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CLIMATE CHANGE AND RAINFALL VARIABILITY IN WEST AFRICA: FOOD SECURITY AND FARMER COPING STRATEGIES: A REVIEW

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ABSTRACT

Rainfall variability is a serious trend that is posing a lot of challenges to agricultural development in many countries across the world in recent times. The majority of these countries can be found in sub-Saharan Africa. These countries continue to suffer due to the fact that agricultural commodities are the mainstay of their economies. In this paper, efforts were made (i) to shed more light on the evidence of erratic rainfall and its impacts on agriculture production in West Africa; (ii) to discuss the possible causes of food insecurity (iii) and how to mitigate the challenges posed by erratic rainfall to agriculture in the sub-region. A narrative review method was used to analyze the literature. The application of a narrative perspective to review the literature enables a broad understanding of the topic. The results provided evidence of an erratic rainfall pattern in the sub-region, with particular reference to Ghana and its impact on food security. It also assessed the feasibility of adopting weather forecast-based advice, integrated soil fertility management practices, and irrigation schemes as farmer coping strategies for mitigating the impact of an erratic rainfall pattern on crop production in West Africa.

1.0 Introduction

The population of Africa is expected to experience an exponential rise by 2050, doubling its present population of 1.2 billion to about 2 billion. The current food production practices employed across the continent with respect to the population surge are unsustainable. There is a great opportunity for Africa to be self-sufficient and also take advantage of the export of food (World Bank, 2020). However, changes in climatic patterns have greatly impacted agriculture. Farmers are experiencing the effects as the rains are coming in earlier than before, and periods of drought spells are lasting longer than normal.

Agriculture plays an important role in the economies of West African states and many other developing countries worldwide. Unfortunately, the agricultural sector is heavily dependent on the climate. Climate factors such as rainfall over the past two decades have become rarely stable. The agricultural sector everywhere in the world has been characterized by unstable rainfall, with sub-Saharan Africa having the highest share of the brunt. For a sub-region with a population of about 70% that obtains its livelihood from agricultural activities (FAO, 2015), any variations in climate factors such as rainfall must be an issue of great concern. This paper discusses the relationship between erratic rainfall and agriculture production, the causes of food security; and the hidden hunger among some West African countries. It also seeks to profess possible mitigation strategies needed to safeguard the nation's agriculture and to ensure adequate food supply within the sub-region.

Food security is defined as the availability, access, and utilization of food (USAID, 1995). Availability of food is said to be attained when everybody within a country has adequate supplies of food available at a time for use. Apart from household production, food can be provided through commercial scale importation or through donor-assisted food programs. There is food access when households and individuals in a given population have enough money or resources to be able to acquire enough quality food for a quality diet. However, this depends primarily on household income availability and distribution among the household population and, more importantly, the cost of food. Lack of money due to poverty inhibits poor people's access to food. Food access could also

be limited physically due to serious natural disasters resulting in the breakdown of transport and communication facilities, and conflicts (Asif, 2015).

Improving food availability and access is critical, but it is insufficient to ensure that people have enough food to live an active and healthy life. Food utilization is the process where consumed food is required to provide the body with the needed energy as well as the essential nutrients for the proper functioning of the body. It also involves a sufficient supply of clean water and good sanitation (Agrilinks Team, 2020).

2.0 Method

This narrative review article intends to clarify and contribute to the scholarly argument on the contribution of climate change and rainfall variability to agricultural productivity and food security in West Africa. Literature from over 15 publications related to the topic was reviewed. Also, possible mitigation strategies to avert food insecurity situations in the sub region were embraced by exploring up-to-date research and outcomes.

2.1 Causes and evidence of rainfall variability in West Africa

The distribution of rainfall in West Africa is caused by the south-west monsoon moist and the dry north-east trade winds. One of the major elements of climate change apart from temperature and carbon dioxide is rainfall. Therefore, any variability in the rainfall pattern within an agro-ecological zone is an evidence of climate change. The climate is the average weather conditions, of any given place, normally estimated at 30 years or more (NASA, 2008). Over the past 40 years in Ghana, climate change has been observed with a temperature rise of about 1^0 C, accompanied by changes in the time the rains begin for the season, and with dry periods during the rainy season becoming longer than normal. The global emissions of greenhouse gases are estimated to increase more causing the temperature to rise in most places and leading to additional changes in rainfall patterns**.**

It is also clear that the average temperature of many parts of Ghana has significantly increased over the last decade (Adiku et al., 2007). The first researchers who linked the erratic rainfall in Ghana to global circulation phenomena such as sea surface temperatures (SSTs) were Opoku-Ankomah and Cordery (1994). They demonstrated that variations in rainfall in many places in Ghana could be linked to the variations in the SSTs of the southern Atlantic. Adiku and Stone (1995) and Adiku et al. (2007) followed this work, and they observed a significant correlation between precipitation in many areas of Ghana and the Southern Oscillation Index (SOI) of the Pacific. Further analysis of climate data revealed a steady annual temperature rise of 0.06 C per year for Ghana (EPA, 2001).

Despite the fact that the causes of erratic rainfall in West Africa could emanate from other global phenomena, it is important to understand their patterns and to have evidence for better decision making. Mahe et al. (2001) evaluated the trajectories and discontinuities in regional rainfall in the West and Central Africa from 1951–1988. Further analysis revealed that, in Ghana, for instance, there was a general decline in the annual rainfall for the period from 1951 to 1989. Logah et al. (2013) also analyzed the rainfall pattern in Ghana. Their results showed an erratic rainfall pattern across the whole country. It further pointed out that between the periods 1981–2010, the mean annual rainfall had eventually declined, but with high precipitation moving to the south-western part of Ghana. As a result of that, northern Ghana's potential in agricultural productivity has been negatively skewed due to erratic rainfall. Also, the average annual rainfall for the five major agro-ecological zones in the country experienced a general downward trend.

In recent times**,** Kyei-Mensah et al. (2019) analysed monthly rainfall data from the Ghana Meteorological Agency (GMet) from 1985 to 2014 for the Fanteakwa District in the Eastern Region of Ghana, and observed a rainfall variability pattern. Their results from the coefficient of variation (CV) of the major and minor seasons of three decades revealed major differences in both seasons, with the highest in the minor season (CV, 5.7%) compared to the major season (CV, 7.6%). As a result, the total average rainfall amount for the 30-year period (1984–2014) of investigation was reduced by 351 mm for the wet season and 267.16 mm for the dry season.

2.2 Effects of rainfall variability on agricultural productivity and food security

Erratic rainfall has a large influence on agricultural productivity. Close to 70% of the population in the West African region depends mainly on rain-fed agriculture, thereby, making climate change a direct threat to progress toward several UN Sustainable Development Goals (SDGs), most notably goal 1 (No Hunger) (Serdeczny et al., 2017; Diedhiou et al., 2018). The climate change model used in West Africa predicted increases in temperatures of 1.5 to 2^0 C higher than global mean temperatures. The implication is severe heat waves for the entire region (Sultan et al., 2019), particularly Sub-Sahara Africa (SSA). Meanwhile, according to (Diedhiou et al., 2018), the Guinea Coast will experience slight variations in average total rainfall with a rise in heavy rainfall periods, leading to droughts and floods, as well as a later start, earlier end, and a shorter length of growing seasons.

Much evidence points to the fact that the economy of Ghana is mainly dependent on agricultural production over the years. Agriculture contributes about 54% of Gross Domestic Product (GDP), employing almost 60% of the population directly or indirectly, while at the same time providing over 90% of the food needs of the nation (Kwadzo et al., 2013: FAO, 2022). Crop production in Ghana is mainly rain-fed, with only 0.2% of land under total irrigation (MoFA, 2010). For example, cocoa production, which contributes

substantially to the GDP and thus about 20–25% of total export receipts of Ghana, is basically rainfed (Kyei-Mensah et al., 2019).

Rainfall variability has a serious impact on the availability of soil moisture for crop growth and development. Recent changes in the distribution of rainfall, and inter-seasonal variations have led to a decline in crop production. Mawunya and Adiku, (2013) observed that variations in the rainfall pattern have adversely affected crop productivity in Ghana in the following ways: (i) delayed arrival and the early end of the rains during the cropping season; and (ii) erratic rainfall or drought resulting in moisture stress or in sufficient soil moisture during crop growth. The consequence of this phenomenon is either complete crop failure or poor growth and yield since soil moisture is a significant variable in the reproductive growth stage of plants. In addition, too much rainfall resulting in high soil moisture creates an anaerobic (low or no oxygen) soil environment, which also adversely affects crop growth and development.

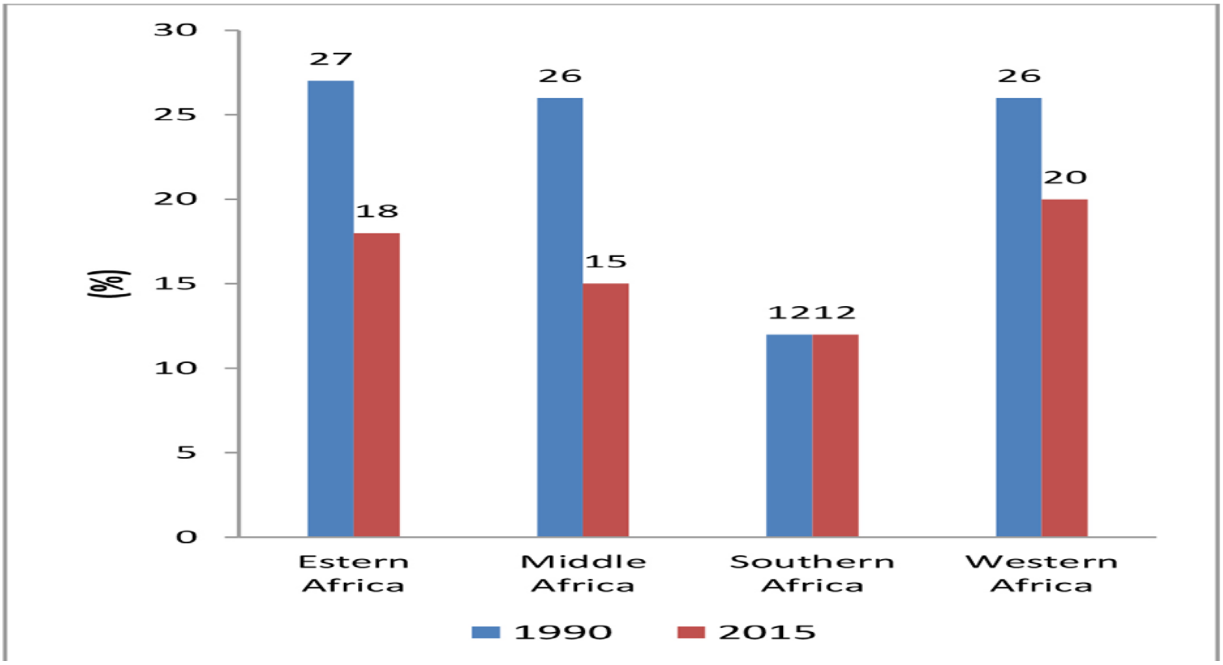
This situation has become a serious concern for those in the agricultural sector as well as policy-makers because of its effect on food production (Wang et al., 2019; Mumo et al., 2019). The major foodstuffs that are mostly affected are the major foodstuffs produced and consumed in Ghana, mostly, cocoyam, maize, cassava, plantain, and vegetables (MoFA, 2011). Antwi-Agyei (2012) observed that despite the fact that recent yields of cassava production in Ghana show trends of increases, future predictions from climate change scenarios revealed significant yield declines of cassava and cocoyam by 3%, 11%, and 13.5% and 29.6%, 53%, and 68% by 2020, 2050, and 2080, respectively. Also, the erratic rainfall experienced in most parts of the country may affect maize production by about a 20% reduction in outputs by the year 2050 (Kwadzo et al., 3013). Maize and rice are hunger-reducing cereal crops and it is important to note that any future yield decline will lead to serious food insecurity in the country.

In recent times, Kyei-Mensah et al. (2019) revealed the relationship that exists between erratic rainfall and the production of some selected crops in the Fanteakwa District in the Eastern Region of Ghana. They observed that erratic rainfall in the dry season was correlated with a yield decline, particularly for traditional crops such as cocoyam, plantain, and cassava, which have all declined. Regardless of these findings, it is important to note that attributing yield decline to erratic rainfall alone within the study area may not be entirely accurate. This is because there are other important variables, such as bushfires, the activities of nomadic herdsmen, and general bad agronomic practices, affecting crop production in the area.

The changes in climate factors such as rainfall and extreme weather events are predicted to adversely affect agriculture and food security across the world, particularly in developing regions such as sub-Sahara Africa, where a significant proportion of the population depends on agriculture and natural resources (Nath and Mandal, 2018; Wunder et al., 2018). Erratic rainfall is expected to affect food production in the sub-region. This is because the IPCC's Fourth Assessment Report (AR4), released in 2000, predicts that by 2050, yields from rain-fed agriculture in some SSA countries could be reduced by up to 50%.

Agricultural productivity will not only be affected by uncertain rainfall resulting in low yields but also by the low quality of the produce such that it cannot meet the nutritional needs of the people. Households may be forced to eat anything for survival, resulting in hidden hunger (Agrilinks Team, 2020). It has been observed over the years that women and children are those most affected by this unfortunate situation. This phenomenon is widespread, particularly among households that are poor. Due to a lack of financial resources, families may be forced to eat cheap foods but may not be able to afford the supplementary fruits, vegetables, and meat needed to provide a balanced diet.

Figure 1: Trend in the prevalence of malnourished underweight children in SSA, 2015.



Source: Word Health Organization, 2015.

In many developing countries, it is estimated that 3 out of 10 children under five years of age are stunted due to malnutrition. However, it is worth noting that many countries in SSA (figure 1), including Ghana, have made consistent progress in reducing malnutrition over the last ten years. This, indeed, is good news and all efforts must be made not to turn back the clock of progress because of the negative impact erratic rainfall is having on agriculture productivity in the sub-region.

2.3. Possible mitigation strategies

The worrying situation in agricultural productivity as a result of the consequence of increased rainfall variability requires immediate and appropriate interventions. Temperature influences the overall relationship between crop production and other factors such as soil, water, and technology (Deihimfard et al., 2018; Mumo and Fang 2018). Three well-reviewed coping strategies that will reduce the devastating impact of erratic rainfall on crop production and food insecurity in West Africa are hereby recommended.

i. Timely and efficient weather forecast services for farmers.

Rainfall variability has brought about a lot of uncertainty that is of great concern to farmers, particularly about the onset of the rain and the length of dry periods within the wet season. For this reason, improved advanced knowledge or reliable information about the coming season may be helpful to farmers in order to plan and organize their next farming activities towards the beginning of the rain. A prompt and accurate weather forecast is very much needed to enable farmers to make informed decisions in respect of the type of crop to plant, time to plant, and appropriate agronomic practices for the next cropping season.

Adiku et al. (2007) show that there is a fairly good correlation established between Ghana's rainfall and the ENSO (El Nino-Southern Oscillation) that could provide a basis for a reliable seasonal rainfall prediction. A properly directed weather forecast is needed for the agricultural sector in the sub-region to ensure farmers get timely and adequate information on the onset of the rain. This will help farmers plan to avoid severe crop failure due to erratic rainfall. In some cases, the major drawback to this important information technology intervention is the complete absence or inadequate modern meteorological service facilities in the West African sub region.

ii. Cost effective integrated soil fertility management

Much of the scientific research points to the fact that good soil management can reduce water stress on the growth of crops significantly. When properly followed, integrated soil fertility management techniques such as crop rotation, manure and inorganic fertilizer application could negate the impact of rainfall variability on crops. The ability of the soil to hold water greatly depends on the management of the soil. The mulching of the crop field through the leftovers of plant residues after crop harvest reduces run-off, evaporation, and increases water infiltration (Adekalu and Olorrunfemi, 2007). In effect, crops grown on fields that are properly mulched could continue to grow with more vigour even during periods of drought than those on fields without any mulch. This helps to effectively manage and reduce the impact of water stress on the crop. Also, soil fertility improvement helps support the growth of plants and improve their ability to withstand stresses compared to crops growing on poor soils (Sajid et al., 2014).

iii. Efficient irrigation schemes

Irrigation is the controlled application of water to crops. This is useful in the growth of agricultural crops that are water stressed in order to bring them back to life. The irrigation scheme must be affordable and easily accessible to farmers; otherwise, the benefits that come with the scheme could not be achieved due to cost. Where the rainfall is erratic and unpredictable, irrigation plays a supplementary role in ensuring a regular and adequate supply of water for growth and development of plants. Crop yields under irrigation are consistently higher than yields under rainfed conditions (Pellegrinia and Fernándeza, 2018). The impact of irrigation results in higher farm productivity through crop yield increases and diversification of cropping patterns and crop technologies. These may indirectly lead to increased household income, consumption, and lower food prices.

The use of irrigation facilities in crop production, particularly vegetable production, is known to significantly increase production. For example, crop yields increased by up to 43% in smallholder fields in rural Ethiopia where an irrigation facility was used for production (Ayalew, 2009), in a region identified with erratic rainfall patterns. Also, other studies in Ghana have shown similar crop yield increases under irrigation fields (Amankwah and Ocloo, 2012; Bagson and Kuuder, 2013; Asamoah, 2019).

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3.0 Conclusion

This paper has examined the issues of climate change, rainfall variability, and their effects on agricultural production and food security in West Africa. It provided evidence of rainfall variability in West Africa, with particular reference to Ghana. The evidence shows that erratic rainfall is clearly worsened by climate change, thereby posing a serious threat to agriculture production, food security, and hunger in the sub-region. To effectively overcome the impact of rainfall variability on agricultural production, the mitigating strategies advanced should be used as a combined package. Thus, forecast-based advice should go with either improved soil man-

agement practices or irrigation schemes. It is important to note that farmers are interested in adapting to changes once there is assurance or evidence that such changes in farming methods will bring about yield increases and profit. However, most farmers in the sub-region are constrained by barriers of access to critical inputs (seeds, fertilizers, modern tools and equipment) and knowledge (limited information on new skills). All these are poor technical capacity issues that could hinder any effort in mitigating the impacts of climate change and rainfall variability in West Africa. To achieve success in these mitigating efforts, technical capacity issues advanced above must first be addressed, most importantly at the local level

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