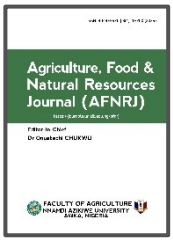
Agr. Foo. Nat. Res. J. Volume 5, Issue 1, Page 95 - 103

e-ISSN: 1597-7153 | p-ISSN: 3043-5420

Agriculture, Food and Natural Resources Journal

The Official Journal of the Faculty of Agriculture, Nnamdi Azikiwe University, Awka, Nigeria

Journal homepage: https://journals.unizik.edu.ng/afnrj



Review Article

Impact of climate change on food production and food security

OPEN ACCESS

Ruth Temitope ONABEGUN*, Bolaji Timothy OLUSOLA & Silas Mauthon HUNGE

[1]*Department of Food Science and Technology, Federal University of Agriculture, Abeokuta, Ogun, Nigeria*
[2]*Department of Food Science and Technology, Lagos State University of Science and Technology, Lagos, Nigeria*
[3]*Department of Animal Production and Health, Federal University of Agriculture, Abeokuta, Ogun, Nigeria*

DOI: https://www.doi.org/10.5281/zenodo.20622967

Editor: *Dr Onyekachi Chukwu, Nnamdi Azikiwe University, NIGERIA*

Received: *January, 2 2026*
Accepted: *March 25, 2026*
Available online: *March 31, 2026*

Peer-review: *Externally peer-reviewed*

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Conflict of Interest: *The authors have no conflicts of interest to declare*

Financial Disclosure: *The authors declared that this study has received no financial support.*

ABSTRACT

Climate change is accelerating at an unprecedented rate, gradually altering ecosystems and threatening global food production and access to nutritious food. With global temperatures rising by an average of 0.18°C per decade over the past four decades, increasing concentrations of greenhouse gases, particularly carbon dioxide and methane, are driving climatic variability that affects plants, animals, and human livelihoods. This review aims to examine how climate change alters food production systems and compromises food security, with a focus on the populations most vulnerable to these impacts. Findings indicate that rising temperatures, shifting precipitation patterns, and increased frequency of extreme weather events contribute to reduced crop yields, degraded soil quality, compromised supply chains, and heightened risk of food shortages. These effects intensify malnutrition, elevate mortality rates, and may lead to long-term population decline in severely affected regions. The review highlights the need for urgent adaptation strategies, including climate-resilient agricultural practices, improved resource management, and targeted policy interventions to protect at-risk communities.

KEYWORDS: *Challenges, Effect, Food System, Sustainability, Variability*

INTRODUCTION

The Global Hunger Index reported that "climate change is a threat multiplier for hunger, destroying livelihoods, driving displacement, widening social inequalities, and undermining sustainable development". Lindsey & Dahlman (2020) reported that with the global temperature increased on average by 0.08°C per decade since 1880, the rate of climate change over the past four decades has more than doubled, averaging 0.18°C per decade. It is impossible to dispute that climate and food security are related because climate change necessarily affects the climatic conditions responsible for optimum food production (El bilali *et al.,* 2020). Researchers have emphasized that climate change, characterized by rising temperatures, shifting precipitation patterns, and more frequent extreme weather events, influences crop growth and development, thereby shifting planting seasons and agricultural zones posing a significant challenge to the 21st century (Farah *et al.*, 2025; Naik *et al.*, 2024).

Recent data from the Food and Agriculture Organization highlights the severity of this crisis, noting that in 2023, approximately 733 million people faced hunger, and 2.33 billion people 28.9% of the global population experienced moderate or severe food insecurity (UNICEF, 2024). Projections for 2030 suggest that despite global efforts, around

*Corresponding author: onabegunruth@gmail.com

512 million to 582 million people will remain chronically undernourished (UNICEF, 2024; UNICEF, 2025). The Intergovernmental Panel on Climate Change Sixth Assessment Report confirms that human-induced climate change has already caused adverse impacts and threatened global food security (Wakatsuki *et al.*, 2023). Without significant adaptive intervention, agricultural yields are projected to decline substantially; specifically, maize yields could decrease by 22%, rice by 9%, and wheat by 14% by the end of the century under high-emission scenarios (Farah *et al*., 2025; Li *et al.*, 2025).

Similarly, World Bank assessments indicate that agricultural output remains highly vulnerable, with potential climate-driven stressors threatening to deepen food insecurity for millions (Herbert *et al*., 2022). Climate change is projected to push between 68 million and 132 million people into income-related poverty by 2030, largely due to agricultural losses and yield reductions (Amaefule *et al.*, 2023; Moyer *et al.*, 2023). Ensuring a sufficient and varied food supply is crucial for enhancing food security, yet climate variability continues to reduce agricultural productivity and compromise food supply chains (UNICEF, 2024). Amidst this variability, access to climate-related information and tools plays a vital role in improving food security by helping stakeholders make informed decisions about agricultural production and food systems (Rehman *et al*., 2024; Anjum *et al.*, 2024).

As the global population continues to grow, ensuring food security becomes increasingly crucial. The purpose of this review is to examine the multifaceted impacts of climate change on food security and identify the challenges it presents for the production of food.

CLIMATE CHANGE

According to Ani *et al*. (2022), the climatic condition is the long-term summation of the atmospheric elements such as solar, radiation temperature, relative humidity and precipitation and their variations over a long period. The climate is a crucial element that determines various characteristics and distributions of managed and natural systems (Skendzic *et al.,* 2021). Climate change is primarily linked to human activities, notably the burning of fossil fuels, deforestation, and changes in land use which leads to the heightened presence of greenhouse gases in the atmosphere (Skendzic *et al.,* 2021). Among the greenhouse gases, CO_2 is the most important and the most abundant. The increase in atmospheric CO_2 is one of the most recorded global changes in the atmosphere in the last half century (Skendzic *et al*., 2021). The consequence of climate change varies, encompassing rising sea levels, more frequent and severe weather events, shifts in precipitation patterns, and alterations in ecosystems as reported by Turner *et al.* (2020). Economic damages from climate change have been detected in climate-exposed sectors, such as agriculture, forestry, fishery, energy, and tourism. Individual livelihoods have been affected through, for example, destruction of homes and infrastructure, and loss of property and income, human health and food security, with adverse effects on gender and social equity (IPCC, 2023).

Impact on Food System

Agricultural systems are highly vulnerable to the impacts of climate change due to their dependence on climate-sensitive factors such as temperature, precipitation, and soil moisture (Shukla *et al.,* 2021). Climate change impacts food systems thereby impacting global food production via changes in yield, biomass food composition and nutritional quality which in turn directly influence human nutrition and health reports Glopan (2020). With a predicted increase of 1.7 billion in world population between now and 2050, man is placing more pressure on the diminishing resources used to produce our food (UN, 2022), making global food production under severe threat (Skendzic *et al.,* 2021). Countries such as Sub-Saharan Africa that are battling conflicts, deforestation, flood, and other environmental hazards may suffer the effects more (Hobert and Negra, 2020). These extreme events can cause widespread destruction of crops, infrastructure, and livestock, disrupting food supply chains and increasing food insecurity. Heat waves, for instance, can accelerate crop maturation, reduce yields, and impair livestock health, leading to economic losses for farmers (Atadoga *et al.,* 2024). Therefore, changes in temperature and precipitation patterns, coupled with the increasing frequency of extreme weather events and the proliferation of pests and diseases, threaten global food security and agricultural sustainability (Subedi *et al*., 2023). Mbow *et al.* (2020) reported that dry land areas, covering 40% of the earth's surface and inhibited by 2.5 billion people, are disproportionately vulnerable to climate related food insecurity steamed from limited climate resilience strategies in measuring up declining crop yields. The vulnerability of agricultural systems to extreme weather events accentuates the urgency of implementing resilient farming practices, enhancing disaster preparedness, investments in research and innovation, policy interventions, and investing in climate-smart technologies to minimize losses and mitigate risks to safeguard agricultural livelihoods and ensure food security (Oriekhoe *et al.,* 2023; Michael, 2024).

Impact on Crop Production

The most sustainable strategy to achieve food security is increasing crop yield per land area unit. However, we cannot attain the potential productivity of many crops worldwide due to various adverse conditions and poor management practices (Siva *et al.,* 2023)**.** One of the primary manifestations of climate change is the alteration of temperature and precipitation patterns which affects the distribution and abundance patterns of plants due to the physiological limits of each species (Javadinejad *et al.,* 2020; Skendzic *et al.,* 2021). Changes in temperature and precipitation patterns influence crop growth and development as different crops have varying temperature and moisture requirements for optimal growth, leading to shifts in planting seasons and geographical distribution of agricultural zones implicating agricultural productivity (Furtak and Wolińska, 2023; Skendzic *et al.,* 2021). Warmer temperatures

can accelerate plant growth but may also increase water stress and heat stress in crops, particularly in regions with limited irrigation infrastructure. Changes in precipitation patterns can result in more frequent droughts or floods, affecting soil moisture levels and crop productivity (Toromade *et al.,* 2024). Additionally, excessive rainfall and flooding can result in soil erosion, water logging, and crop inundation, leading to yield losses and soil degradation (Mhlongo *et al.,* 2024). Moreover, deforestation and land degradation, heightened by climate change, can reduce agricultural productivity and increase food insecurity in regions heavily reliant on natural resources (Ngcamu, 2023; Nguyen *et al.,* 2023). Changes in crop yields and productivity can affect food availability, prices, and access, particularly for vulnerable populations in developing countries (Maja & Ayano, 2021).

Table 1: Effects of weather variables on crop growth and development

Higher CO_2 Fertilizer	Higher Temperature Levels	Precipitation Variability
• Increases photosynthetic rate • Increases biomass • Increases water use efficiency • Increases tolerance for low light levels • Increases optimum temperature for photosynthesis	• Inhibition of seed germination • Reduction in plant growth and development • Alteration in photosynthetic rate • Alteration in phenology and dry matter partitioning • Water loss • Oxidative stress • Yield and quality reduction (C_3 plants are more susceptible to higher temperature stress than C_4 plants)	• Affects the production of traditional crops • Increases crop disease incidence • Soil fertility changes • Variable soil water availability • Water scarcity in productive areas due to reduced freshwater resources • Reduced nutrient use efficiency • Physical damage due to excess rainfall • Economic and community loss due to droughts and floods

Source: (Wijerathna-Yapa *et al.,* 2022; Siva *et al.,* 2023)

Impact on Livestock and Fisheries

The livestock sector is the key component of agriculture, accounting for almost 40% of the overall agricultural GDP. By 2050, global demand for animal origin products is anticipated to double, primarily due to rising living standards (Siva *et al.,* 2023). Increased human competition for limited natural resources, changing feed crop species and quality, disease outbreaks, and heat stress will significantly impact animal production and efficiency (Siva *et al.,* 2023). The health and productivity of cattle are also impacted by variations in rainfall patterns and the availability of fodder, which lowers the amount of meat and milk produced (Anyika, 2023). Heat stress is the critical factor that primarily affects the animals through its influence on milk and meat production, reproductive efficiency, and health. However, temperature, carbon dioxide, and precipitation fluctuations combined affect the forage quantity and quality (Siva *et al.,* 2023).

The reduction in quality and quantity of grazing lands during droughts can lead to poorer animal performance and increased reliance on supplemental feeding (Kumar *et al.,* 2022). Furthermore, heavy rainfall can cause flooding and damage pastures, reducing their quality and availability as a feed source for livestock (Siva *et al.,* 2023). Climate change also affects the quality of livestock, which rely on the same resources as humans to eat, grow, and produce meat, eggs, and milk. Cattles, goats, and other livestock accounts for 36% of all drought-related losses with crops making up 49% of the total losses (Concern worldwide, 2022).

Siva *et al.* (2023) reported that one of the specific consequences of climate change on fisheries is ocean warming which can lead to changes in the distribution and abundance of fish species, as well as their migration patterns. Rising sea temperatures and ocean acidification have an impact on fish populations in coastal locations, impacting fishing community's livelihoods and diminishing the availability of a crucial source of protein (Anyika, 2023). Another specific consequence of climate change is ocean acidification, which occurs due to increasing CO_2 levels in the atmosphere. This can significantly impact the biology and physiology of marine species, including fish, shellfish, and other species that are important for commercial and subsistence fishing (Siva *et al.,* 2023).

Impact on Crop Pests and Diseases

Insects are poikilothermic organisms; the temperature of their body depends on the temperature of the environment. Thus, temperature is probably the most important environmental factor affecting insect behaviour, distribution, development and reproduction (Skendzic *et al.,* 2021). The distribution of insect pests is affected more at high temperatures creating conducive environments for the proliferation of pests, including insects, fungi, and weeds, which can devastate crops and reduce yields as compared to lower temperatures (Raza *et al.* 2021). Furthermore, climate change creates new ecological niches that provide opportunities for insect pests to establish and spread in new geographic regions and shift from one region to another (FAO, 2021). Warmer winters can also result in higher survival rates of pests that would otherwise be controlled by cold weather, leading to more severe infestations in subsequent growing seasons (Skendzic *et al.,* 2021). In addition to pests, climate change also facilitates the spread of crop diseases, such as fungal infections and bacterial pathogens, compromising plant health and reducing crop quality (Michael, 2024).

Consequently, climate change would increase the build-up of insect populations, early infestations and resultant crop damage from insect pests (Skendzic *et al.,* 2021).

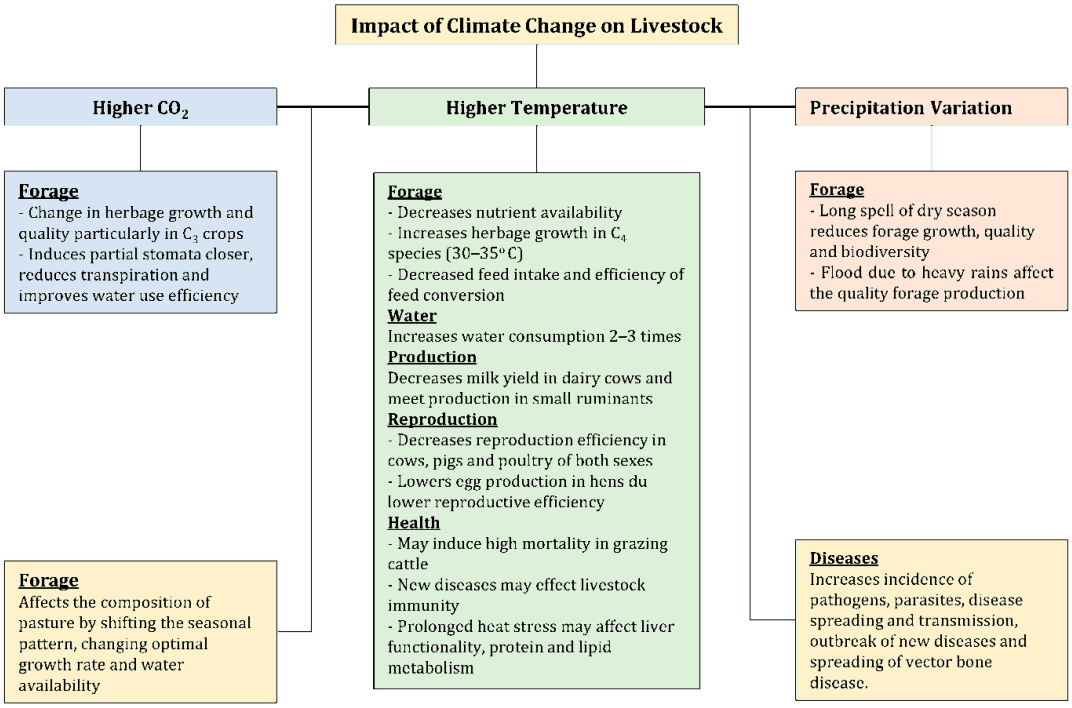

Figure I: The effects of climate change on livestock (Siva *et al.,* 2023)

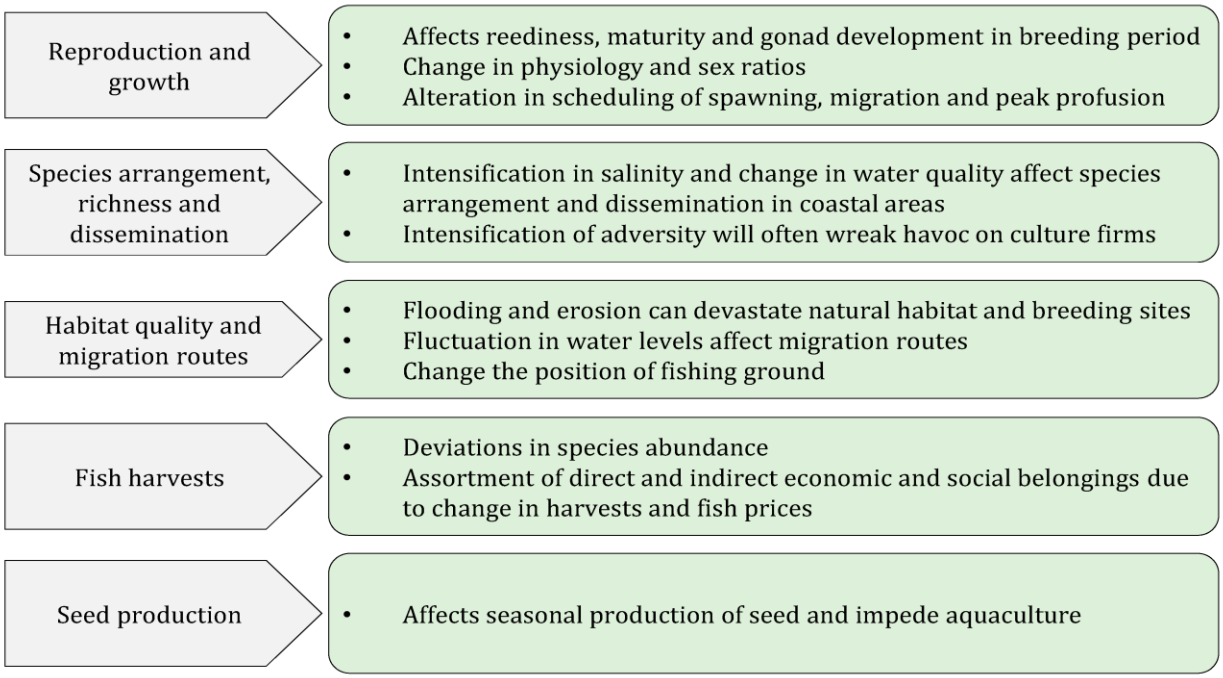

Figure 2: The effects of climate change on Fisheries (Siva *et al.,* 2023)

Table 2: **Climate change's potential effects on crop disease of some selected food crops**

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.

Source: Sirba & Chimdessa (2021)

Impact on Soil

Soil serves as a rooting medium for plants therefore; soil salinity can affect seed germination through osmotic effects; wilting, loss of turgor, growth reduction, decreased photosynthesis, loss of cellular integrity, respiratory changes, tissue necrosis and death of the plant (Mukhopadhyay *et al.,* 2021). Increasing CO_2 levels, rising temperatures, and precipitation variations on soil can be significant and far-reaching. These changes can affect soil fertility, structure, and the ability of soil to support healthy plant growth, which, in turn, affects food security, biodiversity, and the planet's overall health (Siva *et al.,* 2023). As seen in figure 3 below, it can be inferred that the impact of climate change on soil can be felt through increased CO_2, increased temperature and precipitation variation leading to loss of soil organic nutrient, soil moisture, and loss of soil structure as well as nutrient loss through leeching

Impact on Food Availability

Food availability entails an adequate quantity of food with appropriate nutritional value, either sourced from domestic production or obtained through imports such as food aid as elucidated by Bozsik *et al*. (2022). Food production indices, animal ownership indices, and national food balance sheets are examples of indicators used to measure the availability of food (Muringai *et al.,* 2020). Depending on the location, varied effects of climate change on food supply will be felt. For instance, moderate warming increase of 1^0C to 3^0C 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 (Anyika, 2023). The factors contributing to availability encompass domestic production, storage, distribution, as well as import and export, in accordance with research by Rahal and Elloumi (2023). It is crucial to note that climate change can exert both direct and indirect influences on the availability of agricultural products, as highlighted by Agostoni *et al.* (2023).

Impact on Food Access

Food access is the Individual's ability to access sufficient resources for buying the right foods for a nourishing diet. 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 (Anyika, 2023). Climate change will reduce food access through negative impacts on both food prices and rural livelihoods. Climate change can disrupt food supply chains and transportation, hence food price volatility, compromised food security, nutrition and human health, due to negative impacts on yields and production (FAO, 2020; El Bilali *et al.,* 2020). The impacts of climate change will also be high on food importing countries as food exports might be reduced or banned in case of extreme climate events.

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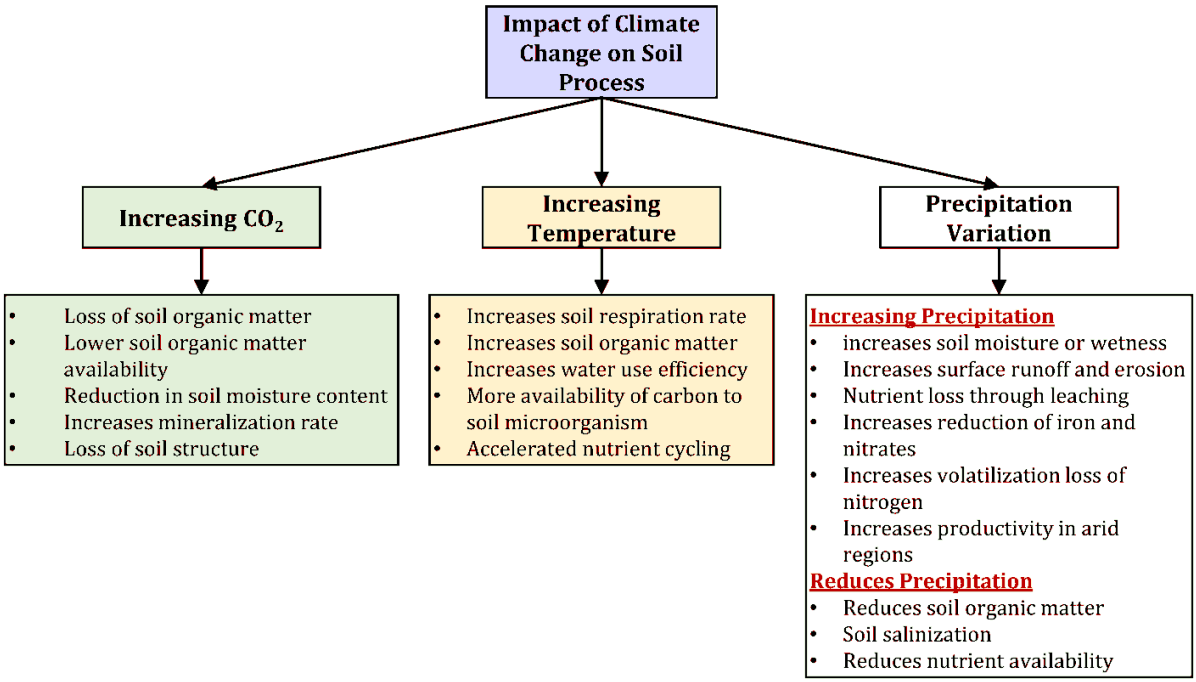

Figure 3: The impact of climate change on Soil (Siva *et al.,* 2023).

Impact on Food Stability

Anyika (2023) reported that a population, household, or individual must always have access to enough food in order to be considered food secured. Therefore, the availability, access, and utilisation dimensions of food security are referred to as stability. As a result, all aspects of food security are intricately linked to agricultural productivity, which provides food and money for rural people (Anyika, 2023). Smallholder farmers often lack the resources to adapt to changing conditions, making their food production systems more susceptible to climate related risks (Kumar *et al.,* 2022). Changes in seasonality, increased variability in ecosystem productivity, increased supply risks, and decreased supply predictability will affect the stability of the food availability, supply chain costs and retail prices (Muringa, *et al.,* 2020; El Bilalli, *et al.,* 2020). To enhance food stability in the face of climate change, there is need for developing climate-resilient crop varieties, improving irrigation and water management, and investing in infrastructure to withstand extreme weather events (Wishwajith *et al.,* 2022).

Impact on Food Utilisation

A person's capacity to benefit from the food they consume is referred to as their food utilisation (Anyika, 2023). Climate variability for instance higher temperature, can favour the development of pathogens, while water scarcity induced by droughts affects water quality and hygiene habits, especially in arid and semi-arid areas, which could increase the burden of diseases for example diarrhea thereby change food utilisation with impacts on the nutrition status of the populations (El Bilali, 2020). 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 (Anyika, 2023). For example, lower dietary quality can contribute to increased incidences of chronic diseases such as anemia and stunting in children, affecting overall health and development (Kumar *et al.,* 2022). Additionally, climate change worsens unsustainable food systems by decreasing macro and micronutrients available in the global food supply as reported Owino *et al*. (2022). El Bilali, (2020) provides that achieving food security necessitates action beyond building climate resilient food production systems to a holistic approach that is able to ensure climate resilience of the entire food system while addressing nutritional concerns arising from impacts of climate change. This implies expanding the narrow focus from the impacts of the changing climate on crop yield and productivity to include the impact on the nutritional value of crops (Leisner, 2020) and, consequently, diets (El bilali *et al.,* 2020).

CONCLUSION AND RECOMMENDATIONS

This review confirms that climate change is indeed a major threat to global food security by reducing agricultural productivity and weakening food systems. These impacts are most severe in vulnerable communities, where reduced food availability and affordability further undermine already limited access to nutritious diets. Addressing this requires that climate adaptation becomes a core component of food system planning and management. Strengthening climate-resilient farming,

supporting smallholder farmers, and improving access to climate-smart tools will be key to maintaining stable food production. Enhancing these measures is essential to protecting food security and sustaining livelihoods under the continuing pressures of climate change.

Acknowledgements

The authors acknowledge Dr. Olusola Bolaji for his supervision from conceptualization to writing, review and editing.

Authors' Contributions

RO conceptualized the study and wrote the original draft. RO & BO curated the data. RO, BO and SH validated, visualized, reviewed and edited the data. BO supervised the review.

Ethical Statement

Not applicable

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