Journal of Agriculture, Aquaculture, and Animal Science (JAAAS)
ISSN: 3079-2533 (Online)
Volume 2 Issue 1, (2025)
https://doi.org/10.69739/jaaas.v2i1.466
https://journals.stecab.com/jaaas

Published by
Stecab Publishing

Research Article

Effect of Climate Change on Agricultural Productivity: A Study of Choma District Zambia

*[1]Mukamaambo Charlton, [1]Musenge Danny

About Article

Article History

Submission: March 16, 2025
Acceptance : April 20, 2025
Publication : May 24, 2025

Keywords

Agriculture Practices, Climate Change, Food Security, Mitigation

About Author

[1] School of Engineering, Information and Communications University, Itezhi Tezhi, Zambia

Contact @ Mukamaambo Charlton
cmukamaambo@gmail.com

ABSTRACT

Systems involved in the production of food should evolve in order to sustain future demands in food supply, due to changes in climate being experienced in recent decades. Climate change has handicapped farming systems while the global is trying to increase production by the use of environmentally friendly farming techniques. The study aimed at finding out causes of environmental degradation, ascertaining the impact of the greenhouse effect on food security as well as establishing possible agricultural practices to mitigate climate change. The study looked at the effect of climate change on agriculture productivity in Choma District Southern Province. The teachers and school managers for the primary schools under study were selected using a purposive sampling technique. The study used both quantitative and qualitative approaches. Quantitative approach adopted a causal research method while qualitative used a questionnaire to solicit responses from farmers and extension officers. Data was analyzed quantitatively, and it was achieved using structured questionnaires, where respondents chose their response from those already suggested by the researcher. However, respondents highlighted some of the challenges that made them not implementing the agricultural practices. Some of the challenges were: lack of finance to implement some agriculture practices like efficient irrigation; lack of technical knowhow; missing information due large catchment areas extension officers have to cover. In addition, it was established that one-on-one as a means for extension education was not feasible in large catchment areas.

Citation Style:

Charlton, M., & Danny, M. (2025). Effect of Climate Change on Agricultural Productivity: A Study of Choma District Zambia. *Journal of Agriculture, Aquaculture, and Animal Science, 2*(1), 195-202. https://doi.org/10.69739/jaaas.v2i1.466

1. INTRODUCTION

In recent years, the devastation of weather pattern shift on harvest yield has become an object of scrutiny worldwide. The consequences of weather pattern shift on farm management are diverse complex with positive as well as negative consequences. Greenhouse effect, otherwise termed as climate variability, is now widely regarded as the most significant danger of our time (Bloem *et al.,* 2010). Climate variability refers to shifts in climate that exceed normal fluctuations, driven by a combination of natural and external influences. Understanding the extent to which climate change impacts agriculture and its distributional effects has become a top priority for researchers in order to inform climate mitigation and adaptation policies. With its effects on food insecurity, access to clean water and sanitation, population migration, and the threat of more natural and man-made disasters, climate change has made the question of how our planet can support and feed this population the most pressing one in history (Crowley, 2000; Paehler, 2007). In its fourth report on climate change (2007), the UN Intergovernmental Panel on Climate Change (IPCC) provided substantial scientific evidence regarding its effects, which are now widely acknowledged.

Despite Asia's low greenhouse gas emissions, climate change has already had a negative impact on the region's economic development and growth (Gouldson *et al*., 2016). Water is becoming scarcer in more areas due to climate change. Extreme precipitation, such as excessive rainfall or protracted drought, combined with inadequate sanitation systems and a lack of safe water, increases the risk of contracting diarrheal and enteric infections from pathogenic microbes. Extreme weather events like droughts and floods are becoming more frequent due to climate change, which has a direct impact on agricultural production and productivity (Jain, 2007; Thurlow *et al*., 2012). Water shortages in already water-stressed areas are made worse by global warming, which also raises the possibility of ecological droughts making ecosystems more vulnerable and agricultural droughts harming crops. Villages and towns that rely on the water that melts from snow-capped mountains may experience water shortages and drought. Destructive sand and dust storms that can transport billions of tons of sand across continents can also be triggered by droughts. As deserts grow, there is less space available for food production. Nowadays, a lot of people regularly run the risk of not getting enough water. The quality of the food produced is another area that is impacted by climate change. Temperature increases and rainfall fluctuations have had a detrimental impact on crop growth and development (Rezaei *et al*., 2018; Asseng, 2019). The production of food should be positively impacted by the fact that CO_2 actually promotes plant growth and photosynthesis; however, recent studies have revealed that elevated CO_2 produces plants with lower protein and mineral content and higher carbohydrate concentrations. Food quantity is adversely affected by deteriorations in food quality. For instance, if the nighttime temperature rises by 2°C above the critical temperature of 24°C, rice yield and biomass will decrease by 16–52% (Yang *et al.* 2017). The vigor and development of seedlings can be significantly impacted by the concentrations of certain nutrients in seeds, as several studies have shown.

It's possible that livestock, crops, and fisheries will be destroyed or become less productive. Eliminating hunger and achieving food security are becoming more challenging due to frequent extreme climate events (Von, 2013). As the ocean's acidity increases, marine resources that sustain billions of people are in jeopardy. variations in the ice and snow cover has interfered with the availability of food from hunting, fishing, and herding in many Arctic regions. Reduced water and grasslands for grazing due to heat stress can impact livestock and result in decreased crop yields. As temperatures rise to the growth inhibition limit (35°C), hot-temperature fruits and vegetables like tomatoes, peppers, and watermelons that need hot temperatures to grow usually grow more quickly and have higher sugar content. High temperatures can cause flowers on some vegetables, such as lettuce, green onions, and onions, to split. While there are yield increases for sugar beets, maize, and wheat in higher altitude and elevation regions, climate change has been found to decrease yields for staple crops like maize and wheat in lower-altitude regions (IPCC, 2014; IPCC, 2019).

The factors that cause and maintain poverty are exacerbated by climate change. Because it ignores the indirect effects of climate change, such as crop conversion and input factor adjustments for adaptation, the agro-economic model, which analyzes the economic impact of climate change using the crop production function, has the problem of underestimating. Climate change is predicted to widen the poverty gap, increase crop failures, alter the length of the growing season, and reduce water availability by 13 percent by 2050 in Zambia, according to some estimates already in place (Ngoma *et al*., 2019; Ngoma & Hamududu, 2019; Mulenga *et al*., 2018).

The expansion of the areas available for the production of tropical and/or subtropical crops, the expansion of two-crop farming due to the extended cultivation period, the decrease in winter crop damage from low temperatures, and the increase in crop productivity due to the fertilization effect caused by the increase in carbon dioxide concentration in the atmosphere are some of the positive effects of global warming. Reduction of heating cost for agricultural crops grown in the protected cultivation facilities.

1.1. Problem statement

It is clear enough that different nations are facing numerous difficulties as a result of climate change. The overall coordination and mainstreaming of climate change in national development planning processes was entrusted to Zambia by its successive governments and the Ministry of National Development and Planning. This is to encourage research and development to enhance comprehension, decision-making, and reporting to the Council of Ministers on the nation's progress in implementing climate change programs. Poor crop productivity (low quantity and poor quality) is one of the issues that many nations are facing as a result of climate change. This has led to a significant discrepancy between Zambia's overall population growth and crop production. Therefore, it is imperative that new agricultural policies be put into place as soon as possible in order to address these issues. New farming methods must also be implemented in order to improve food security, which is declining in opposition to population growth. Food and water resources, which are essential for many people's livelihoods in

Africa, are impacted by climate change.

1.2. Purpose of the study

The purpose of this study is to examine how crop productivity is affected by climate change. Because of its detrimental effects on agricultural productivity, climate change has recently gained international attention. However, this field of study is still in its infancy, and more thorough research is needed to fully understand how climate change affects agricultural productivity.

2. LITERATURE REVIEW

This chapter brings out a review related literature not only from Zambia but also from other parts of the world. Agricultural production is characterized by a special risky environment, as it presents natural and climatic risks, which are dangerous and highly affect the final results of the activity (Chandio *et al.*, 2020b). It is accepted that developing countries are more vulnerable to climate variations and have adaptation issues due to the scarcity of capital, limited capital resources, poor technological implements, scarce arable land
and high dependence on agriculture (Mendelsohn *et al.*, 2006; Stern, 2006; Nelson *et al.*, 2009). Climate change affects food availability through its adverse impacts on crop yields, and fish and livestock productivity, especially in Sub-Saharan Africa (SSA) and South Asia, where most of the food insecure people live. Indeed, Zougmoré *et al.* (2018) suggest that without appropriate interventions, climate change and variability will affect agricultural yields, food security and add to the presently unacceptable levels of poverty in sub-Saharan Africa". The effects of Climate Change will be particularly severe in regions where agriculture is predominantly rain-fed such as in southern Africa, which makes it highly vulnerable to climate fluctuations and droughts (Adhikari *et al.*, 2015; Cooper *et al.*, 2008; Muchuru & Nhamo, 2019). Webersik and Wilson (2009) put that "African economies are closely linked to natural resources and rely heavily on agriculture, largely rain fed. It is predicted that Africa will be particularly vulnerable to climate change and climate variability associated with biodiversity loss, food insecurity, water scarcity and an increase in drought frequency". Climate Change will reduce the yields and productions of the main staple crops such as rice (Akinbile *et al.*, 2015; van Oort & Zwart, 2018), wheat (Trnka *et al.*, 2019) and maize (Davenport *et al.*, 2018; Freduah *et al.*, 2019; Murray-Tortarolo *et al.*, 2018; Waha *et al.*, 2013), Climate Change is also predicted to affect livestock productivity (Godber & Wall, 2014; Mare *et al.*, 2018; Naah & Braun, 2019). Ramasamy (2010) put that "Rising temperatures, more intense droughts, floods, and greater weather variability all mean productivity losses to crops and livestock".

Some studies also report an increase in the incidence of animal diseases that is attributed to Climate Change (Hussain *et al.*, 2016). Furthermore, the impacts of Climate Change on crops and livestock are strongly linked; for instance, the decrease in the growth of forages reduce livestock weight gains (Butt *et al.*, 2005). Further studies also analyse the potential adverse effects of Climate Change on fisheries (Ding *et al.*, 2017; Lam *et al.*, 2012; Lauria *et al.*, 2018). Referring to the Ganges-Brahmaputra-Meghna (Bangladesh/India) and the Volta (Ghana) deltas, Lauria *et al.* (2018) suggest that "changes in temperature and primary production could reduce fish productivity and fisheries income especially in the Volta and Bangladesh deltas".

In recent years, stakeholders have made numerous efforts to mitigate the impact of climate change on the production of safe, nutritious, and adequate food globally. In Sub- Saharan Africa, the most promising efforts to this end are the mass adoption of Climate Smart Agriculture across the region, the deployment of appropriate technology such as push–pull technology, and the establishment of collaborative partnerships among key stakeholders in agriculture. Collaboration among stakeholders streamline the adoption and implementation of appropriate policies such as CSA, which solves the problem of water scarcity and drought through irrigation and farming methods that retain soil moisture (Branca *et al.*, 2021). Many researchers have found that crop rotation can effectively improve the climate resilience of crops through the enhancement of water dynamics, soil health, and biological conditions in planting systems. Bowles *et al.* (2021) supported the view that diversified crop rotation can effectively improve soil health and break the cycle of herbivores, weeds, and pathogens, thereby increasing crop yields and bringing high economic benefits. Irrigation is the most used means of agricultural intensification and will stay a cornerstone in the domain of food security policies towards climatic variability. In fact, about 17% of agricultural land worldwide is irrigated, this 17% accounts for about 40% of the total global world food harvest (FAO, 2002).

3. METHODOLOGY

Using a mixed methods research design, this study thoroughly examines how climate change affects agricultural productivity by combining quantitative and qualitative methodologies. Both quantitative and qualitative methods were employed in the study. While the qualitative approach used a questionnaire to gather responses from farmers and extension agents, the quantitative approach used a causal research method. Quantitative data analysis was accomplished through the use of structured questionnaires, in which participants selected their response from pre-suggested options by the researcher. Purposive sampling is the sampling technique used in this study, with a focus on farmers in Choma District who are from Mbabala, Macha, and Mapanza. Participants will be representative of the population affected by climate change's impact on agricultural output thanks to this focused approach. Each area contributes equally (15 farmers per area), for a total sample size of 45 farmers. This study uses a variety of data collection methods to obtain thorough insights into how climate change affects agricultural productivity surveys.

Below is the data validity and reliability on the first objective which was to establish the possible agriculture practices to mitigate climate change.

The objective is valid because it directly addresses a pressing global concern – the need to mitigate climate change while ensuring food security. By exploring agricultural practices, the research can identify effective strategies for reducing the agricultural sector's contribution to climate change.

The research objective is built on a foundation of scientific

evidence. Many studies have shown that practices like crop diversification, organic farming, reduced tillage, and agroforestry can significantly reduce greenhouse gas emissions from agriculture. For example, conservation agriculture, which involves reducing tillage, can increase carbon sequestration in the soil, effectively drawing down atmospheric CO_2.
The second objective was to ascertain the effect of climate change on food security. The validity is that the research objective directly addresses a pressing issue of global concern, making it relevant and important for policy-making, resource allocation, and adaptation strategies. The reliability on the same objective is that it is the link between climate change and food security is well-established through decades of research and global observations. Numerous studies have documented the negative impacts of climate change on crop yields, livestock, and overall food systems.
The last objective was to establish the possible agriculture practices to mitigate climate change. The reliability is that Many agricultural practices have quantifiable impacts on greenhouse gas emissions and carbon sequestration, making it possible to measure the effectiveness of different approaches. The validity on the same objective is it can be measured by tracking changes in greenhouse gas emissions, soil health, and crop yields. It is achievable through the development and implementation of innovative practices.

3.1. Methods and materials

Using a mixed methods research design, this study thoroughly examines how climate change affects agricultural productivity by combining quantitative and qualitative methodologies. Both quantitative and qualitative methods were employed in the study. While the qualitative approach used a questionnaire to gather responses from farmers and extension agents, the quantitative approach used a causal research method. Quantitative data analysis was accomplished through the use of structured questionnaires, in which participants selected their response from pre-suggested options by the researcher. Purposive sampling is the sampling technique used in this study, with a focus on farmers in Choma District who are from Mbabala, Macha, and Mapanza. Participants will be representative of the population affected by climate change's impact on agricultural output thanks to this focused approach. Each area contributes equally (15 farmers per area), for a total sample size of 45 farmers. This study uses a variety of data collection methods to obtain thorough insights into how climate change affects agricultural productivity. surveys.

4. RESULTS AND DISCUSSION

Based on the responses to the questionnaire that farmers in Choma District completed, the following conclusions were drawn.

4.1. Background information of participants

Table 1. Sex of respondents

Gender	Frequency	Percentage
Male	19	47.5
Female	21	52.5
Total	**40**	**100**

Table 1. above displays the respondents' gender distribution. Based on the table, it can be inferred that males with ages 19 (19) out of 40 (53.33%) made up the majority of responders. The male respondents made up forty-six percent of the total, with fourteen (21) out of forty respondents being male.

4.2. Causes of climate change

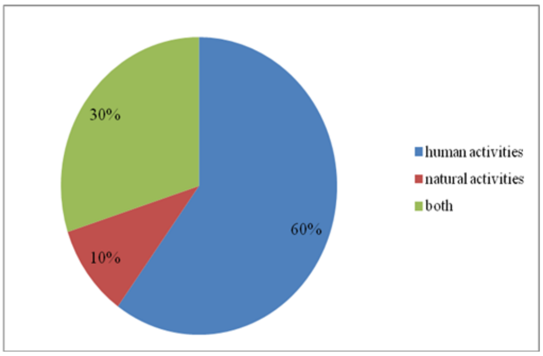

Figure 1. Causes of climate change

According to Figure 1 above, 24 out of 40 respondents, or 60%, stated that industrialization and mechanized farming were the main causes of climate change. Man-made greenhouse gases from burning fossil fuels for electricity, automobiles, trains, airplanes, homes, gas flaring at oil fields like those in Nigeria, and other sources have been shown to be the cause of climate change (Paehler, 2007). Deforestation and land use also increase the pressure on greenhouse gases. Twelve out of forty respondents, or thirty percent, stated that both natural and human activities were to blame for climate change, while four out of forty respondents, or ten percent, stated that emissions from the soil were the cause of climate change. There are two types of causes for climate change: natural and man-made (Crowley, 2000; Paehler, 2007).
Agriculture accounts for 30–40% of anthropogenic greenhouse gas emissions, according to Hornton and Lipper (2013). According to Gebreegziabher *et al.* (2014), developing nations account for three-quarters of agricultural greenhouse gas emissions, and by 2050, this percentage could surpass 80%. According to a FAO (2014) report, the expansion of total agricultural outputs was the primary cause of the notable 14% increase in greenhouse gas emissions in developing nations between 2001 and 2011. About half of the world's emissions of

methane (CH_4) and nitrous oxide (N_2O), two of the most potent non-CO_2 greenhouse gases, come from agriculture, according to the World Bank (2015). Compared to CO_2, these non-carbon greenhouse gases have stronger greenhouse effects and last longer.

As stated by Denman (2007) Study from Ethiopia reported that farmers widely used huge amount of chemical fertilizer to boost their product and considered as one of the main activities to adapt Climate Change. Additionally, the study found that farmers only took into account the detrimental effects of agrochemicals on their crops. This suggests that farmers are only concerned with their crops and choose the best conditions for fertilizer application, not the negative effects fertilizers may have on the environment. All things considered, the primary human source of nitrous oxide emissions is agriculture.

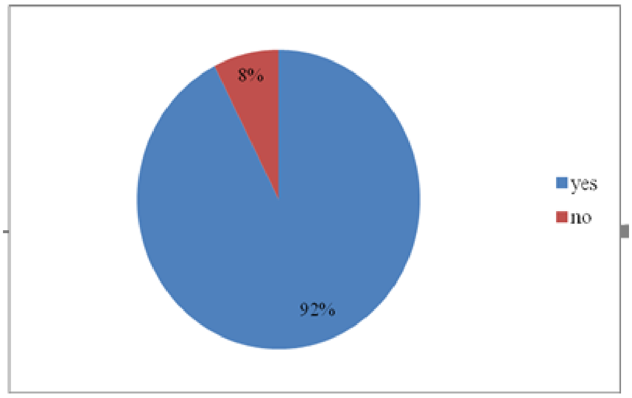

Figure 2. Burning of residues after land clearing.

According to Figure 2 above, 37 out of 40 respondents, or 92% of the sample, stated that crop residues were burned after the land was cleared for appropriate ploughing, whereas 3 out of 40 respondents, or 8% of the sample, stated that crop residues were not burned because they were considered manure. As a rapid and labour-efficient method of getting rid of rice, wheat, maize, and sugarcane crop residues, farmers favour burning them. As it is reabsorbed during the following growing season, emissions of CO_2 from burning crop residues are regarded as neutral. In addition to aerosol particles, burning biomass from forest fires and burning crop residues is a significant source of carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4), volatile organic compounds (VOC), nitrogen oxides, and halogen compounds (Tubiello *et al.*, 2013).

4.3. Effects of climate change

Table 1. Demonstrates any weather variations over the previous ten years.

Undecided	No change	Decreased	Increased	Weather
	9		31	Temperature
		40		Rainfall
			40	Drought
		29	11	Flood

Table 2 above shows that 31 out of 40 respondents representing 77.5% said that temperature increased while 9 out of 40 respondents representing 22.5% said that temperature remained the same over the last ten years. Temperature and precipitation variations have impacted global aggregate wheat and maize yields, contributing to lower crop yields in numerous nations (Porter *et al.*, 2014). All 40 respondents were in agreement that there is vast decrease in the amount of rainfall received and droughts have increased in the last ten years. 29 out of 40 respondents 72.5% said that floods reduced while 11 out of 40 said that the droughts increased in the last ten years. Rising air and sea surface temperatures, retreating glaciers, altered and shifting climate regimes, an increase in extreme events, and sea level changes are all clear indicators of global climate change (IPCC, 2014; Porter *et al.*, 2014).

According to White and Reynolds (2003), the primary reason for lower yields at warmer temperatures is the impact of temperature on shortening the growth cycle, particularly the grain filling phase. High temperatures restrict the amount of solar radiation that plants receive at each stage of development by speeding up crop development. Less solar energy interception is problematic when taken as a whole during the growing season. Using less energy to power photosynthesis (i.e. e. the transformation of carbon dioxide into organic compounds), matured plant biomass falls short of potential levels due to smaller and less numerous plant structures (e.g., leaves) (Sibma, 1970; Duncan *et al.*, 1973; Stone, 2001). It has been found that heat or drought stress during the flowering and pollination stages of maize silk-tasseling can lower yields by up to 7% per day of stress, which is more than the yield reduction for all other possible climatic stresses (Shaw, 1977).

4.4. Agricultural practices to mitigate climate change

Table 2. Shows farming practices to mitigate climate change in Zambia

Climate change mitigating farming practices	Strongly agree	Agree	undecided	Disagree	Strongly disagree
Use of cover crops	29	4		7	
No tillage or minimum tillage	31	5		4	
Smart farming	11	16	3		10
Improved irrigation efficiency	33	6	1		
Rainwater harvesting	5	11		15	9

The data presented in Table 3 above indicates that 29 out of 40 respondents, or 72.5 percent, strongly agree that using cover crops could help mitigate climate change, 4 out of 40 respondents, or 10 percent, agree, and 7 out of 40 respondents, or 17.5%, disagree. 31 out of 40 respondents representing 77.5 % strongly agree that use of no tillage or minimum tillage could mitigate climate change, 5 out of 40 respondents representing 12.5% agree that use of no tillage or minimum tillage could mitigate climate change and 4 out of 40 respondents representing 10% disagree that use of no tillage or minimum tillage could mitigate climate change. 33 out of 40 respondents representing 82.5 % strongly agree that improved irrigation efficiency could mitigate climate change, 6 out of 40 respondents representing 15% agree that improved irrigation efficiency could mitigate climate change and 1 out of 40 respondents representing 2.5% were undecided whether improved irrigation efficiency could mitigate climate change or not.

According to Pembleton *et al.* (2016), the agricultural sector has the potential to significantly mitigate climate change by reducing greenhouse gas emissions and improving agricultural sequestration. In reaction to climatic stresses and changes, it entails changing crop varieties. Tanzanian farmers use drought-resistant crops in an effort to adapt to climate change, according to a study conducted in Tanzania by Siervogel (2006). In Ethiopia, Avena species (Ingedo) were introduced as fodder crops, eventually displacing the stable dominant crop. E. barley in the mountains and act as a way to adjust to the changing climate (Denman *et al.*, 2007).

Implementation of modifications to the crop cycle within a season. In order to increase harvest potential under arid climate stresses, farmers in Brazil's semi-arid regions that are prone to drought have discovered that multiple varieties of a single crop species can coexist on a common land area. These varieties include sorghum, maize, and various bean varieties (Komba & Muchapondwa, 2015). Similarly, Ethiopian farmers plant a variety of crops (including homestead maize) in an effort to adapt to climate change. Modern farm management techniques, like organic agriculture, are changing to emphasize the preservation of varied farming systems (i.e. e. Planting a variety of crop species also helps farmers diversify their potential revenue streams and increases their household's resilience to the negative effects of climate change on agricultural output (Boonpragob, 2007). Crop residue management practices are also regarded as one of the best climate-smart initiatives, according to Oli (2008). Additionally, smallholder farmers in sub-humid Southwestern Cameroon have been using different soil and water conservation techniques to adjust to changes in rainfall. The main method of conserving soil and water that aids Ethiopia in adapting to climate change is the construction of ditch and check dams. Terracing and various water harvesting techniques are also commonly used to adapt to the changing climate, according to a study conducted in Ethiopia.

Given that the forestry industry and land use conversion contribute significantly to greenhouse gas emissions, agroforestry offers a chance to mitigate the negative effects of climate change by combining adaptation and mitigation strategies (Food and Agricultural Organization, 2006). Through crop and income diversification, soil and water conservation, and effective nutrient cycling and conservation, trees on farms help small farmers cope with climate risks (Action Aid, 2008). Various studies on agroforestry in West Africa have concentrated on its capacity to sequester carbon and its impact on soil fertility (FAO, 2010). According to studies conducted in the majority of central African nations, growing maize, sorghum, millet, cotton, and groundnuts close to a Faidherbia albida tree significantly increases crop yields (Muller, 2009).

4.5. Discussion of the findings

Determining the effects of climate change on agricultural productivity in Choma District was the study's primary goal.

According to the research, there are two types of causes for climate change: natural and man-made (Crowley, 2000; Paehler, 2007). The first objective, which focused on the causes of climate change in specific areas of Choma District, revealed that there were two causes of climate change in each of the three areas. Before beginning the following season's farming, the majority of farmers were found to have cleared their land and burned the leftover material. A significant source of carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4), volatile organic compounds (VOC), nitrogen oxides, and halogen compounds, in addition to aerosol particles, is the burning of biomass from forest fires and crop residues (Tubiello *et al.*, 2013). According to Hornton and Lipper (2013), 30–40% of anthropogenic greenhouse gas emissions come from agriculture. According to Gebreegziabher *et al.* (2014), developing nations account for three-quarters of agricultural greenhouse gas emissions, and by 2050, this percentage could surpass 80%. According to a FAO (2014) report, the expansion of total agricultural outputs was the primary cause of the notable 14% increase in greenhouse gas emissions in developing nations between 2001 and 2011.

Determining how climate change affects food security was the second goal. The findings showed that Choma District's crop productivity had drastically declined. The most significant factor in explaining lower yields at warmer temperatures is the effect of temperature on shortening the growth cycle, particularly the grain filling phase (White and Reynolds, 2003). Using less energy to power photosynthesis (i.e. e. the transformation of carbon dioxide into organic compounds), matured plant biomass falls short of potential levels due to smaller and less numerous plant structures (e.g., leaves) (Sibma, 1970; Duncan, *et al.* 1973; Scott *et al.*; Stone, 2001. 2009). It has been found that heat or drought stress during the flowering and pollination stages of maize silk-tasseling can lower yields by up to 7% per day of stress, which is more than the yield reduction for all other possible climatic stresses (Shaw, 1977).

Establishing potential agricultural practices to lessen climate change in Choma District was the final goal. The results showed that the primary mitigation strategies to slow down climate change were farming practices. By lowering greenhouse gas emissions and improving agricultural sequestration, the agriculture sector has a substantial potential to mitigate climate change (Pembleton *et al.*, 2016). It entails changing crop varieties in reaction to climatic fluctuations and stressors. Research conducted by Ziervogel *et al.* (2006) in Tanzania described how Tanzanian farmers use drought-resistant crops in an effort to adapt to climate change. In Ethiopia, the dominant stable crop was gradually replaced by the introduction of Avena species (Ingedo) as a fodder crop. e. barley in the highlands and act as a strategy for climate change adaptation (Denman *et al.*, 2007). Modern farm management techniques, like organic agriculture, are changing to emphasize the preservation of varied farming systems (i.e. e. Planting a variety of crop species also helps farmers diversify their potential revenue streams, increasing the resilience of the farming household.

5. CONCLUSION

From the discussion in the previous captioned heading, according to the study's findings, Choma District's agricultural productivity has significantly increased as a result of climate change. If all farmers used proper agricultural practices, agricultural productivity could rise. This would increase their economical status and change their perception towards farming, hence increase agricultural productivity.

RECOMMENDATION

The results in the study revealed that the effect of climate change on agriculture productivity is inevitable. Therefore, in order to mitigate effectively the impact of climate change on agriculture productivity, the following recommendations must be considered by Ministry of Agriculture, stakeholders and interested parties:

Increasing the number of drought-resistant crops in regions that are prone to drought may help to lessen climate change vulnerability. For instance, when it comes to irrigation water, wheat uses a lot less than dry-season rice.

Cooperatively growing two or more crops in the same field is known as mixed cropping. In Tanzania, the method is widely used, where nuts (groundnuts), legumes (beans), and cereals (maize, sorghum) are all grown together. Crops with different characteristics can be mixed for the following reasons: maturity period (e.g. 3. Corn and beans), drought resistance (corn and sorghum), input needs (cereals and legumes), and product consumers (e.g. 3. maize for sustenance and sunflower for money. One of the most significant adaptations in all countries except Cameroon and South Africa is the planting of different varieties of the same crop, according to a 2009 study by Mendelsohn on the analysis of adaptations made in Africa.

In the medium to long term, diversification toward high-value crops is possible. In both irrigated and non-irrigated regions, crop diversity is a top adaptation strategy. For instance, land use manipulation in Southern Africa results in land use conversion, such as the switch from livestock to game farming.

Farmers must have access to reliable weather forecasts in order to make informed decisions on time. The need for accurate and localized weather information has grown as a result of climate change's unpredictable effects. Nowadays, a lot of farmers depend on weather apps and services that provide them with up-to-date information and long-term forecasts customized for their particular areas. Furthermore, early warning systems for severe weather phenomena, such as floods and hurricanes, have developed into crucial instruments for risk reduction.

REFERENCES

Action Aid. (2008). *The Time is now: lessons from farmers adapting to climate change.* Action Aid.

Bloem, M. Semba, R., & Kraemer, K. (2010). Castel Gandolfo Workshop: An Introduction to the Impact of Climate Change , the economic crisis, and the increase in food prices on malnutrition. *The Journal of Nutrition, 140*(1) 132–135.

Busari, M., Kukal, S., Kaur, A., Bhatt, R., & Dulazi, A. (2015). Conservation tillage impacts on soil, crop and the environment. *International Soil and Water Conservation Research, 3*, 119-129.

Crowley, T. J. (2000). Causes of climate change over the past 1000 years. *Science, 289*(5477), 270-277. https://doi.org/10.1126/Science.289.5477.270.

Denman K, Brasseur G, Chidthaisong A, Ciais P, Cox P, (2007). Couplings between Changes in the Climate System and Biogeochemistry. In: Boonpragob K, Heimann M, Molina M (Eds.). (2007). *Climate Change 2007: the Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

FAO (Food and Agricultural Organization). (2006). *Livestock Report 2006, Animal Production and Health Division.* Food and Agriculture Organization of the United Nations, Viale del Terme di Caracalla, 00100Rome, Italy.

FAO. (2016). *The State of Food and Agriculture Climate Change, Agriculture and Food Security.* Food and Agriculture Organization, Rome, Italy.

Gebreegziabher, Z., Mekonnen, A., Deribe, R., Abera, S., & Kassahun, M. M. (2014). Climate change can have significant negative impacts on Ethiopia's agriculture. *Research Brief. Addis Ababa, Ethiopia. EDRI, EfD.*

Gouldson, A., Colenbrander, S., Sudmant, A., Papargyropoulou, E., Kerr, N., McAnulla, F., & Hall, S. (2016). Cities and climate change mitigation: Economic opportunities and governance challenges in Asia. *Cities, 54*, 11-19. https://doi.org/10.1016/j.cities.2015.10.010.

Hornton, P., & Lipper, L. (2013). *How does climate change alter agricultural strategies to support food security?* Background paper for the conference "Food Security Futures: Research Priorities for the 21st, Dublin.

IPCC. (2019). Summary for Policymakers. In: Shukla PR, Skea J, Buendia EC, Masson-Delmotte V, Pörtner HO, Roberts DC, Zhai P, Slade R, Connors S, van Diemen R, Ferrat M, Haughey E, Luz S, Neogi S, Pathak M, Petzold J, Pereira JP, Vyas P, Huntley E, Kissick K, Belkacemi M, Malley J (eds) Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable management, food security, and greenhouse gas fluxes in terrestrial ecosystems, In press.

Jain, S. (2007). *An empirical economic assessment of impacts of climate change on agriculture in Zambia.* The World Bank. https://openknowledge.worldbank.org/handle/10986/7478License: CC BY 3.0 IGO.

Komba, C., & Muchapondwa, E. (2015). Adaptation to Climate Change by Smallholder Farmers in Tanzania. *Environment for Development.* Discussion Paper Series.

Mendelsohn, R. (2009). The impact of climate change on agriculture in developing countries. *Journal of natural resources policy research, 1*(1), 5-19.

Muller, A. (2009). *Benefits of Organic Agriculture as a Climate Change Adaptation and Mitigation Strategy for Developing Countries.* Environment for Development Discussion Paper Series, EfD DP 09-09.

Oli, B. (2008). Migration and climate change. IOM migration research series no. 31, International Organization for Migration, Geneva (pp. 1-68).

Pembleton, K. G., Cullen, B. R., Rawnsley, R. P., Harrison, M. T., & Ramilan, T. (2016). Modelling the resilience of forage crop production to future climate change in the dairy regions of Southeastern Australia using APSIM. *The Journal of Agricultural Science, 154*(7), 1131-1152.

Rezaei, E. E., Siebert, S., Hüging, H., & Ewert, F. (2018). Climate change effect on wheat phenology depends on cultivar change. *Scientific reports, 8*(1), 4891. https://doi.org/10.1038/s41598-018-23101-2.

Shaw, R. (1977). *Water use and requirements of maize —a review. Agro meteorology of the maize crop.* WMO Publication 481, World Meteorological Organization, Geneva, p 119–134.

Sibma, L. (1970). Relation between total radiation and yield of some field crops in the Netherlands. *Netherlands Journal of Agricultural Science, 18*(2), 125-131.

Von Braun, J. (2013). Climate Change Impacts on Global Food Security. *Science, 341*(6145), 508–513. https://doi.org/10.1126/science.1239402.

White, J. W., & Reynolds, M. P. (2003). A physiological perspective on modeling temperature response in wheat and maize crops. *Modeling temperature response in wheat and maize* (pp. 8-17).

Yang, Z., Zhang, Z., Zhang, T., Fahad, S., Cui, K., Nie, L., ... & Huang, J. (2017). The effect of season-long temperature increases on rice cultivars grown in the central and southern regions of China. *Frontiers in plant science, 8*, 1908. https://doi.org/10.3389/fpls.2017.01908.

Ziervogel, G. Cartwright, A. Tas, J. Adejuwon, F Zermoglio, M., & Smith, B. (2008) *Climate change and adaptation in African agriculture.* Stockholm environment institute.