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CLIMATE CHANGE

EFFECT OF CLIMATE CHANGE ON AGRICULTURAL PRODUCTION: A CASE STUDY OF CHERANGANY SUB COUNTY, TRANSNZOIA COUNTY

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ABSTRACT

The general goal of this research was to determine the effect of Climate Change on Agricultural Productivity in the Cherangany Sub-County of Trans-Nzoia County. To achieve this, specific objectives were: to assess the effect of temperature on agricultural production; to evaluate the effect of humidity on agricultural production; and to estimate the effect of precipitation on agricultural production. The study was informed by The Ricardian Approach Model and the Agronomic-Economic Theory. The study was conducted in the Cherangany sub county in Trans-Nzoia County, Kenya. The study adopted a cross-sectional survey research design. Three hundred and eighty five (385) respondents were issued with questionnaires. Kenya Meteorological Department provided secondary data on temperature, precipitation, and humidity over the past 40 years. The findings of the study were: farmers in Cherengany Sub County have adequate experience in farming and therefore they had experience in identifying the adverse change in climate and take the necessary measures. Majority have adequate land for agricultural production, which they are utilizing for growing crops and animal rearing, Farmers in the sub county majorly produce cash crops like Maize and tea for commercial production in the county, other farmers practice subsistence farming for food security within the households. While dairy farming is being practiced in the sub county due to its good weather, however, climatic change has affected both their crops and animal farming directly or indirectly, the increased rain submerging their crops and causing animal diseases to their livestock. The research concluded that; County government to support agriculture for adaptation and diversification across specific farming systems to avoid losses farmers are undergoing as a result of effects of climatic change on agricultural production through various policy measures in the sector. The study recommended that the county government in partnership with the national government to support specific studies, demonstration initiatives and case studies in agricultural on technology innovation/adaptation in various sub-sectors, farming systems and value-chains.

Keywords: *Climate Change & Agricultural Production*

1.1 Introduction

Agriculture is the backbone of Kenya's economy contributing 27% and 24% indirectly and directly respectively. In the rural areas, this sector accounts for 65% of all the informal employment. It is clear that Kenya faces notable challenges as far as food security is concerned, mainly resulting from overdependence on agriculture that is rain-fed (Government of Kenya, 2013). The number of people who required food assistance in Kenya rose to approximately 3.8 million in 2009/2010 from 650,000 in 2007 (Government of Kenya, 2013). Currently, it is approximated that more than 18 million people are starving with no immediate hope for assistance from the state (Ngwiri, 2016). Agricultural areas that are marginal and pastoral are highly vulnerable to impacts arising from change in climate. Livelihood opportunities as well as the resilience ability for communities have been eroded, as a result giving rise to coping strategies that are undesirable. This background expresses the need to assess and estimate the impact on agriculture resulting from change in climate incorporating both crop and livestock production. The result in doing so will broaden and extend the understanding on agricultural productivity and climate change in Kenya. This will give rise to informed levels of decision making, thus significantly reducing poverty and promoting sustainability in development.

In Kenya's Vision 2030, the agriculture sector has been selected as a sector that will contribute 10% of the country's annual budget under the economic pillar. In order to attain this, there is the urgent need to transform small holders in agricultural sector to be able to innovate, thus being able to operate optimally for improved production (Government of Kenya, 2009). Kenya's agriculture mainly depends on rainfall in almost the entire country. Only 1.7 per cent of the total area of land in the country under agriculture is under irrigation (Agricultural Sector Development Strategy, 2009). Fluctuating agricultural productivity however is a major concern considering the fast-growing population in Kenya. Marginal as well as pastoral agricultural areas are susceptible to the effects of changing climatic patterns. In Kenya, agriculture remains the sole source of food, hence a notable basis of national economy.

1.2 Statement of the problem

Food policy faces a critical challenge in addressing hunger and poverty amidst emerging forces such as climate change. Climate change threatens food security globally, affecting availability, access, and quality of food through temperature increases, precipitation pattern changes, and extreme weather events (Thurston & Walls, 2016). These impacts, comparable to those seen in the United States, are compounded by population growth and limited agricultural resources in developing countries (USDA, 2016). Interruptions in food distribution and transportation, as evidenced by events like the 2012 Mississippi River drought, exacerbate food safety concerns and hinder market access for farmers (Thurston & Walls, 2016).

Livestock production plays a crucial role in global food security, yet its sustainability is threatened by climate change. Livestock contribute significantly to protein and nutrient supplies but can strain resources and exacerbate environmental degradation (Mottet et al., 2017). Gender disparities in livestock ownership and income distribution further compound food security challenges, particularly in rural communities (FAO, 2011b). Despite their multifaceted benefits, livestock systems must adapt to climate change impacts to maintain their contributions to agriculture and food security (Gebresenbet & Kaumbutho, 1997).

In regions like the North Rift of Kenya, where agriculture is a cornerstone of livelihoods, climate change poses significant risks to food production and poverty alleviation efforts. Limited research

on the local impacts of climate fluctuations underscores the urgency for comprehensive studies to inform adaptation strategies (ASDSP, 2014). Encouraging sustainable agricultural practices, such as minimizing tillage and integrating livestock, can enhance resilience to climate change and improve agricultural productivity (Wheeler & Braun, 2013). By filling knowledge gaps and implementing environmentally friendly farming practices, this study aims to understand how climate change affects agricultural productivity in the Cherangany Sub-County of Nzoia County and offers potential solutions to mitigate its adverse effects.

1.3 Study Objectives

The main study objective was to determine the effect of Climate Change on Agricultural Productivity with specific reference to Cherangany Sub-County, Trans-Nzoia County, Kenya.

The specific research objectives were:

i. To determine the effect of temperature on agricultural production in Cherangany Sub-County, Trans-Nzoia County, Kenya.
ii. To evaluate the effect of humidity on agricultural production Cherangany Sub-County, Trans-Nzoia County, Kenya.
iii. To assess the effect of precipitation on agricultural production in Cherangany Sub-County, Trans-Nzoia County, Kenya.

1.4 Research Questions

The study was guided by the following research questions;

i. What is the effect of temperature on agricultural production in Cherangany Sub-County, Trans-Nzoia County, Kenya?
ii. To what extent does humidity affect agricultural production in Cherangany Sub-County, Trans-Nzoia County, Kenya?
iii. In what ways does precipitation affect agricultural production in Cherangany Sub-County, Trans-Nzoia County, Kenya?

2.1 Theoretical Foundation

2.1.1 The Ricardian Approach Model

The vulnerability of the sector of agriculture to both climate change as well as variability is well indicated in literature. It is agreeable that changing temperature and the resulting precipitation will give rise to changes in land and water regimes thereby affecting agricultural productivity. Early crop production models of the impact of change in climate on agriculture employed production function approach (Rosenzweig & Iglesias, 1994). Impact on economy from climate change is overstated by these models (Mendelsohn et al., 1994). The method depended on complex crop-yield models, and rather failed to put into account all activities pertaining to agriculture in farms (used just major grains) and did not include livestock. Also, farmers changing inputs in substitutions or adjustments to reduce their vulnerability to climate change inherently biased them of adaptation measures.

Ricardian method is one approach taking the adaptation into account (Mendelsohn et al., 1994). The Ricardian model makes an estimation of climate impacts through comparison of the net revenues of farmers in various climates across space. Since farmers in various places have adjusted to their unique conditions as an adaptation, it is implicitly captured by the Ricardian approach. Initially, the Ricardian model was applied by part of developed countries, and the United States

agriculture in particular (Adams et al., 1998; Mendelsohn et al., 1994; Polsky, 2004 and Polsky and Easterling, 2001).

Also, the model has been applied to a wider African context. A part of these recent studies includes Iheoma (2014), Kurukulasuriya and Mendelsohn (2008). Van Passel et al. (2012), Massetti and Mendelssohn (2011), Seo and Mendelsohn (2008), Kabubo-Mariara and Karanja (2006) and Kurukulasuriya and Mendelsohn (2008). Majority of these studies indicates that, agricultural activities in majority of the developing countries are extremely susceptible to climate change. They revealed that the impact's magnitude and direction differ depending on the locale.

Massetti and Mendelssohn (2011) states that majority of models that are non-market valuation like the Ricardian model are estimated using cross-sectional methods with yearly analysis of data. Even though multiple years of data ought to raise the robustness of methods like that repeated cross sections suggest the results are relatively stable. Iheoma (2014) and Kurukulasuriya and Mendelsohn (2008) argue that repeated cross sections do not properly specify the model. Because it implicitly considers the subject's adaptation efforts, the Ricardian model is considered as the ideal model for weighing the implications of climate change on agricultural and livestock production. (Van Passel et al. 2012).

In Kenya, Kabubo-Mariara and Karanja (2006) used Ricardian approach in a study investigating the extent to which agriculture has been affected by climate change. The study reveals that change in climate has significant impact on agriculture in Kenya. It further shows that medium as well as low potential zones have high chances to be affected from raised temperature emanating from global warming as compared to fall in precipitation. The study result shows that climate change has an effect on agricultural produce. Increased levels of precipitation have the impact of increasing net crop revenue.

2.1.2 Agronomic-Economic Theory

The Agronomic-Economic Theory of Climate Impact on Agriculture is a conceptual framework that has evolved over time through the contributions of numerous scholars and researchers in the fields of agronomy and agricultural economics. This framework integrates insights from both disciplines to understand how climate variables affect agricultural productivity and economic outcomes. It posits that changes in climate factors such as temperature, humidity, and precipitation directly impact crop physiology and yields, while also influencing agricultural practices, land use, and economic decisions made by farmers and policymakers (FAO, 2017).

The relevance of this integrative approach lies in its comprehensive perspective on the multifaceted impacts of climate change on agriculture. By considering both agronomic and economic aspects, it provides a holistic understanding of how climate variability and change can affect agricultural systems. This makes the framework particularly applicable to studies like yours, which aim to assess the effects of specific climate variables on agricultural production in Cherangany Sub-County, Trans-Nzoia County, Kenya. The Agronomic-Economic Theory enables the examination of not only the direct impacts of temperature, humidity, and precipitation on crop growth and yields but also the broader implications for farming practices, market dynamics, and rural livelihoods. This comprehensive approach can help identify adaptive strategies and policy interventions to enhance resilience and sustainability in the face of climate change.

2.2 Empirical Review

The empirical literature extensively explores the impacts of climate change on agriculture, emphasizing temperature, humidity, and precipitation as key variables. Climate change, defined by the IPCC as significant alterations in atmospheric conditions over extended periods due to natural or human-induced factors, poses threats to agricultural productivity globally (Nkondze et al., 2014). Temperature changes, in particular, have been studied extensively, with research consistently indicating negative impacts on crop yields at various scales, necessitating region-specific adaptation strategies to ensure future food security (Zhao et al., 2016; Liu et al., 2016; Lesk et al., 2016). Rising temperatures not only directly affect crop growth but also exacerbate indirect impacts such as increased water stress and changes in pest and disease dynamics, further challenging agricultural systems (Abdela & Jilo, 2016).

Animal health is also affected by climate change, both directly and indirectly, through alterations in the host-pathogen-environment system (Peterson, 2006). Vector-borne diseases are particularly influenced by climate fluctuations, with changes in temperature and precipitation patterns expanding the geographical and temporal distribution of disease vectors and pathogens (Paz, 2015). This has significant implications for public health, livestock industry income, and biodiversity conservation (Pinto et al., 2008). Humidity, another critical climatic factor, directly impacts plant water relations, photosynthesis, and disease occurrence, affecting crop productivity (TNAU, 2016). High humidity levels can lead to reduced grain production due to negative impacts on pollination and increased pest prevalence, highlighting the complex interplay between climate variables and agricultural outcomes (TNAU, 2016).

Changes in precipitation patterns, driven by global warming, have profound implications for agricultural systems worldwide. While some regions may experience increased rainfall and potential yield gains, others face decreased precipitation and heightened vulnerability to extreme weather events such as hurricanes and floods (FAO, 2017). Effective water resource management and adaptation strategies are crucial for mitigating the adverse effects of changing precipitation patterns on agriculture, highlighting the need for innovative approaches to water conservation and agricultural practices (FAO, 2017).

2.3 Conceptual framework

A conceptual framework is a diagrammatic exposition of the research problem and, as a result, an explanation of the relationship between several components selected as important to the study (Ngechu, 2006). A conceptual framework is illustrated in Figure 1.

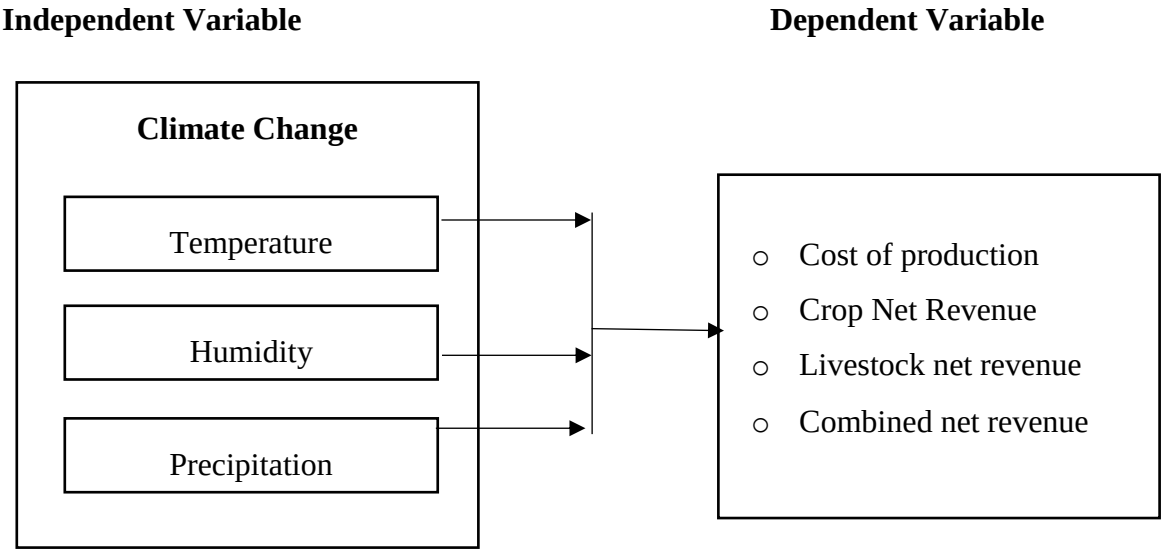

Figure 1: Conceptual Framework

By analyzing trends in temperature variations and rainfall patterns over time in crops and livestock production, potential impacts to net revenue hindering optimal production can be identified and thus enhance resilience.

3.0 Research Methodology

A descriptive survey was used by the researcher. The goal of a descriptive survey was to learn about the nature of the factors at play in a specific scenario, their prevalence, and their relationships (Bell, 1993). The population was as shown in Table 1.

Table 1: Trans-Nzoia population summary

Sub County	Population (Census 2019)	Total Percentage
Cherangany	222,306	23.51
Endebess	105,738	11.19
Kwanza	193,087	20.43
Kiminini	231,191	24.45
Saboti	193,038	20.42
Total	**945,360**	**100.00**

Proportional and random sampling was employed in selecting households during this study. Proportional sampling reduces biasness as well as make sure that particular parts of the population are not overrepresented. Random selection method was done to identify the households. The sampling frame for this study included 385 farmers from several subcounties in Trans Nzoia County.

Because the slum's population is heterogeneous, stratified sampling was employed to reduce study bias and boost the dependability of the findings. A Stratified Random Sample is one in which the population is sorted into relevant strata (subgroups) before being randomly sampled (Beth & Robert 2001). Subjects were chosen for each stratum, and the number of subjects per stratum was decided. Sample size of 385 respondents

Data was gathered from both primary and secondary sources. Data was collected from selected respondents utilizing primary sources with the assistance of professional enumerators. Questionnaires was used to collect primary data. Secondary data for the study was obtained from Kenya Meteorological Department (KMD) and Kenya Agricultural Research and Livestock Organization (KARLO) Kitale. Other major sources of information included Government of Kenya publications, coastal counties websites, dissertations, peer reviewed journals, Institutional websites and textbooks.

4.0 Results and Findings

4.1 Questionnaire return rate

Out of the 385 questionnaires administered to the respondents, 369 (82%) were filled and returned. This was a good response rate. According to Saunders et al. (2003), a response rate of 30 to 50% is sufficient for statistical generalizations. The 16 (18%) questionnaires were not returned. Table 2 shows the response rate for the sample.

Table 2: Questionnaire Return rate

Strata	Administered	Returned
Effects of temperature on agricultural production	220	215
Effect of humidity on agricultural production	156	150
Effect of precipitation on agricultural production	9	4
TOTAL	**385**	**369**

4.3 Gender of the respondents

Farmers were requested to indicate their gender. The results are shown in table 3.

Table 3. The respondents' gender

Gender	Number of the respondents	Percent
Male	205	56
Female	164	44
TOTAL	**369**	**100**

The findings indicated that 205(56%) were male, while 164(44%) were female respondents.

4.4 Farming period of the farmers

The farmers were requested to indicate the period in which they have been practicing farming in Cherengany Sub County.

Table 4: Farming Period

Farming period	Number of respondents	Percent
Less than 5 years	86	23
5-10 years	216	59
11-15 years	37	10
Over 15 years	30	8
TOTAL	**369**	**100**

The findings revealed that most farmers had experience in farming for more than five years (59%), while 23% had experience of less than five years in farming, 10% had experience of 11-15 years, and 8% had experience of over 15 years in farming. This indicated that farmers in Cherengany Sub County had adequate experience in farming.

4.5 Size of the land owned by the farmers

The farmers were requested to indicate the size of the land they own for agricultural production. The table below shows the results obtained.

Table 5: Size of the land owned by the farmers

Size of the land	Number of respondents	Percent
Less than 2 acres	143	39
2-10 acres	211	57
Above 10 acres	15	4
TOTAL	**369**	**100**

The findings indicated that majority of the farmers owned between 2-10 (57%) acres of land, less than 2 acres (39%), while 15% owned more than 10 acres in Cherengany sub-county. This indicates that majority have adequate land for agricultural production, therefore climatic change on agricultural production affected them directed to their output.

4.6 Types of Agricultural activities

Farmers were requested to indicate agricultural activities they are practicing. The table below shows the results.

Table 6. Types of Agricultural activities

	Number of respondents	Percent
Subsistence farming	111	30
Cash crop farming	199	54
Poultry farming	20	5
Dairy farming	30	8
Horticultural farming	7	2
Other farming practices	2	1
TOTAL	**369**	**100**

The majority of farmers practiced cash crop farming (54 percent), subsistence farming (30 percent), dairy farming (8 percent), poultry farming (5 percent), horticultural farming (2 percent), and other farming activities (1 percent) according to the study's findings. This demonstrates that farmers in the Cherangany sub county primarily cultivate cash crops such as maize and tea for commercial purposes, while others practice subsistence farming for food security within their households, and dairy farming is practiced in the sub county due to its favorable climate. Climate change, on the other hand, has had a direct or indirect impact on their crop and animal farming, reducing their profit margin.

4.7 Change in temperature

The farmers were requested to indicate the extend of change in temperature. The results were tabulated as indicated below.

Table 7. Change in temperature

Changes in Temperature	Smaller extend	Small extend	Moderate extend	Great extend	Greater extend	TOTAL
Improved variety	9	20	10	300	30	369
Diversification	10	20	9	40	290	369
Water management	16	41	251	23	18	369
Soil management	148	2	210	5	4	369
Afforestation	102	7	6	250	4	369
Reforestation	214	122	20	10	3	369
Organic fertilizer use	6	15	45	102	201	369
Agro-forestry techniques	121	20	211	7	10	369
Farm mechanization	100	10	232	20	7	369

The findings showed that there was great improved variety of crops and animals as a result of change in temperature, greater diversification to cope with the changing temperature, and moderate water management by the farmers in Cherangany Sub County to combat changes in temperature. There was also moderate soil management by farmers to combat change in temperature, farmers were also satisfied on the great extent of afforestation within the sub county, due to high number of cutting trees and not planting, farmers had smaller extend on reforestation in the sub county. There was greater extend of organic fertilizer use due to high cost of inorganic fertilizer. There was moderate extend of Agro-forestry techniques in the sub county. Farm mechanization was also applied in moderation. Therefore, farmers in Cherangany Sub County are adapting to the changing temperature in the area using different technique in combating the adverse effects of the temperature on both crops and animals within the sub county.

4.8 Change in precipitation

The farmers were requested to indicate the change in precipitation in their sub county. The table below shows results obtained.

Table 8. Change in precipitation

Changes in precipitation	YES (%)	NO (%)
Inundations	1	99
Decline of rains	1	99
Shrinking of rainy season duration	1	99
Late beginning of rains	1	99
Heavy rains	99	1
Early stopping of rains	1	99
Irregular rains	99	1
Strong winds	99	1
Is 50% humidity considered high	99	1
High humidity in your region	99	1
Low humidity in your region	1	99

The findings showed that, as a result of high rain in the region, due to its high level above the ground, the rain did not affect majority of the households, there was high rain in the sub county which occurred irregularly with strong wind causing high humidity in the sub county.

5.1 Conclusion

Agriculture is a critical duty for all counties in the country, both today and in the future, as a source of food, employment, and economic rewards. Support for adaptation and diversification through specific farming systems is thus a strategic choice for avoiding dramatic effects on local farmers, such as abandoning small-scale development and relocating to other regions or adjacent urbanized areas, as well as a significant impact on the industry as a whole, with negative economic and societal ramifications (food-supply). In circumstances where relocation is already occurring, creating sustainable (peri-urban livelihoods is crucial to averting societal instability (and there are many).

Despite the fact that our study identified a number of policy interventions, both sector-specific and for combating climate change in general, to enhance the acceptance and effectiveness of such interventions, more attention should be devoted to the individual needs of farming systems within and across Sub Counties. Existing lessons acquired – both triumphs and failures – must be shared more frequently throughout the community in order to increase mutual knowledge and identify more successful and targeted policy measures across the Sub County and other counties in general. Sharing lessons learned from current international trends in mitigating climate change in order to boost agricultural production in the county should be a top priority.

6.1 Recommendations

The study recommends the following:

Engage more actively with regional decision-makers and the media– through data exchange between sectoral and county data collection bodies, in order to better assess the differences and commonalities across the county, sector value chains (including post-harvesting and soil management), and policy that cuts across sectors (to make the most of available knowledge and financial resources and strengthen National Adaptation Policies across the region).

The county government will fund specific studies, demonstration initiatives, and case studies in agricultural on technology innovation/adaptation across sub-sectors, farming systems, and value chains (including mobilizing funding/financing mechanisms to foster technological innovation in the area), Identify and distribute proven technology and management techniques, as well as the most successful technical recommendations for regional implementation.

The county government to increase investments in agricultural productivity in the county through provision of farm mechanization, fertilizers, educating farmers and providing incentives for the farmers.

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