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What are the impacts of climate change on sustainable food production, food demand, and population numbers in Sub-Saharan Africa? A systematic review

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ABSTRACT

Introduction: *Climate change is a global phenomenon that is one of the key issues our globe faces in the twenty-first century to feed nine to ten billion people sustainably by 2050. It is a common and dynamic phenomenon caused by complex and interconnected physical, environmental, and human elements. Because it relies on agriculture and natural resources, warmer baseline conditions, low precipitation, and limited ability to adapt, Sub-Saharan Africa is regarded as the most vulnerable to the effects of climate change. Climate change affects and contributes significantly to food and agriculture. Sub-Saharan Africa is a rapidly developing region with a population of over 900 million people and a diverse ecological, meteorological, and cultural variety. It boasts the world's youngest and fastest-increasing population, and it is the only region where the rural population, particularly rural youth, will continue to expand past 2050.*

Methods: *My systematic searches were based on past review methods, which included using database platforms or bibliographic databases such as Web of Science, Scopus, CAB abstracts, Science Direct, and JSTOR. I also ran a Google Scholar search. My searches were all restricted to Sub-Saharan Africa. As a result, I gathered all search results and reviewed all articles retrieved using preset inclusion criteria. I found over 50 publications, including key FAO and World Bank reports, that answered the highlighted problems. All articles were screened twice (title and abstract, then full-text), with consistency checks at each stage. Relevant publications were read critically, and meta-data and quantitative data were extracted and entered into a database. All included studies were reported narratively, and those that matched the meta-analysis requirements were presented descriptively.*

Review Findings: *More than 80% of the research agreed that climate change and its implications are current problems in Sub-Saharan Africa. The majority of them forecast predicted changes in population numbers in Sub-Saharan Africa and the related demand for food, as well as examine major climate changes and explain how these changes may affect food production. Food demand in Sub-Saharan Africa is increasing due to socioeconomic and population growth. To increase food security and demand in the face of predicted demographic, economic, and environmental changes, aggressive measures are required. Although international food demand is expected to climb by 60% by 2050 compared to 2005/2007, the increase in Sub-Saharan Africa would be substantially bigger. Food prices in many Sub-Saharan African nations are rising faster than household incomes and other economic prospects. Food demand typically rises with urbanization as the population shifts from rural, presumably food-producing, to urban, primarily for food consumption.*

Conclusions: *Sub-Saharan Africa has been identified as the most susceptible not only because of its significant exposure to severe climate change but also because many of its inhabitants cannot respond to or adapt to the effects of climate change. Over 90% of agriculture in Sub-Saharan Africa is rain-fed, and subsistence is neither technically nor financially robust enough to mitigate the negative effects of climate change, with little room for adaptation. As a result of this analysis, Sub-Saharan Africa is confirmed to be the most vulnerable region to climate change. As a result, governments and development organizations should focus on developing and implementing policies and programs that encourage farm-based adaptation techniques, and then they should be implemented and disseminated with farmers' participation.*

Keywords: Climate change; Food demand; Food security, Population size; Sustainable food production; Sub-Saharan Africa

1. Introduction

One of the biggest challenges our world faces in the 21st century is to sustainably feed nine to ten billion people by 2050, and climate change has caused numerous issues for the agricultural sector (Godfray *et al*., 2010). This is thought to be the biggest obstacle facing the agricultural industry, which is still growing and will continue to do so. According to Kurukulasuriya *et al*. (2006) and Mendelsohn (2014), climate change is primarily attributable to the continued increase in environmental effects like greenhouse gases, such as fluorinated gases, carbon dioxide, methane, and nitrous oxide, which cause changes in rainfall patterns, temperature, and adverse effects on water and land resources, including floods and droughts. By altering biotic factors (like pests and diseases) and abiotic stressors (like changes in rainfall, temperature, water loss, heat waves, warmer nights, and so forth), climate change affects the production of agricultural products, primarily crops, livestock, and fisheries (aquaculture) (Teng *et al*., 2015). The same author also said that in the most recent producing locations, the effects of climate change were more harmful than beneficial. However, because various levels of susceptibility and exposure are formed by socioeconomic, political, and bio-geophysical contexts, the distribution of climate hazards varies among regions (Teng *et al*., 2015).

According to Toman (2001), complex interactions between physical, environmental, and human elements lead to climate change, which is a natural and dynamic process. It is acknowledged as a worldwide issue, but because of their greater vulnerability and less capacity to lessen the effects of climate change, developing nations are more severely affected by its repercussions. The agricultural sector in most developing countries, including those in Sub-Saharan Africa and Asia, is impacted by direct exposure to natural dynamics like floods, droughts, and negative effects on water and land resources (Kurukulasuriya *et al*., 2006; Mendelsohn, 2014). Its effects on food security are being acknowledged more widely around the world, notably in Africa. Africa is without a doubt the continent that is most susceptible to climate change (Bwalya, 2013). In developing nations like Asia and Africa, the effects of climate change on agricultural productivity and sustainable food production are also seen as a severe issue (Kurukulasuriya *et al*., 2006; Mendelsohn, 2014).

Climate change is anticipated to harm agriculture and livestock production systems in the majority of regions, particularly Sub-Saharan Africa (Dickie *et al*., 2014; Wollenberg *et al*., 2016). Because it relies on agriculture and natural resources, warmer baseline climates, low rainfall, and limited ability to adapt, Sub-Saharan Africa is considered the most vulnerable to the effects of climate change (Hassan and Nhemachena, 2008; Thornton *et al*., 2008; FAO, 2015; Wallenberg *et al*., 2016). Climate change-induced temperature rises, rainfall variability, increased drought frequency, and the frequency and intensity of extreme weather events all add to the demands on the world's agricultural and food systems. Furthermore, climate change can cause resource issues such as water scarcity, pollution, soil degradation, and a threat to the availability of freshwater for agricultural production (IFAD, 2009).

Food and agriculture contribute significantly to climate change and are heavily impacted by it, while also providing a variety of opportunities to mitigate greenhouse gas emissions through emission reductions and carbon sequestration (Vermeulen *et al*., 2012; Rosenthal and Kurukulasuriya, 2013; Dickie *et al*., 2014; FAO, 2015; Wollenberg *et al*., 2016).

In 2005, about 33% of Sub-Saharan Africa's population, or close to 200 million people, were malnourished, with close to 60% living in conflict-affected countries (FAO, 2006). Sub-Saharan Africa is the poorest region on the planet, with an average real per capita income of $688 (in constant 2000 US dollars) in 2010, compared to $1717 in the rest of the developing world. GDP growth per capita in Sub-Saharan Africa has averaged 0.16% per year over the last 30 years (Chauvin *et al*., 2012).

According to the Food and Agriculture Organization (FAO) of the United Nations, the number of people suffering from chronic hunger climbed from less than 800 million in 1996 to more than a billion in 2009 (FAO, 2009). However, after three years, this organization, FAO (2012), reported that the prevalence of undernourishment in developing countries has decreased from about 23% in 1990-92 to 15% in 2010-12, with the total number of malnourished people remaining unchanged from 2007-2012 at about 852 million people. South Asia has 304 million, Sub-Saharan Africa has 234 million, Eastern Asia has 167 million, and Southeast Asia has 65 million.

The Food and Agriculture Organization (FAO) estimates that 795 million people worldwide are malnourished. This represents a drop of over 200 million in the last 20 years (FAO, 2017). South Asia and Sub-Saharan Africa account for the majority of the world's hungry people (Arndt and Bacou, 2000; Haile, 2005; Vermeulen *et al*., 2012); South Asia is the most vulnerable region to climate change (Bandara and Cai, 2014). Due to gradually deteriorating resource bases, poor markets, and severe climate hazards, these regions feature large rural populations, widespread poverty, and extensive areas of low agricultural output. Farmers and landless laborers that rely heavily on rain-fed agriculture are especially vulnerable because of high seasonal unpredictability in rainfall and endemic poverty, which compels them to minimize risks. Climate change is especially important for these countries, which are currently dealing with global and regional environmental changes as well as high interannual variability (Arndt and Bacou, 2000; Haile, 2005).

2. Objective of the review

The majority of Sub-Saharan Africans, around two-thirds of the population, live in rural areas and rely on agriculture for a living. Nearly half of the population lives in extreme poverty, earning less than US$1 per day, and one-third is malnourished (FAO, 2006; Toenniessen *et al*., 2008). These mostly small-scale farmers face numerous obstacles, including food insecurity, rising poverty, and resource depletion (Toenniessen *et al*., 2008). Unquestionably, the challenge in Sub-Saharan Africa extends beyond food security. The proportion of the population living on less than $1.25 per day remains about 50%, while the number of connections to water and sanitation is trailing (Hilderink *et al*., 2012).

As a result, the goal of this analysis is to provide some information on the current state of climate change, food production, population numbers, and food demand in Sub-Saharan Africa. This essay could be useful to scholars in this field and could contribute to a discussion about the role of agriculture in Sub-Saharan Africa and how it is expanding to support an ever-increasing population. It also tries to highlight and put forward some important suggestions based on different researchers' agreements or opinions, as well as potential strategies that may lead to sustainable food production to reduce poverty and improve general well-being in Sub-Saharan Africa through better access to nutrients.

3. Methods

This study was based on recent data and figures from the United Nations Secretariat's Department of Economic and Social Affairs, which revealed that Africa is the only continent where population numbers are expected to rise significantly over the next century. At the same time, hunger continues to be a daily concern for about 795 million people worldwide, including 780 million in developing countries.

With this as my initial goal, I used this systematic review to convey my views by descriptively synthesizing numerous relevant literatures to easily share the work in meaningful and easy-to-understand ways. This systematic review technique entails searching exhaustively for all possibly relevant evidence and then screening it, first for relevance and then for bias risk. In doing so, I employed structured methodologies to explain and criticize existing research in Sub-Saharan Africa.

4. Results

I attempted to assemble the possible real knowledge, opinions, and impressions based on the search engine and the stated queries. My result is not quantitative; rather, I concentrated on the most often occurring cases by narrating or describing the effects of climate change. So, depending on my understanding and the issues I wanted answered, I divided the topic into three sub-headings.

4.1. Expected changes in population numbers in Sub-Saharan Africa and the associated demand for food

The global population will rise from slightly over 7 billion in 2012 to 9.6 billion by 2050, according to the Population Division of the United Nations Department of Economic and Social Affairs (UNDESA). Sub-Saharan Africa was thought to account for half of this growth (UNDESA, 2013). Despite its vast agricultural potential, Africa spends over US$35 billion per year on food imports. Because of fast population expansion, changes in eating preferences, and the increasingly severe effects of climate change, this figure may exceed US$110 billion by 2025 (AfDB, 2016). In 2025-2030, Sub-Saharan Africa's population will continue to rise at a rate of 2.1 percent each year. In terms of demand and production, global grain totals must raise by about

a billion tons by 2030, from the current level of 1.9 billion tons, an increase nearly equal to the time since the mid-1960s (Bruinsma, 2017). Climate change poses a significant threat to food security in Sub-Saharan African countries, affecting everything from agricultural production to food distribution and consumption. As a result, it has been observed and proven that climate change, particularly global warming, has an impact on food security via food availability, accessibility, usage, quality, and affordability (Masipa, 2017). Sub-Saharan Africa's population could still be undernourished in 2030, down from 34% in 1997/1999 (Bruinsma, 2017).

Sub-Saharan Africa is a rapidly developing continent with a population of over 900 million people and a diverse ecological, climatic, and cultural landscape (CDKN, 2014). According to the United Nations Development Report, one in every four households in Sub-Saharan Africa lacks access to enough food (United Nations, 2012). According to the IPCC (2007) assessment, as mentioned in Masipa (2017), Southern Africa is more vulnerable to climate change and the implications might be severe, affecting many people's livelihoods. As a result of climate change, agricultural productivity in Sub-Saharan Africa will fall from 21% to 9% by 2080.

Sub-Saharan Africa has the youngest and fastest-increasing population in the world. The region's population is forecast to double by 2050, while the Subcontinent's share of the global population is expected to climb from 12% in 2015 to over 23% (United Nations, 2017). Sub-Saharan Africa is the only region in the world where the rural population, particularly rural youth, will continue to rise beyond 2050 (World Bank, 2013). Continued population expansion, increased land demand, and rising land costs are causing median farm sizes to shrink over time, prompting many households to seek work outside of their farms, either as agricultural wage employees or in non-agricultural informal companies. This is especially true for young people aged 15 to 34, who account for about 60% of Sub-Saharan Africa's labor force (World Bank, 2013; Jayne *et al*., 2017). The labor force in Sub-Saharan Africa is also growing at a 3% annual rate, with an additional 375 million young people predicted to reach working age by 2035. This expanding cohort of young people will provide an important opportunity for economic transformation if they can be involved in gainful jobs (Jayne *et al*., 2017).

According to Hilderink *et al*. (2012), socioeconomic developments raise food consumption in Sub-Saharan Africa. Sub-Saharan Africa's predicted demographic, economic, and environmental changes necessitate intense strategies to boost food security and demand. Population and wealth

growth is expected to result in a more than fourfold increase in total food consumption by 2050, compared to 2000, a substantially higher increase than in other parts of the world.

The region's population is expected to more than double to 1.7 billion people by 2050, up from 814 million in 2010. The ensuing increase in food consumption will be exacerbated by the predicted yearly economic growth of more than 5% between 2010 and 2050. Higher-income levels cause people to consume more food and switch to alternative diets, such as eating more meat or other animal products (Hilderink *et al*., 2012).

Although global food demand is anticipated to increase by 60% by 2050 compared to 2005/2007, the increase in Sub-Saharan Africa would be substantially bigger. Certainly, Sub-Saharan Africa is the region most vulnerable to food insecurity because its population will more than double by 2050, and cereal demand will nearly treble, even though current levels of cereal consumption rely on substantial imports (van Ittersum *et al*., 2016). Since agricultural production systems have not kept up, an increasing proportion of food consumed in Africa is imported (Rakotoarisoa *et al*., 2011). Between 2001 and 2014, the Subcontinent's food import bill increased sevenfold, from US$ 6 billion to US$ 45 billion (FAOSTAT, 2017). The greatest share of Sub-Saharan Africa's total food imports is coming from countries outside the region. According to de Graaff, *et al*. (2011), report although Sub-Saharan Africa encompasses a large number of countries, with a great variety of agro-ecological zones and large differences in land, labor, and other resources, its food imports have increased in the past 40 years since domestic production could not keep up with its population growth. Food grain and oilseed imports are driving rising food deficits, accounting for roughly 60 percent of the region's total food import bill (FAOSTAT, 2017).

Food prices in many Sub-Saharan African nations are rising faster than household incomes and other economic prospects. Food prices are predicted to stay high, and hidden hunger, such as micronutrient deficits and other kinds of malnutrition, will continue to be prevalent. Aside from the increase in food prices, this region's challenges with receiving main foods and distribution gaps have not eased (Rosen *et al*., 2012). An urban population is substantially more vulnerable to food price increases, whether the result of increased demand or dietary changes (Satterthwaite *et al*., 2010). Despite unprecedented global affluence and technological advancement, numerous people, particularly children, die from malnutrition every day. Globalization left Sub-Saharan

Africa practically unaided, and very few nations saw small increases in per capita income; more often, already meager earnings contracted (Annan, 2001).

As the world's population and per capita income rise so does the need for food and agricultural products. Food demand in the region is expected to grow by 55% by 2030 (World Bank, 2015). Scholars also point to significant changes in dietary patterns across the region, with urban and rural consumers eating more diverse and processed diets (Tschirley *et al*. 2015). According to Barrett *et al*. (2017), Sub-Saharan Africa's per capita income increased by more than 30% in real terms between 2000 and 2014.

Economically, many Africans, including Sub-Saharan Africa, rely on primary sectors such as agriculture and fisheries for food, fiber, and income generation, and some of Africa's vulnerability to climate change stems from the fact that its current development gains have been in these very climate-sensitive sectors, which continue to be affected by rising temperatures, rising sea levels, and increasingly variable precipitation (CDKN, 2014). Agriculture is an extremely important sector on the African continent, accounting for 70% of the labor force and more than 25% of GDP on average (UNECA, 2009), and according to Godfray *et al*., (2010), the agriculture sector of Sub Saharan Africa generates 20 to 40% of these countries' gross domestic product. Furthermore, agricultural expansion in Sub-Saharan Africa has been reported to be eleven times more successful in eliminating poverty than GDP growth in any other sector (IFAD, 2013). However, if food security is to be reached, Sub-Saharan African economic growth must improve by 4-5% yearly, and a modest standard of living must be given to the predicted 1.3 billion people in the region by 2025 (World Bank,1989). According to Mohammed-Seleem's (1995) FAO prediction, 55% of Africans will live in urban areas by 2025 as a result of rapid population growth and higher income generation, resulting in a need for better quality food, particularly animal products, from rural dwelling population that is expected to feed 592 million by 2025, up from 350 million in 1990. This is a massive task in a region that had a negative per capita GDP in the 1980s. The 3.2 percent average yearly population growth rate, as well as serious financial and environmental issues, portend an even bleaker future (Mohammed-Saleem, 1995).

Sub-Saharan Africa has the potential to significantly enhance food security. However, agricultural yields in the region have been static concerning population expansion, resulting in a

reduction in per capita food availability since the 1970s (Niang *et al*., 2014). There are also plenty of agricultural fields in the region, albeit most of them are owned by smallholders who use traditional farming methods. Mechanization of these lands can feed numerous households locally or regionally, thereby satisfying and enhancing food demands. Increased agricultural production through agricultural area expansion and higher agricultural productivity is expected to meet the growth in food demand. As a result, malnutrition is anticipated to be nearly eliminated by 2050 (FAO, 2006; Niang *et al*., 2014).

According to UN data, 37% of Sub-Saharan Africans live in cities, making this region one of the least urbanized (UN, 2010; Hilderink *et al*., 2012; UN, 2014). Although Sub-Saharan Africa is one of the least urbanized regions, the number is expected to rise to roughly 60% by 2050. In absolute terms, this represents a more than tripling of the population, from 321 million in 2010 to 1052 million by 2050, meaning that the majority of future population expansion (700 out of 900 million) would occur in urban areas (Hilderink *et al*., 2012). Food demand typically rises when the nature of the population shifts from rural, possibly food-producing, to urban, primarily for food consumption. Urbanization causes significant changes in agricultural product demand due to growth in urban populations as well as changes in their diets and preferences (Satterthwaite *et al*., 2010).

4.2. **Assessment of the main changes in climate and how these changes may impact food production**

Sub-Saharan Africa is a fast-developing region with a rich biological, climatic, and cultural diversity, where the effects of climate change are currently being felt and generating a variety of issues in both natural and human systems (NASAC, 2015; Sedeczny *et al*., 2017). Forecasts for climate change in this region show a warming trend, notably inside the interior Subtropics, an increase in the frequency of extreme heat events, an increase in drought, and changes in rainfall, with a particularly pronounced reduction in southern Africa and a rise in East Africa. Under a 4oC warming scenario, the region might see up to one meter of sea-level rise by the end of the century. Sub-Saharan Africa already has high rates of undernutrition and higher loads of infectious diseases, which are anticipated to worsen as a result of climate change (Sedeczny *et al*., 2017).

Climate change has a significant impact on agricultural systems because it affects the health of both plants and animals. In this regard, studies have found that agriculture has been the engine of growth in most developing countries, with the relationship running from agricultural growth to overall economic growth in most cases, and that even minor changes in agricultural productivity have had significant implications for the speed and pattern of overall economic growth. However, agricultural output in Sub-Saharan Africa is low, and there have been several attempts to move agriculture forward (Chauvin *et al*., 2012).

Sub-Saharan Africa has been identified as the most vulnerable region to the effects of global climate change due to its reliance on agriculture, which is highly sensitive to weather and climate inconsistencies such as temperature, precipitation, and light and extreme events, as well as a lack of adaptation capacity (IPCC, 2007; Shackleton *et al*., 2015; Sedeczny *et al*., 2017). The vulnerability of this region's agriculture to climate change stems from the fact that its agricultural systems are largely rain-fed and underdeveloped, with the majority of Sub-Saharan African farmers being traditional and small-scale farmers with few financial resources, limited access to infrastructure, and poor access to information (Shackleton *et al*., 2015).

Although Sub-Saharan Africa has the required and abundantly available fertile agricultural land as well as sufficient labor to feed itself, Chauvin *et al*. (2012) report that there are also binary food production problems due to a lack of inputs such as adequate water and fertilizers. Agriculture in Sub-Saharan Africa is primarily rain-dependent, which makes it sensitive to late rainfall begins and prevents it from producing the maximum amount of output or essential products (Chauvin *et al*., 2012).

Water and food security are the most pressing climate change challenges in Sub-Saharan Africa, as both are highly vulnerable to changing climatic trends. Furthermore, this region is one of the world's driest, with a serious water issue. According to Batino and Waswa (2011), over 90% of agriculture in Sub-Saharan Africa is rain-fed and primarily managed by smallholders. Furthermore, by 2050, rainfall in Sub-Saharan Africa could fall by 10%, reducing drainage by 17% (Misra, 2014). Because rainwater provides a source of water for both agricultural and drinking for the majority of rural communities, it will have a big impact on both the region's health and development difficulties. According to a WHO/UNICEF report, over one billion people consume contaminated water. Furthermore, de Wit and Stankiewicz (2006) reported on

this issue, including their prediction. As a result, such a climatic shift not only affects food production but also generates a scarcity of natural resources.

In numerous Sub-Saharan African countries, 20 percent to 60 percent of animal population losses have been observed during severe drought occurrences during the last two to three decades. Such losses have a direct impact on food production and consumer supply. In South Africa, for example, Niang *et al*. (2014) reported that dairy yields are expected to fall by 10 to 25% as a result of climate change. Another case study published by the same authors predicted a 23 percent increase in the cost of supplying water to animals in Botswana using boreholes. Furthermore, in Sub-Saharan Africa, one out of every two people keeps livestock, and one out of every three is a poor livestock keeper (FAO, 2012). Livestock, particularly small ruminants (such as sheep, goats, and fowl), is also critical to women's empowerment and gender parity.

Sub-Saharan Africa's overall food production, basic crops, and meat output have been increasing, although at a relatively modest rate of less than one percent per year. This is particularly alarming given that the rate of growth in food production isn't statistically distinct from the rate of rise in population, raising concerns about the region's ability to self-sufficiency in the face of food insecurity. Sub-Saharan Africa would be unable to secure an adequate food supply for its population without both food imports and major efforts to enhance food production (Chauvin *et al*., 2012).

4.3. **Suggestions on the potential strategies that may lead to sustainable food production in Sub-Saharan Africa**

Climate change's effects on our ecosystems are already severe and broad, and ensuring food security in the face of climate change is one of the most daunting issues facing humanity. Sub-Saharan Africa is confronted with many distinct and difficult challenges. Food insecurity and food sustainability are likely to worsen in Sub-Saharan Africa unless bold action is made to address the primary concerns. As a result, it is critical to describe and implement feasible strategies for ensuring sustainable food production and enabling speedier adaptation without jeopardizing sensitive livelihood systems as they attempt to cope with environmental challenges. Although some of the challenges linked with climate change are developing gradually,

immediate action is required to enable ample time to incorporate resilience into agricultural production systems.

Sub-Saharan African regions are involved in subsistence agriculture and are not technologically or financially advanced enough to mitigate the detrimental effects of climate change. Furthermore, they exhibit essentially no adaptability (Kurukulasuriya *et al*., 2006). This harms the population in these nations because they rely on agriculture for a living (UNECA, 2009; Godfray *et al*., 2010). Sustained economic growth in Africa will be impossible unless farm productivity and agricultural food production increase dramatically. Vermeulen *et al*. (2012) identified many essential alternatives and techniques to assist farmers, particularly smallholder farmers, in expediting agricultural changes to increase food production and sustainability. Crop breeding, improved agricultural methods, the application of biotechnological capabilities, enabling policies in food systems, enhancing value chains, trade, and stability, and bringing understandings to the regional scale are examples of these.

According to Chuku's (2009) explanation, Sub-Saharan African cropping systems require improvements and changes; therefore, scientists must provide more information on what the appropriate adaptation options are, which must be supplemented by an evaluation of adaptation measures as well as strategies for increasing resilience and coping with risks. Changes in crop mixes (Liu *et al*., 2008; Nelson *et al*., 2009) must be accompanied by increased international trade (Parry *et al*., 2005), which must be facilitated by improved infrastructure, particularly roads (Nelson *et al*., 2009). However, most developing countries, especially Sub-Saharan Africa, face greater hurdles in responding to climate change due to weak institutions and limited access to technology (Agrawal and Perrin, 2009; Masipa, 2017). Climate change will have different effects on different regions and countries in Sub-Saharan Africa. Parts of Africa that are hot and arid are anticipated to be badly affected (Kotir, 2011). As a result, adjustments should be carried out based on critical analyses or repeated experimental confirmation while taking into account local circumstances.

Another issue is that there is a significant disparity between the cost of climate change adaptation and the necessary financial and instructional support from the government. There is also a need to invest in technologies that will resist and manage climate risks to food security, as well as address food system vulnerabilities and weaknesses (Godfray *et al*., 2010). Crop yields in Africa

are among the lowest in the world due to inferior seeds and deteriorated soils, a lack of fertilizer and other key inputs, and inadequate mechanization and transportation infrastructure. A transition from farming as a subsistence activity to farming as a business is required, which must be accompanied by the appropriate mix of policies, institutions, and investments (Bruinsma, 2017). As a result, an integrated policy approach to protecting arable land from global warming is required to offset these threats. Furthermore, rural small-scale farmers require more assistance to boost agricultural production, particularly at the household level. Because agriculture provides a living for the vast majority of Sub-Saharan Africans, the productivity of existing smallholder farmers must increase dramatically.

Increased agricultural production is important but not sufficient for Sub-Saharan Africa to achieve long-term food security and demand. If incomes are to rise and food security issues are to be alleviated, a fundamental transformation of the agricultural sector in the region must be ensured (Masipa, 2017). This is correct; a move from farming as a subsistence activity to farming as a commercial activity is required, and it must be accompanied by the appropriate combination of policies, institutions, and investments.

Smallholder farmers in Sub-Saharan Africa, on the other hand, lack the means to adapt to rising temperatures and adverse weather events such as droughts and floods; there is a critical need to strengthen farming communities' ability to cope with the impacts of climate change (Thornton *et al*., 2011; Toulmin, 2013). As a result, adaptation to climate change is used to mitigate the negative effects of climate change. It can be defined as spatial (both localized and widespread) or behavioral, technical, institutional, informational, or financial adaptations (Wandel, 2000). Furthermore, investments in weather forecasting systems, insurance schemes, efficient irrigation equipment, and heat- or drought-tolerant crop varieties can assist enhance farm productivity in increasingly harsh climate circumstances (Thornton *et al*., 2011). Although there are some experiences in the perceptions of adaptation to climate change in sub-Saharan Africa, its performance should be increased due to disparities in knowledge and abilities across individuals. For example, in some sections of the region, farmers altered crop varieties, enhanced water conservation, and turned to non-farm occupations to sustainably continue food production (Maddison, 2007).

To promote and sustain food productivity increases, opportunities must be developed to ensure optimal use of current resources and technology, as well as the development of new and improved technologies that are adapted to the specific environment of Sub-Saharan Africa. Improvements in agricultural production necessitate technological advances, as well as their adoption and use. The importance of research and extension techniques in adapting technical packages to farm-level settings and disseminating them to farmers is critical. Furthermore, sustainable intensification is highly demanding, such as producing qualitatively and quantitatively more crops, better nutrition, and higher rural incomes from the same set of inputs such as farmland, water source, credit, and knowledge while reducing environmental impacts on a sustained basis (Godfray *et al*., 2010; Thornton *et al*., 2011; Toulmin, 2013). Other intensifying and adapting techniques are also used. For example, crop breeding has proven to be an efficient method of increasing food production (Evenson and Gollin, 2003) and possibly alleviating the effects of climate change (Burney *et al*., 2010).

Crop improvement investments to address specific aspects of a changing climate (e.g., heat, drought, waterlogging, and pest resistance) are a crucial component of any worldwide attempt to adjust farming systems to produce sustainable food (Godfray *et al*., 2010). Although agricultural intensification has occurred gradually over many years in other emerging regions, it began extremely quickly in Africa, particularly Sub-Saharan Africa, due to the fast population increase. Development efforts that promoted crop-livestock systems, on the other hand, have failed to achieve the intended agricultural transformation at the required speed (Mohammed-Saleem, 1995). Following research-based crop breeding for future climates has a better chance of success if done in collaboration with farmers, taking into account their ability and desire to take on new risks or use input-intensive methods. One of the various possibilities or techniques for resource-conserving, sustainable food production, and yield-enhancing agriculture is the breeding of novel crop varieties depending on their adaptability for certain regions (Bharucha, 2013).

Furthermore, the development of agroecological approaches and innovative crop management systems is required, as they boost yields, and food production, and are particularly successful at improving environmental and social results. As an input, these agroecological systems rely on management rules and technology packages that are meticulously tagged to suit local conditions and farmer preferences. Agroforestry, conservation agriculture, crop intensification systems

(such as rice intensification), integrated pest management, the incorporation of aquaculture and small livestock into farming systems, water harvesting, soil conservation, and integrated nutrient management are examples of techniques (Bharucha, 2013). In addition, conventional crop breeding and biotechnology have significant biological potential for enhancing agricultural yields (Godfray *et al*., 2010).

Sustainable food production alone is insufficient for Sub-Saharan Africa; there is also a need to build and strengthen agricultural value chains, including agro-processing industries. Thornton *et al*., 2011; Toulmin, 2013) see these as having enormous potential for employment generation and value development. Efficient practice and measurable reductions in food and nutrition insecurity necessitate a concerted dual effort: One is action to increase access to income-generating opportunities for today's hungry and to confirm social protection, as well as quick access to food for the most vulnerable. The other is an investment in long-term, sustainable agricultural growth and development. Individual, business and public action and behavioral change will be required at all levels (National Research Council, 2012).

African governments should revise their private-sector development and industrial policies to attract more agribusinesses and investors. They, in turn, should collaborate with smaller farmers and related economic sectors (Thornton *et al*., 2011). Certainly, governments and their higher officials in all of these countries share a critical role in setting the circumstances for successful and sustained development within a context of political stability and sound governance systems. They must have the administrative will to shift priorities, mobilize public investment, and reform institutions for the sake of long-term food and nutrition security. Furthermore, it should be recognized that stability and peace are necessary conditions for agricultural development, food security, and the long-term sustainability of food systems in Africa, particularly Sub-Saharan Africa. This will necessitate a focus on rural smallholders, who represent the majority of the poor, but it must increasingly address urban food security problems, particularly by improving agricultural productivity, conserving biodiversity, and creating jobs.

5. Conclusion

Climate change is a natural and dynamic phenomenon caused by the intricate interdependence of physical, environmental, and human elements. According to the majority of the literature, it

harmed both crop and livestock production systems in Sub-Saharan Africa. Sub-Saharan Africa is the world's poorest region, with the highest rate of malnutrition. Despite its vast agricultural potential, it spends a significant amount of money each year on food imports. Climate change poses a significant threat to food security in Sub-Saharan African countries, affecting everything from agricultural production to food distribution and consumption. Food security is impacted by climate change, particularly global warming, through food availability, accessibility, use, quality, and pricing. Sub-Saharan Africa may still have 15% of its population undernourished in 2030, down from 34% in 1997/1999, and the region faces the greatest food security risk because by 2050, its population is expected to increase 2.5 times and cereal demand nearly triple, although current levels of cereal consumption rely on substantial imports. Population and wealth growth is expected to result in a more than fourfold increase in overall food consumption by 2050, compared to 2000, a far greater increase than in other parts of the world. Sub-Saharan Africa possesses the necessary and abundant productive agricultural land and workforce to be self-sufficient in food. However, its agriculture is primarily rain-dependent, making it sensitive to late rainfall onsets and preventing it from attaining the best possible yield. To promote and sustain food productivity increases, opportunities must be developed to ensure the optimal use of existing resources and technology, as well as the development of new and improved technologies that are adapted to the specific environment of sub-Saharan Africa. Finally, based on the literature, I propose that governments, higher officials, policymakers, and development agencies focus on developing and implementing policies and programs that promote farm-based adaptation strategies to improve food security in the face of climate change and that farmers should be involved in its implementation and dissemination.

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