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LIMATE CHANGE AND FOOD SECURITY IN SUB-SAHARAN AFRICA: EVOLVING AFRICAN-BASED ADAPTABILITY STRATEGIES

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Abstract

Climate change has significant and wide-ranging effects on Sub-Saharan Africa. The region is considered most vulnerable due to its high dependence on rain-fed agriculture and low adaptive capacity. Food security is one major area where people living in Sub-Saharan Africa have been negatively impacted by climate change. Farmers have suffered significant losses due to drought, repeated torrential downpours, and protracted flooding. Agriculture is now highly unpredictable due to the alteration of the typical pattern and proportion of rainfall brought about by climate change. Food security is impacted by climate change in a number of ways, including through its effects on the availability, affordability, accessibility, utilisation, nutritional value, and stability of the food system, as well as through its effects on crop yield, water availability, fisheries production, agricultural pests (weed, insect, and disease pests), and livestock production. The Sub-Saharan region of Africa, in particular, is considered to be world's most drought-prone region. Droughts that recurred frequently in the area have led to chronic food insecurity and malnutrition. Many Africans were severely affected by food crises and famine brought on by catastrophic weather events or drought. For instance, famine brought on by a drought in Africa affected more than 120 million people. With a regional average of 26.8% undernourished people and a potential hunger growth rate of above 50%, Sub-Saharan Africa is regarded as the region with the highest level of food insecurity in the world. Having outlined and discussed the threatening effects of climate change on food security, the paper submits that adaptability strategies must be put into practice as the only alternative impact reduction strategies.

Keywords: Impact of Climate Change, Food Security, Food Insecurity, Adaptability strategies

Introduction

One of the major issues facing sub-Saharan African countries is the threat that climate change poses on food security. Due to the effects of climate change, the region has become the most vulnerable and food

insecure region due to its reliance on economically vulnerable and climate-sensitive sectors (rain-fed agriculture), as well as its limited capacity for adaptation in terms of resources, skills, and technology, and its traditional farming practises. In addition, Sub-Saharan African is considered the most food insecure region in the world due to the existence of the greatest number of people who depended on subsistence and climate-dependent agriculture. This extremely climate-sensitive economic sector is a source of livelihood and food security for Africans, indicating that the climate change has a significant impact on their food security and way of life. On the other side, the Sub-Saharan Africa is a region that is most susceptible to drought. The recurrence of droughts in the region, affects many Africans through chronic food insecurity and malnutrition (hunger, displacement, and death).

The fact that many countries in Sub-Saharan Africa have low capacity to evolve and implement effective adaptation strategies has left agriculture very vulnerable. Climate change is thought to pose the greatest threat to agricultural production and food security in Sub-Saharan Africa (Ethan, 2015). The bulk of the region is already arid, farming practises are still rudimentary, and the smallholder systems that dominate the agricultural landscape have very little ability to adapt (Ayinde, Muchie & Olatunji, 2011). Africa is expected to suffer a greater temperature increase trend than the world average due to the fact that some sections of the continent are becoming drier over the past century such as the Sahel, for example.

Climate change is anticipated to negatively affect food security due to its predominantly negative effects on sub-Saharan African agriculture (Ikem, 2018). According to Muringai, Naidoo, Mafongoya, and Lottering, (2020), food insecurity is the outcome of a complex interaction between numerous stressors (socioeconomic and environmental) over extended periods of time and with abrupt shocks. On the other hand, extreme droughts and climate change in sub-Saharan Africa are already making it difficult for people to raise cattle and grow food. To retain their food security and general well-being, pastoralists and agro-pastoralists will need to adjust to changes in water regimes (Ethan, 2015). Beyond temperature rises, sub-Saharan Africa is predicted to experience changes in rainfall intensity (Ogbo, Ebele, & Ukpere, (2019), an increase in the frequency of extreme weather events like droughts and floods (Ayinde, et al., 2011), an increase in desertification, and changes in some disease vectors that will affect the spatial and temporal transmission of infectious diseases (Okoli, &

Ifeakor, 2014). Agriculture losses were caused by the drought, which is also a key contributor to food insecurity in Africa. According to IPCC's 2007b report, food insecurity and malnutrition have had a substantial impact on African people's lives and are on the rise globally. In general, it is discovered that climate change is the primary cause of food insecurity and malnutrition in Africa, indicating that it has a negative impact on the continent's agriculture and food security. Therefore, the goal of this is to examine how climate change is affecting food security and suggest some strategies for reducing those effects.

Aim and objectives of the paper

The aim of the study is to analyse the impact of climate change on food and human security in sub-Saharan Africa and propose feasible adaptive strategies for dealing with the effects. The specific objectives of the study are:

i. to identify the food security situation in Sub-Saharan Africa;
ii. to identify the specific effects of climate change on agricultural productivity in Sub-Saharan Africa; and
iii. to propose feasible adaptive strategies for dealing with the effects of climate change on food security.

Methodology

This study is a descriptive case study that involves the use of primary and secondary sources of data. It is a multidisciplinary study that draws information from relevant disciplines. Its' analysis is based on data on the effects of climate variability on agriculture in Sub-Saharan Africa obtained from reliable sources. Also data derived from special reports from Intergovernmental organizations on the subject matter were also used in the study. The findings of the study were based on an in-depth analysis of secondary sources of data.

Literature review

The concept of food security

Food security refers to having access to basic nutritious food. According to the United Nations Committee on World Food Security, food security means that "all people at all times have physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for an active and healthy life." The 1974 World Food Summit defined food security as the "availability at all times of adequate supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices." According to FAO (2017), food insecurity occurs when "all people do not have adequate physical, social, or economic access to

food". According to the World Food Summit of 1996, "food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life." According to this concept, food security has four components: availability, accessibility (both physically and monetarily), utilisation (how it is utilised and assimilated by the human body), and stability of these three components. When everyone, at all times, has physical and financial access to enough, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life, then there is food security (FAO, 2017).

Components of food security

According to FAO (2021), the four main components of food security are: food availability, food accessibility, food utilisation, and food stability.

Food availability: This refers to the availability of sufficient amounts of food in acceptable quality, whether it is produced domestically or imported. The domestic production, distribution, storage, import, and export of food also has an impact on its availability. Food availability is the entire physical amount of food that is available in a nation or region in the form of domestic production, import, exchange, processed food, and stocks after taking into account all exports (Ikem, 2018). Crop production and/or food production indices, animal ownership indices, and national food balance sheets are examples of indicators used to measure the availability of food (Muringai, Naidoo, Mafongoya, & Lottering, 2020). The most common way to gauge food security is probably by looking at food availability.

Access to food: This is the ability to protect one's food entitlements is referred to as access to food. Individuals' ability to access sufficient resources for buying the right foods for a nourishing diet. Given the legal, political, economic, and social structures of the community in which a person resides, entitlements are defined as the collection of all commodity bundles over which a person can exercise control. A person's ability to obtain entitlements—a collection of resources that include legal, political, economic, and social support—is measured by how easily they can receive food.

Food utilization: Utilising food to fulfil all physiological needs requires a healthy diet, access to clean water, sanitary conditions, and medical care. According to FAO (2017), food utilisation includes "the nutritional value of the diet, including its composition and methods of preparation;

the social values of foods, which specify what types of food should be served and eaten at different times of the year and on different occasions; and the quality and safety of the food supply, which can result in the loss of nutrients in the food and the spread of food borne diseases if of insufficient standard. Simply put, a person's capacity to benefit from the food they consume is referred to as their food utilisation (Ethan, 2015).

Food stability: A population, household, or individual must always have access to enough food in order to be considered food secure. They shouldn't have to worry about losing access to food because of cyclical occurrences (like seasonal food insecurity) or unexpected shocks (like an economic or climatic disaster). Therefore, the availability, access, and utilisation facets of food security are referred to as stability. As a result, all aspects of food security (Figure 1) are intricately linked to agriculture productivity, which provides food and money for rural people.

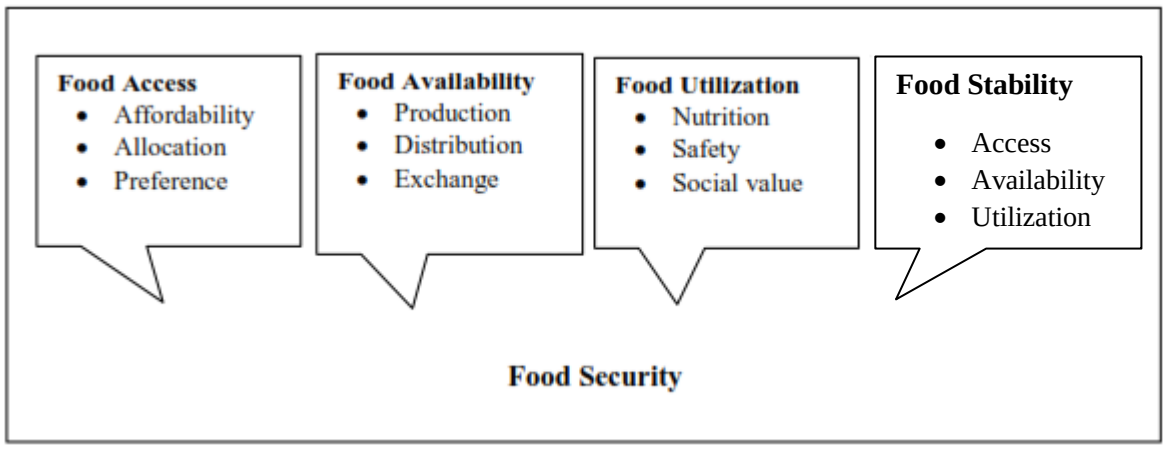

Fig. 1: Components of Food security
Source: Adapted from Sirba and Chimdesa (2021)

Effects of climate change of agricultural productivity

Reduced crop yield: Crop yields are directly impacted by changes in temperature, rainfall patterns, and the frequency of extreme weather events. Heat stress, a reduction in photosynthesis, and decreased crop output can all be caused by rising temperatures. Inconsistent rainfall patterns, such as extended droughts and heavy downpours, interfere with planting and harvesting schedules, stunting agricultural development and lowering yields.

Irrigation challenges and water scarcity: In many areas of sub-Saharan Africa, water scarcity is a result of climate change. The amount of water that is available for agricultural use is constrained by shifting rainfall patterns, rising evaporation rates, and decreasing water supplies. Lack

of consistent irrigation has an impact on agricultural productivity and makes farming more difficult, especially during dry spells.
Decrease output and food price volatility: Shocks to agriculture brought on by climate change and decreased food output results to higher food costs. This has an impact on the cost and availability of food, especially for vulnerable groups that spend a large portion of their income on food. Political instability and societal unrest can both be exacerbated by price volatility.

Increased pressure from pests and diseases: Crop health and yield are impacted by pest and disease spread and behaviour due to climate change. The expansion of pests, such as insects and fungi, is made possible by rising temperatures and changed rainfall patterns, which increases agricultural damage. By destroying broad swaths of crops, pests like locusts can result in catastrophic losses and add to the problem of food poverty.

Land degradation and desertification: In sub-Saharan Africa, land degradation and desertification are made worse by climate change. Soil erosion, the depletion of nutrients, and the loss of vegetative cover are all caused by rising temperatures, droughts, and irregular rainfall patterns. These processes decrease the amount of land that is suitable for agriculture, endangering food production.
Impacts on livestock and fisheries: In addition to having an impact on agricultural output in sub-Saharan Africa, climate change also has an impact on livestock production and fisheries. The health and productivity of cattle are impacted by variations in rainfall patterns and the availability of fodder, which lowers the amount of meat and milk produced. Rising sea temperatures and ocean acidification have an impact on fish populations in coastal locations, impacting fishing communities' livelihoods and diminishing the availability of a crucial source of protein.

Impacts of Climate Change on Access to Food
People's access to food is reduced as a result of increased exposure to climate change events, which puts their food security at risk (FAO, 2017). Food access is significantly influenced by changes in the levels and volatility of food prices. The purchasing power and food security of the poor are being significantly impacted by the rising level and volatility of agricultural prices (Idumah et al., 2016). According to a World Bank research, the rise in food prices since 2010 has resulted in a net increase of 44 million people living in extreme poverty in low and middle-income countries (Ayo, Omosebi & Suleiman, 2014). It is

possible to anticipate changes in the distribution of net food sellers and purchasers as a result of the process of economic development (Okoli & Ifeakor, 2014). Food distribution pattern has been affected by climate change leading to price volatility and invariably affects food accessibility. The ability of individuals to pick the food they wish to consume (preferable ability) will also be impacted by climate change, which will also have an impact on affordability (Oyinloye, Akinola, Akande, Akinyele, and Mosimabale, 2018).

Effects of Climate Change on the Availability of Food

According to Wossen, Berger, Haile, and Troost (2018, p. 10), "the pathway through which climate change directly affects food security is the availability of food". Depending on the location, varied effects of climate change on food supply will be felt. For instance, moderate warming (increases of 1 to 3^{o}C) is anticipated to increase crop and pasture yields in temperate countries, whereas it is anticipated to have detrimental effects in tropical and seasonally dry portions of Africa, especially for grain crops. A warming of more than 3^{o}C, according to Ughaelu (2017), is anticipated to have a negative impact on production everywhere. When paired with rising food demand, global temperatures of 4^{o}C or higher would pose serious threats to both regional and global food security (Zwedie, 2018).

According to the 2019 report of the FAO, famine brought on by drought in sub-Saharan Africa affected more than 120 million people. The report estimated that 26.8% of the regional population is undernourished and a potential undernourishment growth rate of above 50% was speculated. Sub-Saharan Africa is therefore regarded as the region with the highest level of food insecurity in the world. Additionally, the chance of rise in hunger would rise by 15–25% in 2050 (FAO, 2019). Similar projections show that the number of malnourished children in sub-Saharan Africa will rise from the baseline (35 million) to 44 million and 51 million, respectively, in 2030 and 2050 as a result of the effects of climate change.

Effects of climate change on food utilization

Due to a decrease in the productivity of small-scale farmers and the availability of wild crops, climate change has an impact on how food is used. There has been significantly less research done on the effects of climate change on diet. There are numerous possible impact routes due to climate change. As was already indicated, climate change will have an effect on the livelihoods and income of small-scale food producers as well as the livelihoods of poor net food consumers due to rising and

fluctuating food prices, which will force these groups to cut back on both the quantity and quality of the food they consume. They may also cut back on medical expenses, which could have an impact on nutrition. Another typical response is to prioritise calorie-dense, nutrient-poor foods by rationing consumption (Zwedie, 2018). A decrease in dietary quality as well as quantity has long-term negative effects on health, productivity, and income (Ethan, 2017). The nutritional quality of foods may also change as a result of elevated CO, notably for flour made from grain cereals and cassava (lower concentration of proteins and certain minerals like zinc and iron), according to studies (Oyinloye, 2018). As it is typically accompanied with greater yields, which itself might increase food intake, the main issue is frequently, this effect does not necessarily transfer into effects on nutrition (Olagunju, 2015). The WHO (2019) predicted that climate change will lead to an increase in diarrheal infections, which would primarily affect low-income communities. In particular, the incidence and prevalence of food-borne diseases are impacted by climate change, which also has an effect on food safety.

Effects of climate change on food stability

Many authors are of the view that extreme weather events related to climate change have an impact on food stability. Climate-induced disasters like droughts and floods will become more frequent and severe as a result of climate change (Ayinde, et al., 2011), which will have a detrimental effect on the stability of food supplies. According to Berhanu and Wolde (2019), climate change events pose serious risks to the stability of food systems, particularly for households with low food consumption capacity. For instance, temperature rises and a sharp decline in rainfall in the semi-arid region of Northern Nigeria led to decreased crop and livestock productivity. It further exacerbates the water shortage, which has a detrimental impact on household income, livelihood, and health (Muringai, 2020). It also contributes to the loss of farm and pasture fields. The occurrence and frequency of some types of extreme climate events are predicted to increase due to climate change, and this will have a significant impact on food security (FAO, 2019). There is growing evidence supporting this prediction. Changes in seasonality, increased variability in ecosystem productivity, increased supply risks, and decreased supply predictability will affect the stability of the food supply (Muringa, et al., 2020). These factors may also have significant effects on supply chain costs and retail prices. The stability of the food supply, access, and consumption will be impacted by increased climate variability, increased frequency and intensity of extreme events, as well as slow, continuous changes.

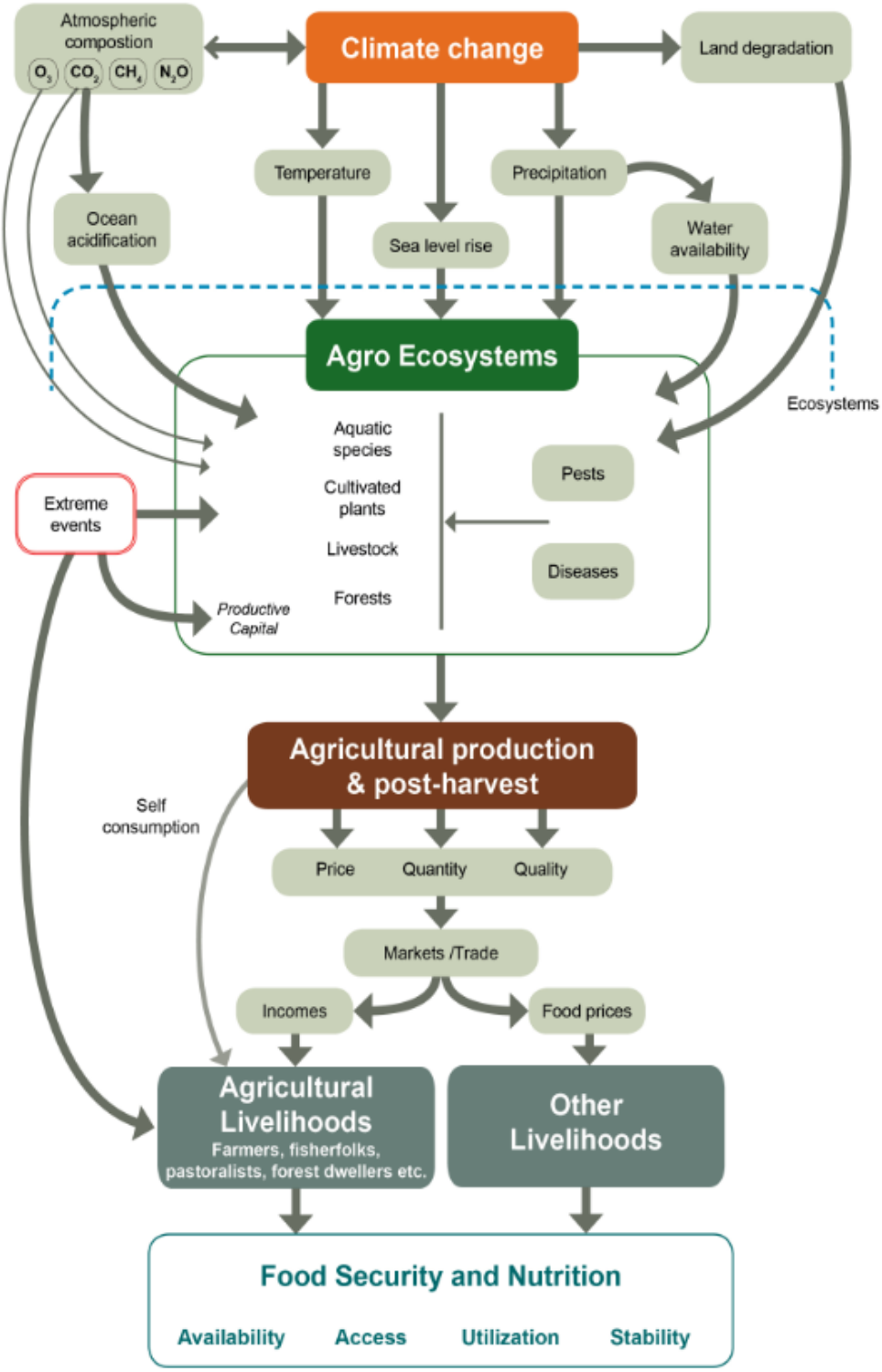

Fig. 2: Schematic representation of the effect of climate change on food security and nutrition
Source: FAO, 2021

Findings and Analysis

Effect of climate change on food utilization

One of the key indicators of food utilization is the nutritional quality of food. Variability in climatic condition has implication on the quality of agricultural produce. When the climatic needs of plants are not optimally met, the quality of produce is affected. Some crops fall short of some essential nutrients as a result of climate change. Thus, consumption of such food leaves one undernourished. Often poor yield or unavailability of some food qualities leads substitution of the needed with other food commodities that are nutritionally deficient. This condition results in undernourishment. Figure 3 shows the projected number malnourished children in Sub-Saharan Africa from year 2000 baseline to 2050.

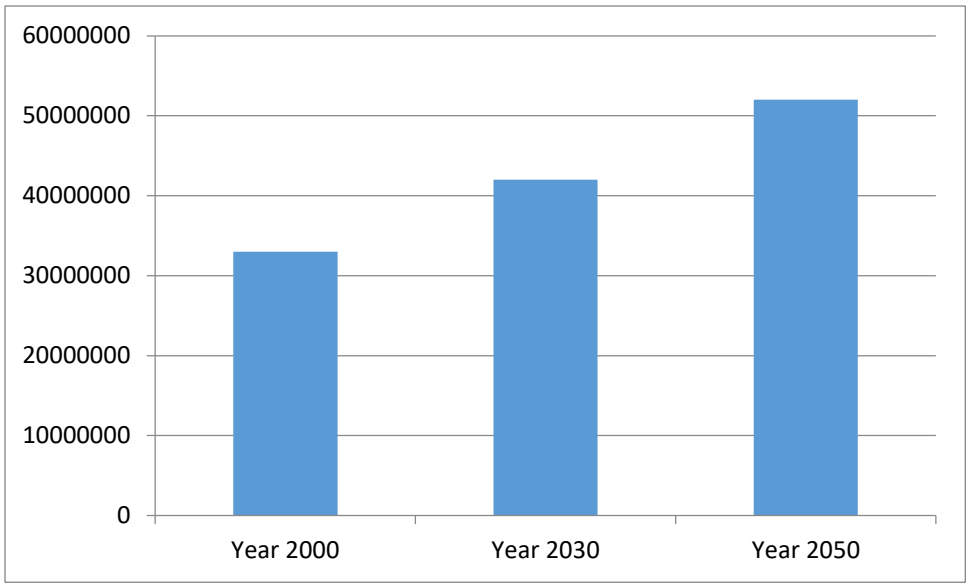

Fig. 3: Projected number of malnourished children in Sub-Saharan Africa

Source: Derived from FAO's report of 2017

The chart shows that the increasing effects of climate change will continue to escalate the rate of children's malnourishment. This demands concerted efforts to mitigate the impact of climate change on food security.

The effect of climate change on crop diseases

Types of crops	Potential impact of climate change
Coffee	The likelihood of disease and pest infestations is increased by rising temperatures and irregular rainfall.
Rice	Weather elements like increased temperatures, air humidity, or soil moisture considerably exacerbate two major diseases (blast and bacterial

	leaf blight) that have an impact on rice harvests.
Maize	Aflatoxin contamination poses a major risk to both human health and the sale of maize, and will probably get worse if the amount of rain during the dry season rises.
East African highland banana	While bananas are less susceptible to temperature increases than coffee, the crop is nonetheless at risk from pests and diseases.
Beans	When too much rain falls during crucial growing phases, beans are susceptible to viral and fungal infections.
Several grains	Erratic rain may cause post-harvest storage losses of crops (such as maize, beans, coffee, and rice) that are generally dried in the sun to increase because of an increase in pests and rotting.
Sorghum and maize	Increased temperatures, when combined with variable precipitation, could cause striga, a parasitic plant that affects sorghum and maize and is common in places with deteriorated soils, to spread.
Sweet potatoes and cassava	Both crops thrive in temperatures significantly higher than those seen today, but they are also susceptible to pests and disease.

Table 1: Climate change's potential effects on crop disease
Source: Sirba & Chimdessa (2021)

Climate change has significant impact on crop diseases. This poses a challenge to formers as the yields of crops are negatively affected by increasing disease outbreak. Table 1 shows some popular plant diseases induced by climate change.

Impact of rising rainfall of crop production

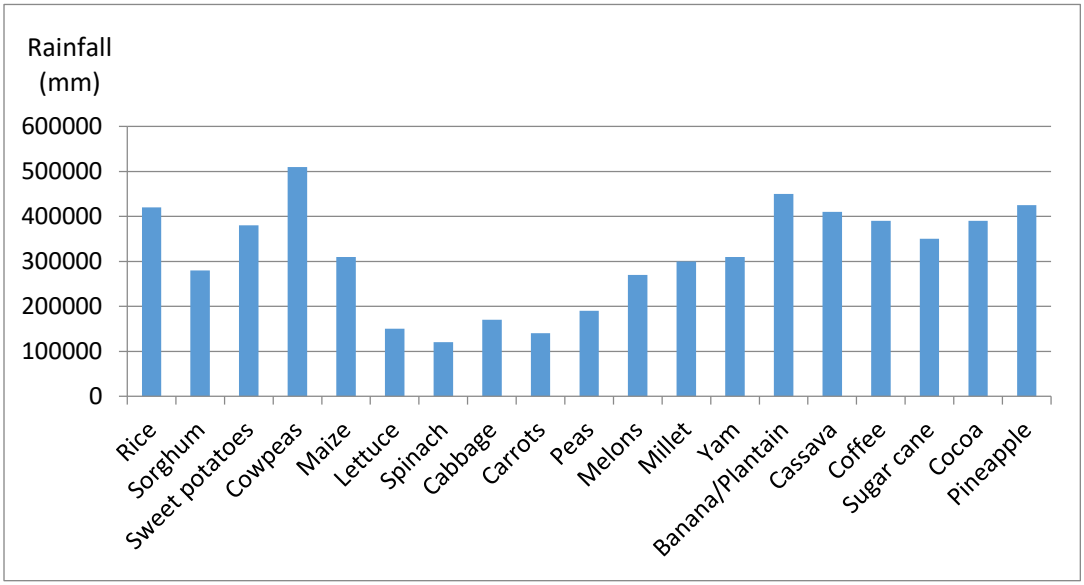

Fig.4: Optimal rainfall requirements of crops

Figure 3 shows that the crops represent would normally perform yield desired output when their respective rainfall requirements are met. Thus, variations in the amount of rainfall resulting from climate change will affect the performance of the crops.

Impact of climate changes on agricultural productivity

Country	**Observed changes in climatic events**	**Impact on food production**
Nigeria	Temperature rise Changes in rainfall pattern Sea level rise	Desertification Loss of agricultural productivity Increasedfrequency of extreme weather event such as flood and drought
Ethiopia	Recurrent drought and floods	Crop failure Water scarcity
Kenya	Decreased rainfall Rising temperature Increasing frequency of drought Increasing frequency of flood	Threaten agricultural productivity Threaten water resources
South Africa	Rising temperature Changing rainfall pattern Prolonged drought	Water scarcity Reduced agricultural yield

Tanzania	Shift in rainfall pattern Rising temperature Coastal erosion	Reduction in agricultural productivity Stress of water resources
Uganda	Altered rainfall pattern Increased frequency of drought	Decrease in agricultural productivity Flooding of farmlands Plant disease outbreak
Mozambique	Rising sea level Coastal erosion Extreme weather events such as cyclones and floods	Significant damage to agriculture
Democratic Republic of Congo	Changing weather patterns Rising temperature	Depleting water resources Reduced agricultural productivity Deforestation

Table 2: Effects of climate change on agriculture in some countries

Table 2 shows that climate affects many counties in Sub-Saharan Africa. the effects upon the various countries of Sub-Saharan Africa vary and some cases similar. One common denominator is that agricultural productivity is affected negatively. This reality poses serious threat to food security across the region.

Optimal soil temperature requirement for crop production

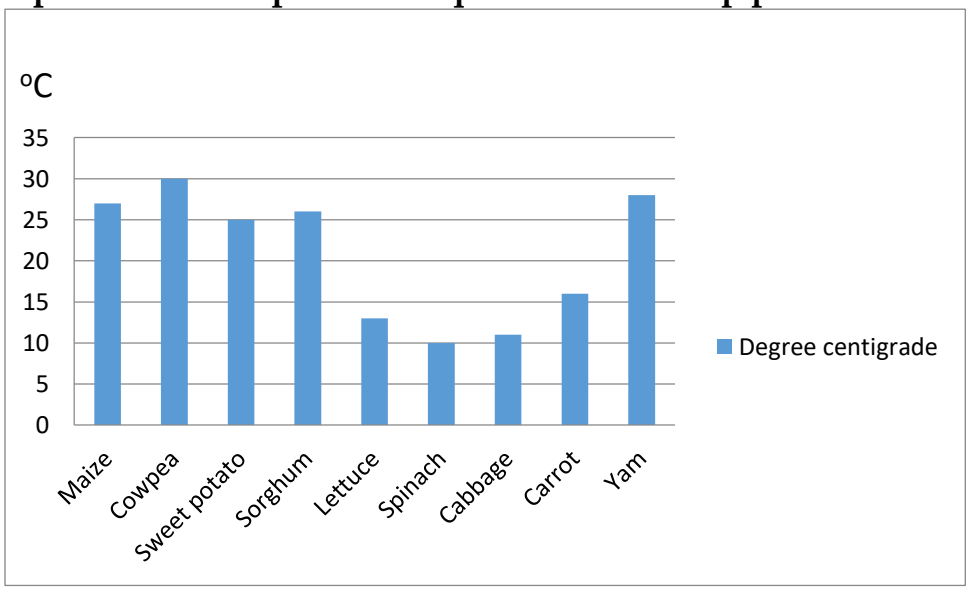

Fig. 5: Optimal soil temperature for crop production

Figure 5 shows that the crops presented would normally yield high when their respective soil temperature requirements are met. Thus, any

variation in the soil temperature criteria for these crops would have negative effect on crop yield. Gradual increase in temperature due to from increasing concentration of CO_2 and other greenhouse gases results in poor yield, flood and drought.

Discussion of findings

Climate change is found to have serious implications for agricultural productivity. Variation in climatic condition affects the performance of crops in a negative way. The fact that climate change is anthropogenic and not easily reversible leaves man with no option than to develop adaptive strategies for dealing with changing climatic conditions.

Some of the adaptive strategies found suitable for the people of Sub-Saharan Africa the following:

i. Adopting climate change-resilient agricultural system

An agricultural system that is climate change resilient is one that is built to endure and adapt to the effects of climatic change. It is essential to design agricultural practises that can continue to provide food and maintain productivity under such circumstances since climate change presents numerous difficulties to agriculture, including changing rainfall patterns, rising temperatures, and extreme weather events.

Here are some crucial components and tactics that can help create an agricultural system that is climate change resilient:

Crop diversification: Growing a variety of crops lowers agriculture's sensitivity to climate change. Diversification helps reduce risk and guarantee some degree of production even if one crop fails because different crops have varying tolerances to temperature, water availability, and pests.

Conservation agriculture: Conservation agricultural practises include crop rotation, minimal soil disturbance, and soil cover maintenance. These methods improve the resilience of agricultural systems by enhancing soil health, increasing water retention, and reducing erosion.

Implementing effective water management strategies is essential for climate resilience. To maximise water use and minimise water loss, this includes the use of strategies like drip irrigation, rainwater collection, and water recycling.

Agroforestry: There are several advantages to incorporating trees into agricultural landscapes through agroforestry systems. Windbreaks, shade, and additional revenue opportunities from fruit or timber

production are all provided by trees. Additionally, they increase soil fertility, biodiversity, and carbon sequestration, which aids in reducing greenhouse gas emissions and preparing for them.

Better livestock management: By implementing techniques that improve animal nutrition, breeding, and health, livestock production can become more robust. Livestock can adapt to changing climatic circumstances with the help of appropriate housing, breeding for heat tolerance, and effective feeding techniques.

Climate-smart technology: Adopting cutting-edge technologies can improve agricultural systems' resilience to climate change. To maximise resource utilisation and crop management, this includes adopting precision farming tools like remote sensing and data analytics.

Access to climate data: In order to make educated decisions, farmers require timely and reliable climatic data. Farmers may organise their agricultural activities properly and reduce risks by having access to weather forecasts, climate change projections, and advice services.

Financial and insurance procedures: Putting in place financial and insurance mechanisms can aid farmers in recouping losses brought on by the climate. Support during extreme weather conditions or crop failures can be obtained through crop insurance, weather-indexed insurance, and other risk-sharing programmes.

Building farmer capacity and educating farmers is crucial for helping them implement climate-smart practises. Farmers can adjust to changing conditions by completing training programmes on sustainable agriculture, water management, conservation methods, and climate adaptation tactics.

Support for policy: Promoting climate-resilient agriculture requires the active involvement of governments and policymakers. Farmers may adopt climate-resilient practises if supportive policies are put in place, sustainable practises are encouraged, and research and development funding is made.

Overall, developing an agricultural system that is climate-resilient necessitates a comprehensive strategy that incorporates multiple technologies, regulations, and tactics. We can guarantee food security, save livelihoods, and lessen the effects of climate change on rural communities through enhancing agricultural resilience.

ii. Use of grow bags for farming

Grow bags are adaptable plant-growing containers made of cloth or other breathable materials. They have a number of advantages for farming and gardening, especially when conventional soil-based agriculture is difficult or unworkable. The following are some typical applications and benefits of grow bags for farming:

Space optimisation: Grow bags are a great choice for urban farming or small locations where conventional gardening beds or containers might not be practical. They enable people to cultivate plants even in small spaces and can be installed on rooftops, balconies, or small yards.

Grow bags are convenient for gardeners who want the freedom to move their plants about because they are lightweight and portable. By moving the bags as needed, you may maximise solar exposure or benefit seasonal plants in particular.

Better drainage: Grow bags frequently include several drainage holes, which encourage excellent drainage and prevent water logging. This promotes healthier plants by preventing root rot and giving the plant roots better aeration.

Improved root health: The air can reach the plant roots thanks to the grow bags' breathable fabric or material, which reduces root circling and encourages root pruning. This promotes the establishment of healthier plants with a well-developed root system.

Better water retention: Grow bags hold moisture better than conventional pots or containers, despite having good drainage. The fabric's ability to hold onto moisture helps to prevent overwatering or under-watering and lowers the likelihood of drought stress.

A well-balanced growing medium, such as a combination of manure or compost and vermiculite, can be placed inside grow bags to improve nutrient uptake. As a result, the environment for plants is favourable, enabling effective nutrient uptake and root development.

Use of grow bags reduces the risk of contracting any soil-borne diseases that might be present in your garden soil. The growing media used in the bags is new and sterile, which lowers the risk of disease transmission and eliminates the need for chemical treatments.

Increased growing season: Some plants can have their growing seasons extended by using grow bags that can be brought indoors or placed in greenhouses. As a result, crops that are not suited to the local environment can be grown there all year long, and seedlings can be started earlier in the season.

Easy maintenance and harvesting: Grow bags are simple to upkeep and harvest. They don't require extensive digging or upsetting the plant's root system because they are simple to clean and reuse, and plants can be picked by simply emptying the bag or cutting it open.

Versatility: A variety of plants, including vegetables, herbs, flowers, miniature trees, and shrubs, can be grown in grow bags. They are appropriate for both indoor and outdoor gardening and can fit different plant sizes.

When using grow bags, it's crucial to choose the right size for the plant's root system, offer enough support, and make sure to deliver the right amount of water and fertiliser based on the needs of the plant. Grow bags can be a practical and effective alternative for growing plants in a range of farming situations if they are handled carefully.

iii. Exploring and deploring the use of African rain-making technology

Another plausible approach to mitigating the impact of climate change on agricultural productivity in Sub-Saharan Africa is the deployment of the African rainmaking techniques in the control of weather conditions especially during planting seasons and droughts. The practice of rainmaking in Africa dates back to the ancient period. Rainmaking has been an important part of African history and culture. It is a common practice among many African groups such as the Bantu, Zulu, Khoisan, Luo, Abanyore, Akamba, Ameru, Turkana, Maasai, Igbo, Yoruba, among many others.

Rainmakers possess knowledge on how to manipulate or alter the elements of nature to bring about rainfall or to restrain rainfall. Although the knowledge of rainmaking is preserved for the initiated and is often clouded in traditional spiritual belief, it is possible for such knowledge to come to limelight as a means of dealing with the issue of climate change. The impacts of climate change on agricultural productivity could be mitigated if rainmakers are amalgamated and deployed for the controlling weather conditions

Conclusion

The impact of climate change on Sub-Saharan Africa's food security must be addressed, and adaptation and mitigation techniques are crucial. These could entail promoting climate-smart agricultural practices like agroforestry and conservation agriculture, enhancing irrigation and water management systems, creating crop varieties resistant to pests and drought, improving early warning systems for extreme weather events, and diversifying livelihoods to lessen reliance on agriculture. For these initiatives to be implemented for the region's agricultural systems to become more resilient, international assistance, funding, and knowledge transfer are essential.

Recommendations

The paper suggests that states in Sub-Saharan Africa should put in place strategies for coping with the effects of climate change on agricultural productivity. Such strategies include:

i. Farmers and extension personnel need to get ad hoc, brief training on the detrimental effects of climate change and how to use coping mechanisms and adaptation techniques.
ii. Modernising African agriculture through the application of enhanced technologies and management techniques.
iii. Planting food crop varieties that mature quickly and those that can withstand droughts.
iv. The use of irrigation-fed agriculture should be encouraged as opposed to rain-fed agriculture.
v. The use of grow-bags for urban agriculture should be encouraged.
vi. Raising public awareness of the current state of climate change and the potential harmful effects.
vii. Co-opting rainmakers in finding solutions to issues relating to climate change effects on agriculture.

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