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John Mbaraka

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John Baraka

Sokoine University of Agriculture

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Abstract

Purpose: The aim of the study is to examine the effect of global warming on Agricultural productivity

Methodology: This study adopted a desktop methodology. This study used secondary data from which include review of existing literature from already published studies and reports that was easily accessed through online journals and libraries.

Findings: The study revealed that farmers are experiencing changes in temperature and precipitation patterns including more frequent and intense droughts and floods. These changes are leading to lower crop yields and incomes. The study also found that farmers were aware of the impact of climate change on agriculture and had adopted several adaptation strategies, including changing planting dates, selecting heat-tolerant rice varieties, and applying organic fertilizers

Unique Contribution to Theory, Practice and Policy: The study was anchored on Resilience Theory which originated from the work of C.S. Holling and Social-Constructivist Theory which originated from the works of Lev Vygotsky. The study recommends that farmers should adopt climate-smart agricultural practices, such as conservation agriculture and improved water management, to increase their resilience to climate change. The study also recommends that farmers should be given support to enable them to adapt to the changing climatic conditions including access to finance, education and training

Keywords: *Global Warming, Agricultural Productivity, Low Crop Yields, Adaptation Strategies*

INTRODUCTION

Agricultural productivity is a crucial aspect of a nation's economy, as it directly influences food security, employment, and overall economic growth. Developed economies such as the USA, Japan, and the UK have made significant advancements in agricultural productivity. For instance, in the USA, agricultural productivity has steadily increased over the years. According to Smith et al. (2016), the total factor productivity (TFP) in US agriculture grew at an average annual rate of 1.45% between 1948 and 2011, indicating a consistent improvement in efficiency and technological advancements. This increase in productivity has been facilitated by factors such as improved seed varieties, advanced farm machinery, and precision agriculture techniques.

Japan is another example of a developed economy that has achieved notable agricultural productivity. A study by Gollin et al. (2014) highlights that Japan's agricultural TFP has experienced significant growth, reaching an average annual rate of 2.3% between 1955 and 2008. This increase has been attributed to factors such as the adoption of high-yielding crop varieties, investments in research and development, and effective land management practices. The use of advanced technologies, including automated machinery and robotics, has also played a significant role in enhancing agricultural productivity in Japan.

Agricultural productivity has also shown positive trends, although at varying rates. In Brazil, for example, agricultural productivity has witnessed significant growth. According to a study by Silva et al. (2017), between 1975 and 2013, Brazilian agriculture experienced an average annual growth rate of 2.15% in TFP. This improvement can be attributed to factors such as increased investment in agricultural research and development, adoption of advanced farming practices, and expansion of commercial agriculture.

In India, agricultural productivity has also been on the rise. A study by Kumar et al. (2019) indicates that between 1980 and 2013, India's agricultural TFP increased at an average annual rate of 1.88%. This increase has been facilitated by the adoption of modern agricultural technologies, improved irrigation systems, and government policies supporting agricultural development. However, challenges such as fragmented land holdings and limited access to credit and markets continue to hinder further improvements in agricultural productivity in India.

In Sub-Saharan economies, agricultural productivity has shown a mixed picture, with some countries experiencing significant progress while others face persistent challenges. One example of improved agricultural productivity can be observed in Ethiopia. According to a study by Asfaw et al. (2018), between 2001 and 2014, Ethiopia's agricultural TFP grew at an average annual rate of 3.2%. This growth can be attributed to factors such as increased adoption of improved seed varieties, expansion of irrigation infrastructure, and the promotion of agricultural extension services.

On the other hand, challenges in agricultural productivity persist in many Sub-Saharan economies. For instance, in Nigeria, agricultural productivity has been hindered by factors such as limited access to modern inputs, inadequate infrastructure, and land degradation. A study by Omotesho et al. (2016) points out that Nigeria's agricultural TFP growth has been relatively slow, averaging only 0.38% per year between 1961 and 2010. The study emphasizes the need for investments in research and development, improved access to credit, and infrastructure development to enhance agricultural productivity in the country.

Global warming refers to the long-term increase in Earth's average surface temperature primarily caused by human activities, such as the burning of fossil fuels and deforestation, which release greenhouse gases into the atmosphere. The consequences of global warming extend beyond temperature changes and have far-reaching impacts on various aspects of the environment, society, and economies, including agriculture. One of the most likely effects of global warming on agricultural productivity is changes in precipitation patterns. As temperatures rise, some regions may experience altered rainfall patterns, including increased frequency and intensity of extreme weather events such as droughts and floods (IPCC, 2014). These changes can lead to water scarcity or waterlogging, affecting crop growth, yield, and overall agricultural productivity.

Another significant effect of global warming is the increased occurrence of heatwaves. Rising temperatures can lead to prolonged periods of extreme heat, which can negatively impact crop growth and development. Heat stress can reduce crop yields, affect pollination and flowering, and increase the risk of pests and diseases (Wheeler et al., 2018). Additionally, global warming can lead to shifts in pest and disease dynamics. Warmer temperatures and altered rainfall patterns can influence the geographical distribution and population dynamics of pests and diseases, potentially exposing crops to new threats or increasing the prevalence of existing ones (Chakraborty et al., 2018). Such changes can result in reduced crop quality and quantity, further impacting agricultural productivity.

In addition to changes in precipitation patterns, heatwaves, and shifts in pest and disease dynamics, two other likely effects of global warming that can impact agricultural productivity are changes in growing seasons and soil degradation. With global warming, there can be alterations in the length and timing of growing seasons. Warmer temperatures can cause the onset of spring to occur earlier, leading to shifts in planting and harvesting schedules. Such changes can disrupt the synchronization between crops and optimal environmental conditions, affecting crop development and productivity (Lobell et al., 2011). Moreover, global warming can contribute to soil degradation through various mechanisms, including increased erosion, decreased soil fertility, and increased soil salinity. These changes can reduce the productivity and nutrient content of soils, making it more challenging to sustain high agricultural yields (Lal, 2015).

To mitigate the potential negative impacts of global warming on agricultural productivity, adaptation strategies are essential. These can include the development and adoption of heat-tolerant crop varieties, implementation of efficient irrigation systems, improved soil management practices, and the use of climate-smart agricultural techniques (Smith, 2022). Investing in research and development to enhance agricultural resilience and promote sustainable practices is crucial to ensure food security in the face of global warming.

In addition to the previously mentioned effects, two more significant impacts of global warming on agricultural productivity are changes in water availability and increased risk of crop diseases. Global warming can alter water availability and distribution, leading to shifts in water resources and availability for irrigation. Changes in precipitation patterns, including increased evaporation rates and reduced snowpack, can result in water scarcity for agriculture (Rosenzweig et al., 2014). Insufficient water supply can limit crop growth, yield, and overall agricultural productivity.

Furthermore, global warming can increase the prevalence and severity of crop diseases. Higher temperatures and changes in moisture levels can create favorable conditions for the proliferation and spread of plant pathogens, leading to increased disease incidence and crop losses (Bebber et al., 2013). For example, warmer temperatures can facilitate the growth and reproduction of fungi, bacteria, and viruses that cause plant diseases, negatively impacting agricultural productivity. The higher disease pressure can require increased use of pesticides and fungicides, posing additional challenges in terms of sustainability and environmental impact.

Statement of the Problem

The rise in global temperature and changes in precipitation patterns caused by anthropogenic activities have led to significant negative impacts on agricultural productivity, including reduced crop yields, increased incidence of pests and diseases, changes in planting and harvesting seasons, and loss of arable land. These impacts are expected to increase in severity and extent in the future, posing a significant threat to food security and livelihoods of millions of people globally, especially in vulnerable and developing regions. Therefore, understanding the mechanisms and impacts of global warming on agriculture is essential for developing effective adaptation and mitigation strategies to minimize the risks and enhance the resilience of agricultural systems. Opiyo (2015) and Agyekum (2019), there is a contextual gap because those studies concentrated on impact of climate change on small scale farmers, whereas the current study concentrates on how all forms of agriculture are affected by global warming, therefore the need to carry out the study.

Resilience Theory

Resilience theory focuses on understanding the capacity of systems to withstand and recover from disturbances. It originated from the work of C.S. Holling and has since been further developed by other scholars in the field of sustainability science. Resilience theory is relevant to the suggested topic as it provides a framework for investigating how agricultural systems can adapt to the impacts of global warming. It emphasizes the ability of agricultural systems to absorb shocks, maintain functionality, and bounce back from disruptions caused by climate change. This theory helps researchers identify strategies and practices that enhance the resilience of agricultural systems, such as diversification of crops, water management techniques, and sustainable land management practices (Folke et al., 2010).

Social-Constructivist Theory

Social-constructivist theory emphasizes the role of social processes and human interactions in shaping knowledge, perceptions, and actions. It originated from the works of scholars such as Lev Vygotsky and Jean Piaget. In the context of the suggested topic, social-constructivist theory is relevant as it recognizes that understanding the impact of global warming on agricultural productivity requires considering the social, cultural, and contextual dimensions. This theory highlights the importance of stakeholders' knowledge, beliefs, and behaviors in shaping responses to climate change in agriculture. It encourages participatory approaches, knowledge co-production, and collaborative decision-making processes that involve farmers, policymakers, scientists, and local communities in addressing the challenges posed by global warming (Braun et al., 2017).

Empirical Review

Adjei-Nsiah (2015) assess the impacts of climate change on maize production in Ghana, specifically in the Ejura-Sekyedumase Municipality. The study used a combination of qualitative and quantitative methods, including surveys of maize farmers, focus group discussions, and secondary data analysis. The surveys collected information on farming practices, climate variability and change, and maize yields over the past decade. The data were analyzed using regression analysis to identify the relationship between climate variables and maize yields. The study found that the Ejura-Sekyedumase Municipality has experienced increasing temperatures and decreasing rainfall, which have led to a decline in maize yields over the past decade. Specifically, the study found that a 1°C increase in temperature during the growing season led to a 3.5% decrease in maize yields. The study also found that farmers have employed various adaptation strategies, such as changing planting dates and crop varieties, but these strategies have had limited success. The study recommends that farmers in the Ejura-Sekyedumase Municipality adopt climate-smart agricultural practices, such as conservation agriculture and improved water management, to increase their resilience to climate change.

Agyekum (2019) examined the impacts of climate change on smallholder maize farmers in Ghana, including changes in temperature, precipitation, and growing seasons, and the resulting effects on crop yields and income. The study was conducted using a mixed-methods approach, combining a survey of 200 smallholder maize farmers in two regions of Ghana with a review of climate data from the Ghana Meteorological Agency. The survey collected data on farmers' perceptions of changes in weather patterns and their impacts on crop yields and income, as well as their adaptation strategies. The climate data were used to analyze changes in temperature and precipitation patterns over the past 30 years. The study found that smallholder maize farmers in Ghana are experiencing changes in temperature and precipitation patterns, including more frequent and intense droughts and floods. These changes are leading to lower crop yields and incomes, with farmers reporting losses of up to 50% of their harvests in some years. The study also found that farmers are adopting a range of adaptation strategies, including changes in crop varieties, planting dates, and water management practices. The study recommends that policies and programs aimed at supporting smallholder maize farmers in Ghana should focus on promoting adaptation strategies that are affordable and accessible to farmers, including improved access to weather information, drought-resistant crop varieties, and water management technologies.

Dubovitski (2021) assessed the climate risks for agriculture in Russia. The study was conducted using techniques and tools of multivariate correlation analysis. The authors investigated the influence of deviations of the average monthly amounts of temperatures and precipitation from the average long-term values on the deviation of grain yields, using a set of data for 17 regions of the Central Federal district of Russia for the period of 2000-2019. The results showed that a smooth change in the parameters of heat and precipitation does not significantly affect the yield of grain crops. At the same time, increasing annual temperature variability and precipitation significantly reduce yields. An increase in the frequency of extreme events causes a growth in the probability of environmental and economic damage and the magnitude of climate risks. The maximum level of climate risk requires an appropriate adjustment of the agribusiness development strategy and the creation of an institution in society of fair compensation for damage caused by global warming factors.

Opiyo (2015) examined the perceptions of smallholder farmers in Sub-Saharan Africa regarding the effects of climate change on agriculture. This study uses a qualitative research design, specifically, semi-structured interviews with smallholder farmers in three countries in Sub-Saharan Africa (Kenya, Tanzania, and Uganda). The study sample includes 30 smallholder farmers (10 from each country) selected through purposive sampling. Data was collected through semi-structured interviews conducted in the local language by trained researchers. Thematic analysis was used to identify key themes and patterns in the data. The findings reveal that smallholder farmers in Sub-Saharan Africa are experiencing a range of negative effects of climate change on their agricultural activities, including erratic rainfall, increased pest and disease incidence, and reduced crop yields. The study recommends that highlights smallholder farmers and rural communities should be given support to enable them to adapt to the changing climatic conditions, including access to finance, education, and training.

Huang (2015) assessed the impact of climate change on crop yields in China and explore potential adaptation strategies for farmers. The study uses a panel data set of 22 provinces in China over the period of 1980 to 2010. The study applies a fixed-effects regression model to estimate the impact of temperature and precipitation changes on crop yields. The study also conducts a survey of 1,500 farmers in six provinces to identify adaptation strategies used by farmers. The study finds that rising temperatures and changing precipitation patterns have a negative impact on crop yields in China. The study also finds that farmers are adopting a range of adaptation strategies, including changing cropping patterns, using irrigation, and applying new technologies. The study recommends that policymakers focus on developing and promoting new technologies that are better adapted to the changing climate.

Suphachalasai (2019) examine the impact of global warming on the productivity of rice cultivation in Thailand, as well as to identify potential adaptation strategies that could be implemented to mitigate these impacts. The study used data from the Thai Rice Department for the years 1981-2010 to analyze the relationship between temperature and rice yield. Multiple regression analysis was used to estimate the effects of temperature on yield, while a linear regression model was used to forecast rice production under different climate scenarios. The study also conducted interviews with rice farmers in the central and northeastern regions of Thailand to understand their perceptions of climate change and their adaptation strategies. The study found that higher temperatures had a negative impact on rice yield in Thailand. The linear regression model predicted that rice production could decrease by up to 20% by 2050 if the temperature continues to rise at the current rate. The study also found that farmers were aware of the impact of climate change on rice cultivation and had adopted several adaptation strategies, including changing planting dates, selecting heat-tolerant rice varieties, and applying organic fertilizers. The study recommended that the government of Thailand invest in research and development to develop heat-tolerant rice varieties and promote their adoption among farmers.

METHODOLOGY

This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low cost advantage as compared to a field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

RESULTS

The results were analyzed into various research gap categories, that is, contextual and methodological gaps.

Contextual and Methodological Gaps

Adjei-Nsiah (2015); Dubovitski (2021); Opiyo (2015) and Huang (2015) posit a conceptual gap as none of these studies addresses the effects of global warming on agriculture. Agyekum (2019) and Suphachalasai (2019) present a methodological gap as these studies used mixed-methods approach and descriptive research design while the current study adopts desktop study research design.

CONCLUSION AND RECOMMENDATIONS

Conclusions

The study concludes that smallholder farmers are experiencing changes in temperature and precipitation patterns, including more frequent and intense droughts and floods. These changes are leading to lower crop yields and incomes. Farmers were aware of the impact of climate change on agriculture and had adopted several adaptation strategies, including changing planting dates, selecting heat-tolerant rice varieties, and applying organic fertilizers. Negative effects of climate change on their agricultural activities, including erratic rainfall, increased pest and disease incidence, and reduced crop yields.

Recommendations

The recommended that farmers should adopt climate-smart agricultural practices, such as conservation agriculture and improved water management, to increase their resilience to climate change. Smallholder farmers and rural communities should be given support to enable them to adapt to the changing climatic conditions, including access to finance, education, and training. Policies and programs aimed at supporting farmers should focus on promoting adaptation strategies that are affordable and accessible to farmers, including improved access to weather information, drought-resistant crop varieties, and water management technologies.

Theory:

Develop a comprehensive model that integrates climate change projections, agricultural practices, and socioeconomic factors to understand the complex interactions and feedback loops between global warming and agricultural productivity.

Investigate the role of microorganisms, such as soil bacteria and fungi, in mitigating the negative effects of climate change on agricultural systems. Explore the potential of microbial-based interventions to enhance soil health, nutrient cycling, and resilience to climate change.

Practice:

Promote climate-smart agriculture practices that focus on sustainable intensification, conservation agriculture, and agroforestry. Develop guidelines and training programs to help farmers adopt these practices, which can improve soil health, water use efficiency, and carbon sequestration.

Encourage the adoption of precision agriculture technologies and data-driven decision-making tools to optimize resource use, reduce greenhouse gas emissions, and enhance productivity. This includes the use of remote sensing, GIS (Geographic Information System), and IoT (Internet of Things) devices for precise monitoring and management of agricultural systems.

Policy:

Advocate for the development and implementation of climate-resilient agricultural policies at national and international levels. These policies should promote sustainable farming practices, provide incentives for carbon sequestration, and support farmers in adapting to changing climatic conditions.

Collaborate with policymakers and stakeholders to establish climate change adaptation and mitigation funds specifically for the agricultural sector. These funds can support research, innovation, and capacity-building initiatives that help farmers and rural communities respond to the challenges posed by global warming.

Promote cross-sectoral collaboration between agriculture, energy, transportation, and forestry sectors to develop integrated climate change strategies. This includes exploring opportunities for renewable energy generation on agricultural lands, promoting bioenergy crops, and creating synergies between carbon sequestration initiatives and biodiversity conservation efforts.

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