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Development of Climate Friendly Models and Approaches for the Mitigation of a Food Crisis in Africa.

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A B S T R A C T

The study was conducted to highlight the impact of climate change on food security in Africa as well as discussing mitigation measures and drivers for the development climate friendly models. Africa is particularly vulnerable to climate variability and climate change, which affects millions of people and make adaptation efforts compelling as rapid changes in weather patterns alter agricultural productivity. The combination of climatic, non-climatic factors and agents will intensify the vulnerability of Africa's agricultural systems to climate change, but the impacts will not be homogenous across the globe because climate change will impact farmers and their agricultural systems in different ways, and adapting to these impacts will need to be context-specific. Upon the SDGs era, adaptation efforts have been increasing across the continent, but it is expected that in the long term these will be insufficient in enabling communities to cope with the changes due to longer-term climate change. Mitigation measures are a pathway for the transformation of food systems into better adaptive, more affordable, and highly nutritious systems that depend largely on indigenous crops and traditional knowledge.

Keywords: Food security, Climate change, Mitigation

1. Introduction

The climate of Africa is warming faster than the global average over oceans and lands. According to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), predictions indicate that the critical climate crisis levels will likely be reached earlier than mid-century in Africa. (IPCC, 2021). Africa is particularly vulnerable to climate variability and climate change, which affects millions of people and makes adaptation efforts compelling as rapid changes in weather patterns alter the productivity of local water and food systems and generate unintended consequences for sustainable development. (IPCC, 2022)

Warming of the earth is considered as the major adverse effect of climate change along with other abnormalities such as non-availability of water resources, decreased agriculture production, food insecurity, rise in seawater level, glaciers melting, and loss of biodiversity. Over the years, decreased agriculture production and water quality degradation have been observed due to climatic abnormalities. Crop production is highly sensitive to climate because it gets affected by long-term trends in average rainfall and temperature, annual climate variations, shocks during different stages of growth, and extreme weather events.

Across West Africa, multiple shocks largely induced by agricultural risks, have increased food costs and scarcity levels and increased malnutrition. In 2021, approximately 27 million West Africans needed immediate food assistance due to a combination of drought, poverty, high cereal prices, environmental degradation, displacement, poor trade integration, and conflict. (FSRP, 2022)

Grave predictions of more persistent extreme weather conditions, coupled with agricultural productivity that is not keeping pace with population growth, means long-term sustainable development is under threat. (World Bank, 2021). In lieu of this, safeguarding food security is a priority which demands contextual understanding and management of dynamics that control and influence agricultural production, such as the development of climate friendly models and measures aimed at sustainable agriculture.

1.1 Background to the Study

Agriculture is the principal medium through which climate change will impact people, ecosystems and economies. According to the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC), climate change is no longer perceived as a potential threat but an evidenced, inevitable reality. It is expected to make agricultural development in Africa more challenging.

Rainfall is generally expected to become more varied; floods are expected to become more frequent; droughts are expected to be more severe and prolonged, while sea-levels are expected to rise.

By 2030, 118 million extremely poor people across Africa are expected to be facing protracted periods of droughts, severe heat and extreme flooding resulting from climate change. In the event that action is not taken, many parts of North Africa could become engulfed in climate crisis and unfit to live in. Overall, the projected impacts of climate change are just as severe on food systems and agriculture.

Agriculture and its related industries depend immensely on climate. Crop production and livestock are the largest global food industries and are highly sensitive to climactic shifts. Increases in temperature, changes in precipitation patterns, and changes in storm frequency and severity often significantly affect food production. Because temperature determines plant growth cycles, seasonal variations and temperature extremes pose dangers to crop production. Crops only tolerate specific temperatures which, if exceeded, result in lessened crop productivity. (Bita, 2013)

Overall, the combination of climatic, non-climatic factors and agents will intensify the vulnerability of Africa's agricultural systems to climate change, but the impacts will not be homogenous across the globe because climate change will impact farmers and their agricultural systems in different ways, and adapting to these impacts will need to be context specific.

The gross effect of these impacts is food insecurity while an understanding of the dynamics of current changes and future climate change as they affect food supply and demand across all sectors and increasing the capacity to respond is mandatory. Climate smart and sustainable Agriculture is urgent and crucial than ever as it holds a greater significance to livelihoods, employment and food security.

1.2 Statement of the Problem

The global food system is indispensable to food nutrition security and livelihoods yet generates 21–37% of greenhouse gas emissions, and is responsible for 33% of agricultural soil degradation, 20% of aquifer overexploitation and 60% of biodiversity loss. To support climate adaptation and mitigation and ensure a more sustainable future, a systems transformation is now urgent. Research by AGRA showed that despite Africa having some of the most arable lands in the world, the continent still has the lowest agricultural productivity, and one in five people on the continent is hungry. Much of African agriculture's vulnerability to climate change lies in the fact that its agricultural systems are rain-fed and are yet to tap into technological advancements, as the majority of Africa's farmers are small-scale farmers with inadequate financial resources, limited access to infrastructure and information.

Climate change will affect agricultural food systems in all countries, including exporters and importers as well as those at subsistence level. Changes in mean rainfall and temperature as well as the increase in extreme weather conditions will affect agriculture, livestock, forestry as well as fisheries. Many impacts, such as increased land degradation and soil erosion, changes in water retention and availability, biodiversity loss, more intense pest and disease outbreaks as well as disasters need to be addressed across sectors. In the past, agrarians whose livelihoods depend on agriculture developed coping strategies aligned with climate variability independently. Today, the rate of climate change will modify known variability patterns which may overwhelm people and confront them with situations they are not equipped to handle.

To provide result-oriented interventions on food crisis mitigation, there is a need to conduct more research, to obtain data and general understanding of food systems approaches. Advanced knowledge among decision-makers is mandatory to stimulate both policy action and investment in food systems solutions and food security.

The major questions following are: How does climate change affect agricultural production; and what strategies can be adopted to mitigate climate challenges; including the development of climate friendly models? The impact of climate change has been reported by a number of studies, people, government departments and non-state actors and this paper highlights the impact of climate change on water sources and food security while recommending mitigation strategies.

2. Literature Review

Sub-Saharan Africa is a rapidly developing region with a population of about 900 million, with wide ecological, climatic, and cultural diversity (CDKN, 2014). Although, it has six of the ten fastest growing countries' economies in the world, but growth in these economies is viewed with a background of three decades of poor development, conflict, and economic marginalization. (Barton & Leke, 2016).

With respect to the economic system, the agriculture and fisheries sector is heavily depended on for income, food and fibre by Africans. However, these sectors are highly vulnerable and sensitive to climate change. Much of African agriculture's vulnerability to climate change lies in the fact that its agricultural systems are rain-fed, with little technological inputs, as the majority of Africa's farmers work on a small-scale or subsistence level and have inadequate financial resources, limited access to infrastructure, and varied access to information.

Adverse poverty and socioeconomic inequality, low levels of development, limited economic capacity as well as governance challenges have further exacerbated the continent's limited capacity to adapt to climate change (Shackleton et al., 2015). Unprecedented risks from climate change are foreseen to have major negative impacts on agriculture, fisheries, and food security across the region and feedback into development, thereby counteracting the progress that has been made to tackle poverty and inequality (Shackleton et al., 2015).

Studies show that there is no singular factor that causes climate change, but research indicates that both humans and non-humans can cause climate change (Cracknell 2011; Shabangu 2017). Human activity that increases the number of heat-trapping gases in the earth's atmosphere, a phenomenon called 'greenhouse gases' can be responsible for climate change. According to Cracknell (2011), greenhouse gases occur naturally in the atmosphere and are important as they make the earth's temperature warm enough for life to exist. Without these heat-trapping gases, the planet would be far too cold, making it uninhabitable.

According to Shabangu 2017, climate has always been changing naturally; the current impact of human activities is causing the climate to change in an unnatural way and at a rapid pace than ever. This unnatural and human-induced climate change is chaotic as it is causing shifts in the normal climatic conditions such as rainfall and temperature, which, in turn, are pressurizing the planet's natural environment and have negative impacts on people and their livelihoods.

Over the last century, temperatures across the continent have increased by 0.5°C or more, with minimum temperatures rising faster than maximum temperatures (Niang et al., 2014). There is a high likelihood that heat waves will last for longer periods, resulting in hotter days approaching the year 2100 (Niang et al., 2014). Meanwhile, subtropical southern and northern Africa have seen temperature rises, twice the global rate of temperature increase—with the most significant warming in southern Africa having been experienced in the last two decades. Similar increases in seasonal mean temperature in areas of Ethiopia, Kenya, South Sudan, and Uganda have been observed over the last 50 years, and extreme warm events in countries bordering the western Indian Ocean have increased in frequency (Niang et al., 2014).

In December 2015, the Paris agreement became the centrepiece of global climate policy. The Paris Agreement brought together, for the first time, all nations under the common cause of mitigating climate change, adapting to its adverse effects and making finance flows consistent with a pathway towards climate-resilient development. In addition to the Paris agreement, adaptation is pursued under the Convention through the process to formulate and implement NAPs. The only multilaterally agreed, comprehensive adaptation process of its kind, the NAP process takes a medium- to long-term approach to reducing vulnerability to the adverse effects of climate change that is integrated with national development planning processes and strategies. (UNCCS, 2017)

Upon the SDGs era, adaptation efforts on the continent have been increasing across the continent, but it is expected that in the long term these will be insufficient in enabling communities to cope with the changes due to longer-term climate change. African famers are increasingly adopting a variety of conservation and agro ecological practices such as agroforestry, contouring, terracing, mulching, and no-till. These practices have the double opportunities of lowering carbon emissions while adapting to climate change as well as broadening the sources of livelihoods for poor farmers.

A most promising climate change adaptation strategy for Africa is agroforestry, this view is supported by research as it provides the opportunity to produce assets for farmers, offers climate change mitigation opportunities, and has the potential to promote sustainable production that enhances agro ecosystem diversity and resilience (Mbow et al., 2014). There are agroforestry technologies that can fulfil "climate-smart" requirements, such as trees that improve soil, indigenous fruit trees to provide added nutrition and income, and trees that can provide medicinal plant products (Molua, 2005; Mbow et al., 2014).

Also, it enables the sequestering of carbon in biomass and soils; reduces greenhouse gas emissions and avoids emissions through reduced fossil fuel and energy usage on farms. As a windbreak, the growing trees store carbon directly in their biomass and in the soil. At the same time, the system releases fewer greenhouse gases, like nitrous oxide, because the trees take up extra nutrients and less area is fertilized. (USDA, 2016). Finally, less fossil fuel and energy are used in the agricultural operation because some of the field will no longer be cultivated. Agroforestry can be a suitable land management system to reduce gender inequalities related to natural resource access, while contributing to increased control of their benefits.

The cultivation of small-grain crops such as sorghum and millet, which have been proved to be a viable means of mitigating the effects of climate change because of the higher tolerance to drought (Chazovachii, Chingwenya & Mushuku 2012), also serves as a means of improving communities' food security. This can be cited as poor strategic planning on the part of the government, which keeps distributing maize seed in areas that are prone to drought instead of encouraging people in these areas to grow small-grain crops (Manyeruke, Hamauswa & Mhandara 2013).

Interventions implemented by Governments or funded by international organisations play significant roles in the African food systems by providing food security initiatives through agricultural financing and capacity building. The West Africa Food Systems Resilience Program (FSRP) was approved in 2021 by the World Bank's Board of Executive Directors for a total amount of 570 million US Dollars in International Development Association (IDA) financing. (World bank, 2018). The first phase of the program brought together four countries —Burkina Faso, Mali, Niger, and Togo— and three regional organizations —the Economic Community of West African States (ECOWAS), the Permanent Interstate Committee for Drought Control in the Sahel (CILSS), and the West and Central Africa Council for Agriculture Research and Development (CORAF) to implement a broad program that will simultaneously increase agricultural

productivity through climate-smart agriculture, promote intraregional value chains and trade, and build regional capacity to manage agricultural risk. According to the ECOWAS, "food crisis prevention and management are best achieved at a regional level to mitigate, diversify, and transfer production risks and allow for economies of scale producing long-term results."

As a means of increasing agricultural productivity in Burkina Faso, improved agricultural technologies, such as drought- and pest-resistant seed varieties, composting and erosion-control techniques, and livestock and poultry feeding technologies are being adopted which will increase feed production and crop yields. This activity is being implemented under the FSRP. "The FSRP supported the second phase of Burkina Faso's National Rural Sector Program, targeting 125 communes in nine regions, chosen for their high agricultural potential and relatively favourable climate conditions, impacting an estimated 300,000 poor people, including 120,000 women and 30,000 youth." (GAFSP, 2018).

3. Methodology

This paper is based on a literature review. 'Climate change' related articles were searched using various search engines in journals, briefs, and press release search engines. Reports from the Intergovernmental panel on climate change (IPCC), West Africa Food System Resilience Program, Global Agriculture and Food Security program and 16 articles were found from journals, giving the number of required studies to undertake this study. This means that many articles were consulted, and the viewpoints were collected as the basis and parameters for this paper. As indicated, general reports about the impact of climate change on Food security were used as well as those that reported on challenges of climate change in various regions of Africa.

4. Discussion

The realisation of climate crisis in Africa and the implementation of climate-smart actions offers a long-term approach for achieving food security and improved livelihoods. In developed economies, one of mitigation measures for agriculture includes carbon farming. According to the IPCC special report on climate change and Land, agriculture covers more than half of the earth's terrestrial surface and contributes roughly one-third of global greenhouse gas emissions. Paying farmers to restore carbon-depleted soils offers an attractive opportunity for a natural climate solution that could help nations to attain commitments under the international Paris climate agreement to stabilize global warming below 2 degrees celsius. As the effects of climate change intensify and nations seek to define solutions on global warming, state actors, media and environmental experts support "carbon farming" as a mutually beneficial strategy for society, the environment and farmers.

African countries need to obtain the needed technical knowledge by optimizing adaptation and mitigation measures. However, considerable barriers exist to the capacity of Africa and other regions with the tools to close yield gaps. Providing agricultural technology and knowledge to numerous farmers requires strong political leadership and large public investments. These actions are perceived as ambitious and have been challenging besides the damaging effects of climate change, and subsequent efforts may require considerably intentional and intensified effort to close these gaps.

Structural barriers include the failure of extension services in poor African countries to help scale up innovations in agroforestry and limited investments in agroforestry compared to intensified monoculture systems, which have seen strong support during the postcolonial era, mostly for export as cash crops (e.g., peanut, cocoa, cotton) (Mbow et al., 2014). Despite intensive modelling efforts, the effects of climate change on agroforestry systems (and vice versa) are yet to be properly understood, which means that the specific trees and management options that are the most suited for future climates need to be understood to best minimize negative climate change impacts on farming systems (Mbow et al., 2014).

Increasing agricultural production limits occurs in a variety of ways such as improved farming practices, technological advances, and alternate food source utilization can catalyse new production potentials. In developed countries with low yield gaps, increasing production limits helps to maintain strong food market systems and enable the distribution of more aid to countries in need. Also, maintaining depositories of genetic material is critical to expanding yield potential. According to the United States Department of Agricultural Forest Service, maintaining large depositaries of various crop seed genotypes and genetic materials allows farmers to select optimal crop variations each season, based on soil, weather, and pest conditions. Similarly, the Nigeria Agricultural Development Program Department has facilitated improved agronomy practices by encouraging farmers to utilise improved varieties for increase in crop yield. Additionally, through the anchor borrowers Program, the ministry of Agriculture through funds from the Central Bank of Nigeria is increasing maize grain yields to alleviate food scarcity resulting from the Russian-Ukraine war.

Other measures for mitigating climate crisis include:

- Developing data, tools and evidence for food systems transformation: Provision of subnational, national and global actors with the critical data, methods, tools, evidence and capacity required to induce and report on food systems and greenhouse gas emissions.
- Prioritizing mitigation approaches that demonstrate potential for delivering sustainable development co-benefits, such as climate adaptation, increased yields and more equitable socio-economic benefits for vulnerable groups.

- Scaling low-emission food systems: Supporting countries to create the enabling environment for scaling up of at least five CGIAR technologies and innovations with the potential to transform food systems and reduce emissions.
- Civic Engagement and agenda transformation for policy on climate change and food systems: To achieve the Paris Climate Agreement, policymakers and practitioner communities and non-state actors should have the information, analysis, tools and social networks needed to achieve efficient and cost-effective reduction of food systems greenhouse gas emissions, alongside equitable impacts and shared benefits, at national and international scales without duplicated efforts.

While this paper sparsely highlights the impact of climate change in the African region, it is important to emphasize the unique linkage between agricultural production, climate change impacts, and food security. Climate change provides both an impediment to food security because of its generalized negative impacts on staple crop production and an opportunity to metamorphose African food systems into better adaptive, more affordable, and highly nutritious systems that depend largely on indigenous crops and traditional knowledge that are adapted to the local context rather than on mono-cropping systems that are prone to climate extremes. (Laura, 2017)

5. Recommendations and Policy Recommendation

The implementation of agroforestry can help countries reach their goals related to climate change adaptation and mitigation, reforestation as well as SDG-targets related to food and water security. The United Nations Framework Convention on Climate Change (UNFCCC) and other international organisations and scientific panels are emphasizing the importance of using sustainable land management systems, such as agroforestry, to generate multiple environmental and socio-economic benefits (e.g. FAO, 2019; IPBES, 2019; IPCC, 2019).

Regional institutions should work together to strengthen shared agricultural and hydrometeorological information services, so they are more accessible and useful to decision-makers, farmers, pastoralists, and other actors in the food systems in the sub-region. They will also collaborate on strengthening national and regional agricultural research and the policy environment for landscape governance to avoid, reduce, and reverse land degradation.

Tools are needed for evaluating the adaptation and mitigation potential of different policies and technologies from local to global scales, covering the impacts of both extreme events and slow-onset changes on agriculture and food security, assessing means of increasing resilience in agriculture and food systems, and identifying options for, and costs of reducing emission growth.

A people-centred approach should be utilized such that farmers do not seek to implement adaptation, sustainable development and disaster risk reduction separately, but rather address them all at once as they work to improve their livelihoods.

As regards crop modelling, the availability of input data functions as enablers to advances in crop research in Africa. The availability of appropriate input data for crop models could provide valuable information on how, where crops should be planted in specific areas and reduce the margin of error in agronomic and field management practices. However, the unavailability of input data is limited for most crops, including cereals, oilseeds, pastures, and forage.

There is particular need for robust studies that improve understanding of context-specific approaches for different agro-ecologies and farming systems, facilitating identification of the strategies that constitutes ‘climate smart action’ in different ecosystems and socio-economic contexts.

A priority action area for CSA is building enabling policy and regulatory frameworks through increased coordination of agricultural, climate change/environmental and food system policies. An enabling policy environment requires alignment across policy domains, facilitated by dialogue across relevant ministries to address trade-offs, gaps and overlaps. Coordination is particularly important among national agricultural policies, strategies and investment plans and climate change instruments, including national adaptation programmes (NAPs).

6. Conclusion

Climate change alters agricultural production and food systems, and thus the approach to transforming agricultural systems to support global food security and poverty reduction. Climate change introduces greater uncertainty and risk among farmers and policymakers but need not lead to analysis paralysis. (Vermeulen et al,2013)

An integrated, evidence-based and transformative approach to addressing food and climate security at all levels requires coordinated actions from the global to local levels, from research to policies and investments, and across private, public and civil society sectors to achieve the scale and rate of change required. With the right practices, policies and investments, the agriculture sector can move onto CSA pathways, resulting in decreased food insecurity and poverty in the short term while contributing to reducing climate change as a threat to food security over the longer term.

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