where agriculture depends largely on natural circumstances. Many studies have examined the role of mean climate change in agriculture, but an understanding of the influence of inter-annual climate variations on maize yields remains elusive. How mean historical and future climate change affects maize yields has received a great deal of attention, but how variations in temperature and precipitation influences maize yield, and how they vary over time, has received

less attention. As a consequence of placing less attention on the influence of inter-annual climate variations on maize yields, it is difficult to accurately establish how climate and maize yields are linked over time and also for ensuring proper adaptation measures and coping strategies. The general objective of this study was to assess the potential effects of climate change and variability on maize yield in Matungulu West in Machakos County for the period 1984-2014. The study therefore sought to determine the effects of climate variability and change on maize production in Matungulu area of Machakos County. To address this problem, the study determined the effects of inter-annual climate variability on maize yield in Matungulu West in Machakos County for the period 1984-2014.

METHODOLOGY

3.1 Study Area

The study was undertaken in Matungulu West Sub-Location, Machakos County (Fig 3.1). The area stretches from latitudes 0° 45' south to 1° 31' South and longitudes 36° 45' East to 37° 45' East; and covers an area of 6,208 square Km (GoK, 2009).

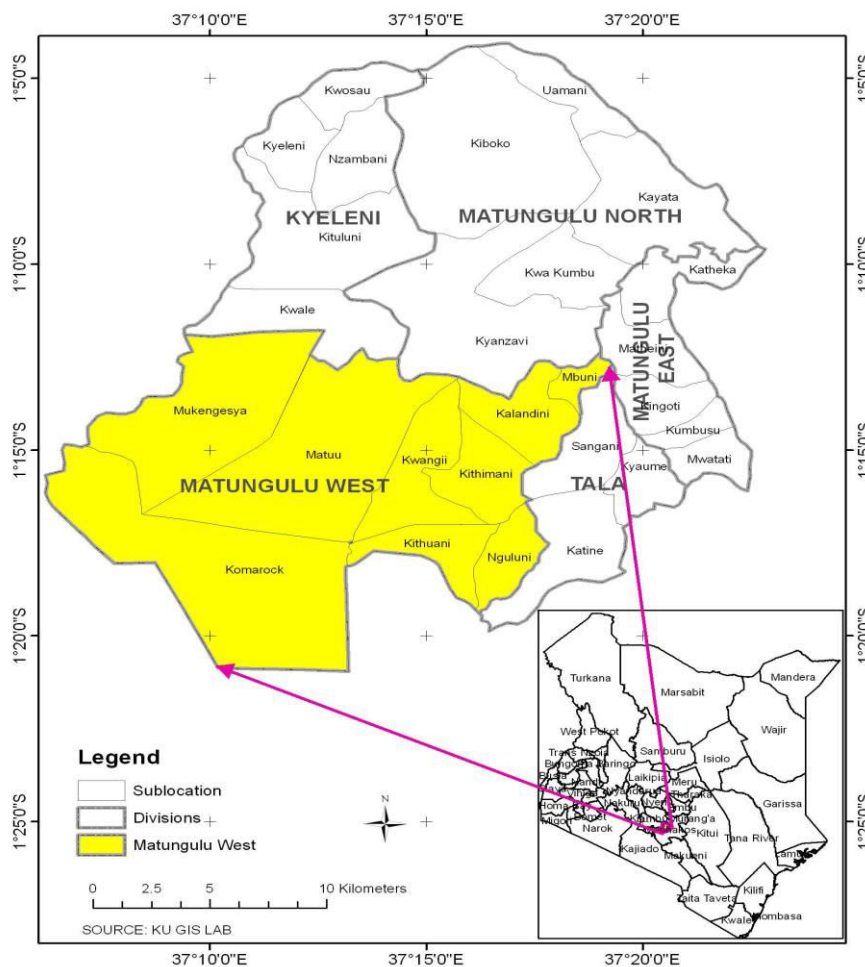


Figure 3.1: Map of Matungulu West.

Matungulu west Sub-County is made up of nine administrative Sub-Locations namely; Komarock, Kithuani, Nguluni, Kwangii, Kithimani, Kalandini, Matuu, Mukengesya, and Mbuni in Machakos County. Matungulu west is bordered by several constituencies including Mwala to the North, Mbooni to the south, Kathiani to the west, Yatta to the East and Mwala to the North West. Matungulu west covers an area of 246.90 Sq. km most of which is semi-arid. The Sub-County receives low, unevenly distributed and unreliable rainfall ranging between 250mm-1300mm per year. The area's population is estimated to be 33,808 with 7792 households (KNBS, 2010).

The major part of Matungulu West is regarded as semi arid (KNBS, 2010). It is estimated that less than 40% supports agricultural activities and water mass occupies 15sq. km, mostly perennial rivers and dams (GoK, 2009). The sub-county receives low, unevenly distributed and unreliable rainfall ranging between 250mm-1300mm per year. The study area experiences regular crop failure and due to erratic weather conditions. The Sub-Location is predominately rural with most of the population engaged in agricultural activities especially in high potential areas.

The rainfall distribution of the study area occurs in two models. The area experiences both long and short rains spread across the year. Between March and May, Matungulu West experiences long rains and short rains are normally between October and December. The Machakos County Metrological Department has also corroborated this report by affirming that the annual average rainfall of the Matungulu West sub-county is between 250 mm and 1300 mm. it is established that this trends is not constant since it keeps changing every year. The area lies in agro-climatic zone Lower Midland Zones LM4 and LM5. These are zones characterized by short to medium and short cropping seasons respectively. The main economic activities in the area are trade and small scale farming (GoK, 2009).

The rationale for the choice of Matungulu Su-Location in Machakos County for the study was grounded on the fact that due to unpredictable rain, maize yield in the area has significantly dropped (GoK, 2009). Even though rainfall amounts and distribution have often been below the required amount to support maize growing, rain-fed agriculture constitutes 70% of rural employment and economic activities (GoK 2009). The main issue in Matungulu area has been revealed to be how to deal with the unpredictability or rainfall and unprecedented drought.

3.2 Research Design

Research design is a plan of action to be carried out in connection with a proposed research work. Mugenda and Mugenda (2003) argue that research design can be classified based on the purpose, method of analysis and research type. The study used an exploratory survey design that enabled a visit to the region in search for responses from the target population. According to Russell (2005), exploratory research aids in establishing the best research design, data collection method and selection of subjects. The survey research design identified the respondents by selecting the appropriate stakeholders in the study area. The essential plan behind research design was to gauge variables by asking the respondents questions and then to scrutinize interactions among the variables. The research design endeavor was to capture the manner or prototype of the questions being sought.

3.3 Target Population

Target population is a complete set of individuals, cases or objects with some common observable characteristics (Mugenda and Mugenda, 2003). The population of respondents constituted the bulk of the population in the region and was picked in order to evaluate how factors affecting climate affects maize yield in the region and their effects on the production quantities that target population in the area. The target population for the study was all the 33,808 inhabitants of Matungulu West area of Machakos County (KNBS, 2010). This population is distributed in the nine sub-Sub-Location of Matungulu West area of Machakos County.

3.4 Sample Size Determination

According to Mugenda and Mugenda (2003) sample population is a representative population selected from the accessible population to act as a representative. The researcher applied the formulae designed by Yamane, (1967) in determining the sample size.

$$n = \frac{N}{1+N(e)^2}$$

Where n = Sample size

N = Population size

e =level of precision which is 0.05%

The study area has 7792 household thus using the above formula, the sample size will be calculated as follow:

$$n = \frac{7792}{1+7792(0.05)^2}$$

From the calculation above, the required sample size is 380 households.

3.5 Sampling Procedure

Kothari (2004) defines sampling procedure as a definite plan for obtaining a sample from a given population. The study employed the sampling techniques explained below:

3.5.1 Systematic Random Sampling

Systematic random sampling was used to select the households where questionnaires were administered. A starting point was to be randomly chosen, and thereafter the sample was determined using a sampling interval. Every 8th house hold was visited with replacement so as to avoid bias and give everyone an equal chance.

3.5.2 Purposive Sampling

Purposive sampling was used to sample the key informants from the relevant institutions for instance, Machakos County Meteorological Department and National Cereals and Produce Board Machakos Depot.

3.6 Data Collection Research Instruments

Different types of data collection tools were used to allow for triangulation. Research instruments are the techniques and materials used by the study to collect information (Gillham, 2000). The study used questionnaires, interview schedules and observation to collect required data. Both quantitative and qualitative data was collected in the study. Questionnaires were used to collect qualitative data from households of the study area. The questions that were asked were identical in order to solicit homogeneous information from all households. Qualitative data was collected using interview schedules to gather firsthand information from the key informants. The interviews followed a semi-structured format, with an in-depth focus in regards to the area of expertise of the informant. According to Yin (2004), interviews are important to assist the research to get more information on a particular area of interest in the study. Additionally, observation was used and results included illustrative pictures taken in the field.

3.6.1 Primary Data

Key Informant and Personal Interviews

The Key Informant interviews were focused on Machakos County Metrological Department and the National Cereals and Produce Board Machakos Depot. The interviews were aimed at getting insights into various climate variability scenarios and the effects on maize yield in the study area. Questionnaires were administered to small scale maize farmers in Matungulu West with the objective of getting information about the impacts

of climate variability on maize yield and what the mechanism employed by the farmers in the area to cope and adapt to the effects of climate variability on maize yield.

The study formulated an open ended questionnaire so that reliable information could be collected. The questions were asked in a way that their responses would answer the objectives of the research.

3.6.2 Secondary Data

Secondary data was obtained from desk top research conducted. This focused on publications by the Ministry of Agriculture as then was, books and articles that have information on maize production in Matungulu West in Machakos County for the past thirty years, climatic conditions and how it is affecting maize production and different theories on the adaptation and coping measures employed by different household in the study area.

Maize yield data was sourced from the National Cereal and Produce Board Machakos Depot. Climate data for the study was obtained from Machakos County Metrological Department.

3.7 Validity and Reliability of Research Instruments

3.7.1 Validity

Mugenda & Mugenda, (2003), defined validity as the degree to which results obtained from analysis of the data actually represents the phenomenon under the study. If the data is true reflection of the variables, then inferences based on the data will be accurate and meaningful. For the study to be rated as bearing the desired quality, the data collection procedures must be proper which in turn rely on the validity of the instruments used.

Hypothesis testing validity was used to test the validity of the research tools. The questionnaire was prepared to capture the relationship between the measured concept (independent variable) and other concepts (dependant variables). From this theory, it was derived a hypothesis stating a positive correlation between climate variability and maize yields.

3.7.2 Reliability

Reliability of research instruments has been defined by a study carried out by (Mugenda & Mugenda, 2003), as the measure of the degree to which a research instrument yields consistent results. The study states further that to maintain the consistent results the researcher will employ the test- reset technique and the split- half technique to ensure the instruments used will be free of random errors.

Short Note on SPSS was used to test the reliability of research tools. A pilot test was used to collect data from 20 respondents from Matungulu West not included in the sample. The data collected was analyzed using Statistical Package for Social Sciences.

3.8 Data Analysis and Presentation

The data collected from the field was analyzed qualitatively and quantitatively. The data collected was screened to identify omissions and removal of non-answered questions. For qualitative data analysis, coding and entry was done using an electronic spreadsheet with the aid of Statistical Package for Social Sciences. The data generated was analyzed using descriptive and inferential statistics. Qualitative data from interview schedules was analyzed through content analysis. Leedy and Ormrod (2013) confirm that content analysis is a meticulous methodological evaluation of the content of a specific form of material with an intention to identify preconceived notion. The responses from the key informants' interviews was analyzed and presented in a narrative form

according to themes of the study. The temperature and rainfall data analyzed by Statistical Package for Social Sciences was presented using tables and graphs.

RESULTS AND DISCUSSIONS

4.9 Coping Strategies to Climate Variability in Matungulu West

Most (52.2%) of the farmers have reduced or spread risks by replanting with early maturing maize, (26.4%) staggering planting dates, (2.9%) changing crops when replanting, 6.6% grazing of failed parcels of land and 11.9% carrying out varietal selection of stress resistant to suit the prevailing conditions (Table 4.13). This is a finding that corroborates a study by Blench, (2003) which established that farmers come up with coping strategies as staggering planting dates as a temporary measure to cope with climate variability.

However, coping strategies tend to differ from household to household as was established by the study (Table 4.13).

Table 4.13: Coping Strategies by Respondents to Climate Variability in Matungulu West

Coping Strategies	F	%
Replanting with early maturing maize	199	52.2
Staggering planting dates	100	26.4
Changing Crops when replanting	11	2.9
Grazing of failed parcels of land	25	6.6
Varietal selection of stress resistant	45	11.9
Total	380	100

This study corroborates a study by (Alumira, 2002) who stated that there is a broad range of contrasting diversification strategies employed between different types of households headed by either females or males with the ownership or lack of ownership of cattle being a key factor that cuts across household types and which provided considerable additional flexibility.

4.10 Adaptive Measures to Climate Variability in Matungulu West

According to the respondents, an overwhelming (64.8%) stated that they preferred early sowing as an adaptation option while (1.4%) indicated that they were practicing irrigation farming to combat climate variability (Table 4.10)

Table 4.14: Adaptive Measures to Climate Variability in Matungulu West

Measures	F	%	Adaptive
Early sowing	123	64.8	
Plant early maturing maize	111	29.2	
Change crop variety	118	31.1	
Irrigation	5	1.4	
Reduce the size of farm to cultivate	23	6.1	
Total	380	100	

Bantilan and Anupama, (2002) did a study on adaptive capacity in two villages of Aurepalle and Dokur. The found out that most of the wells dug by people in the study area were completely dry and even those areas that practiced irrigation could no longer access water. The study established further that the effects of such adverse weather conditions affected households severely.

This confirms the findings in Matungulu West Sub-Location which established that most households have diversified in ways of adapting to the effects of climate variability. The research finding also confirms the work of Quansah *et al.*, (2010) and

Adger *et al.*, (2007) which established that there are varieties of ways through which communities can adapt to climate variability. The adaptation can range from local to national levels initiatives.

4.11 Hindrance to Adaptation Measures and Coping Strategies

An overwhelming majority (51.1%) of the respondents attribute inadequate information as a major hindrance to adaptation measures while (3.4%) believe that lack of modern technology as a hindrance to adaptation measures and coping strategies (Table 4.15).

Table 4.15: Hindrance to Adaptation Measures and Coping Strategies

Hindrances	F	%
Lack of finances	122	32.1
Poor infrastructure	32	8.4
Inadequate information	194	51.1
Lack of modern technology	13	3.4
Culture and Traditions	19	5.0
Total	380	100

This contradicts the study by EPA, (2013) which indicated that most societies have information relating to climate variability. It is apparent that people lack adequate and required information regarding climate variability and this has compromised the adaptation measures and coping strategies. The study also established that (32.1%) were of the view that finances were the major hindrance to achieving proper adaptation measures and coping strategies.

The study made a conclusion that as it was reported indeed 21.2m people are poor and 7.5m live in extreme poverty as was established by the Kenya Economic Report (KIPPRA, 2009). An underwhelming 5% of the respondents indicated that culture and traditions were the hindrance while

a smaller percentage of 3.4 were of the view that lack of modern technology was the main hindrance. In adapting to climate variability modernization of agricultural activities is paramount

4.11.1: Hypothesis Testing

H₀: There is no significant difference in adaptation measures and coping strategies to climate variability devised by households in Matungulu West, in Machakos County across demographic variables.

H₁: There is significant difference in adaptation measures and coping strategies to climate variability devised by households in Matungulu West, in Machakos County across demographic variables.

Table 4.16: Difference in Adaptation Measures and Coping Strategies

ANOVA ^a					
Model	df	SS	MS	F	Significance F
Regression	1	3.891	1	3.627	.043 ^b
Residual	2	8.199	1.626		
Total	5	18.090			

From the study it can be noted that a p-value of .043 is obtained indicating that the null hypothesis is to be rejected in this scenario and the alternative is picked (Table 4.16). The p-value is less than the set significance level of 0.05. Therefore, it can be

concluded that there is a significant difference in adaptation measures and coping strategies to climate variability devised by households in Matungulu West, in Machakos County across demographic variables.

Bantilan and Anupama, (2002), state that coping strategies applied by small scale farmers depend on risks and vulnerability, which will determine the coping measures to be employed by the farmers. The study established that several parts of India like Aurepalle and Dokur were persistently being affected by the changing climate and they had not employed any meaningful strategy to address these disastrous impacts of climate variability. Most of the wells dug by people in the study area were completely dry and even those areas that practiced irrigation could no longer access water. The study made a finding that the effects of such adverse weather conditions affected households severely. The study made an interesting finding that climate variability also affects income either positively or negatively. In the year the study was carried out, the selected region posed negative results in terms of income having a decline having declined from 91% overall to 41%. This is a significant decline in terms of income and it clear that many households were and continue to feel the effects of climate variability.

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