

The Significance of Food, Nutrition and Water Security: The African Story

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Abstract— Globally, the hidden costs attributed to food systems amount to US\$12.7 trillion annually, about 10% of the world's Gross Domestic Product (GDP), while agriculture accounts for only 4% of global GDP. Africa has distinguished levels of hunger and malnutrition that are incompatible with the African Union's agenda for 2063. Almost 300 million people in Africa are estimated to be at risk of intensifying hunger due to the destructive impacts of conflict, climate variability and extremes, economic slowdowns and downturns. This research review highlights the status of global food, nutrition, and water security, factors affecting food security, effects of food insecurity, and food safety and value addition in Africa. The qualitative research review is based primarily on literature review from secondary data sources. Food systems have become the central theme among food actors and scholars to comprehend and adequately address food, nutrition, and water security. African governments need to incorporate sustainability and climate resilience strategies to achieve food, nutrition, and water security. Most African countries have limited awareness of food security, nutrition, and water issues, as evidenced by the lack of comprehensive policies and initiatives. The consequences of these issues are profound, and substantial action is required to prevent Africa from becoming desolate in the coming decades.

Keywords— Food systems; climate change; food supply chain; food insecurity; hunger and malnutrition; dietary energy.

I. INTRODUCTION

Globally, the hidden costs attributed to food systems amount to US\$12.7 trillion annually, about 10% of the world's Gross Domestic Product (GDP), while agriculture accounts for only 4% of global GDP [1]. The highest hidden cost of agri-food systems globally comes from the productivity losses linked to the burden of diseases caused by dietary patterns, costing the globe approximately US\$9.3 trillion annually [1]. In the 21st century, Africa continues to have distinguished levels of hunger and malnutrition in the world that are incompatible with the African Union's agenda for 2063 [2]. Hunger and malnutrition are common areas under discussion in almost all African countries. In this review paper, water is included as part of food and nutrition security.

Food security, nutrition and water are essential rights of everyone, and many Africans are deprived of these rights [2]. Several studies have pointed to various factors that contribute remarkably to food insecurity in Africa, and these include limited availability and adoption of yield-increasing technologies, food price inflation, rapid population growth, low economic growth, storms, cyclones and droughts [3]. In previous incidences, references are made to food and nutrition security only; rarely does one find the mention of water as part of food and nutrition security. Due to unknown factors, the importance of water has not been highlighted.

These challenges have exposed the vulnerability of Africa's food systems, compromising the ability to meet the rapidly increasing population's food demand [4]. Africa's food systems are at a critical stage, and climate change will likely deepen food insecurity and potentially jeopardise hard-earned development gains [5]. The percentage of arable land irrigated in Africa is only 7% as compared to South America (10%), East Asia (29%) and South Asia (41%), and this clearly shows that there is untapped potential for the development of the continent's water resources for increasing agriculture production (food

production) [6]. Food insecurity remains a problem in Africa, regardless of the efforts to increase the quality and production of global food resources [7].

Objectives and Research Questions: The objectives of this review are: (i) to synthesize the current status of food, nutrition and water security in Africa; (ii) to examine the principal factors affecting food, nutrition and water security on the continent; (iii) to assess the consequences of food insecurity; and (iv) to identify policy pathways for improving food, nutrition and water security. The review is guided by the following research questions: What is the current status of food, nutrition and water security in Africa? What are the principal drivers of food insecurity on the continent? What are the consequences of food insecurity? What policy responses are required? The review also applies Amartya Sen's entitlement theory to examine access-related dimensions of food security.

II. BACKGROUND

The recovery from the COVID-19 pandemic (2019-2022) worldwide and Russia's invasion of Ukraine (2022-date) has been marked by sluggish progress and varying effects on global economic stability [8]. Factors such as high inflation, monetary policy tightening, reduction of fiscal support and repercussions of extreme weather events have contributed to a decline in global economic growth and financial strain in many countries [8]. An evaluation of the state of food security, nutrition and water in the world in 2022 portrays that the repercussions of the COVID-19 pandemic and the war in Ukraine have distressed food markets [9].

The percentage of the world population facing chronic hunger in 2022 was about 9.2% compared with 7.9% in 2019, and projections bring to light that hunger afflicted between 691 million and 783 million people worldwide in 2022 [9]. New estimates of food insecurity based on the Food Insecurity Experience Scale confirm that for 2022, no progress has been made on food insecurity at the global level [10]. The cost of a healthy diet increased internationally by 6.7% between 2019 and 2021, with a notable single-year increase of 4.3% in 2021 [10]. A projected 29.6% of the global population was moderately or severely food insecure, implying they did not have access to adequate food, and the widespread presence of moderate or severe food insecurity rose slightly in Africa, North America and Europe and decreased non-significantly in Asia from 2021 to 2022 [10].

Progress toward realising the global nutrition targets by 2030 remains low in Africa, as millions suffer from widespread micronutrient deficiencies [11]. Estimates show that in 2021, the majority of Africa's population, about 78%, was incapable of affording a healthy diet compared with 42% at the global level. The average cost of a healthy diet has been increasing over time and was US\$3.57 per person per day in 2021 on the continent, much higher than the extreme poverty threshold of US\$2.15 per person per day [11].

The high cost of living in Africa drives strained outcomes as harvested food stocks shrink for households in typically low-producing areas [9]. The strong El Niño will probably result in below-average 2024 harvests, including in surplus-producing Zambia and South Africa [9]. The anticipated below-average cereal and crop harvests in 2024 will also result in a typical increase in imported maize prices [9]. It will be problematic for Africa to have sustainable economic development if its people are malnourished [12]. Africa has seen many economic changes, and no matter how hard people work, economies are still shrinking and jeopardising everyone's way of life, especially those in rural areas [12]. Sustainable Development Goal 2 of the 2030 Agenda for sustainable development to end hunger and malnutrition in Africa is not on track to accomplish this objective [12].

III. PROBLEM STATEMENT

Africa is facing a food crisis of unmatched proportions [11]. Almost 300 million people in Africa are estimated to be at risk of intensifying hunger due to the destructive impacts of conflict, climate variability and extremes, economic slowdowns, downturns, the effects of the COVID-19 pandemic and, of late, the consequences of the war in Ukraine, which are having an impact on the vulnerable [11]. The challenges incited by the COVID-19 pandemic and the war in Ukraine, which include rising unemployment, falling incomes and the lasting adverse impact on food supply chains from lockdowns in 2020 to 2021, continue to affect food security, nutrition and water in Africa [13]. Africa is a continent with 60% of the world's unused arable land, but it cannot feed itself due to poor farm management practices and distortions in agricultural markets [14]. The costs due to poor dietary patterns in Africa are the highest, costing the continent \$391 billion yearly and another \$18 billion due to the burden of diseases caused by undernourishment [1].

Food security, nutrition and water challenges and poverty are interconnected, and hunger has increased in Africa [15]. Poverty has contributed mainly to malnutrition, communicable diseases, and marginalisation in the continent [16]. Current estimates show that almost 282 million people in Africa were undernourished in 2022, an increase of 57 million since the COVID-19 pandemic began [10]. Reports further state that in 2022, at least 868 million people were moderately or severely food insecure, and more than 342 million were severely food insecure [11]. In 2019, out of 144 million children under five years of age affected by chronic malnutrition or stunting globally, over 57.6 million live in Africa [17]. In the same year, an estimated 12.7 million children under five years old were acutely malnourished or wasted, of whom 3.5 million were severely wasted [17]. Despite efforts being made in several countries, the African continent is not on track to achieve Sustainable Development Goal 2 of putting an end to zero hunger and the Malabo target, which seeks to eliminate hunger and all forms of malnutrition by 2025 [11].

In many East and Southern African areas, the intense summer season is anticipated to diminish harvests and increase food prices [8]. The El Niño is forecasted to peak in late 2023 and dispel by mid-2024 in Southern Africa [8]. Food security, nutrition and water security is likely to dilapidate and this will result in gaps of food consumption leading to higher than average rates of acute malnutrition and loss of livelihoods in weather-shocked areas of Mozambique and Malawi and conflict-affected areas in Eastern Democratic Republic of Congo and Cabo Delgado in Mozambique [8].

In West Africa, food insecurity continues to be observed in many conflict-affected areas, which include the Diffa region and the extreme south of the Maradi region in Niger, and civil insecurity has led to a crisis in the area because of funding shortfalls in food assistance operations [9]. Food insecurity in West Africa is also expected to persist in Burkina Faso, Cameroon, Chad and Nigeria [9]. In East Africa, as of 30 June 2023, at least 65.7 million people across Ethiopia, Kenya, Rwanda, South Sudan, Tanzania, and Uganda needed food [18]. According to [19]: (i) Africa spends \$70 billion to \$100 billion annually on commercial food imports and the average baseline for a healthy diet is \$444.33 to \$4.41 purchasing power parity per person per day. (ii) Transformation/Intervention Gap: Estimated \$21 billion to \$77 billion per year in extra public funding is required to fully transform Africa's agri-food systems and eliminate chronic deficiencies. (iii) Human Capital Losses: Country-specific studies under the Cost of Hunger in Africa project estimated losses equivalent to anywhere from 2% to 16.5% of GDP annually due to child stunting, lost productivity, and excess healthcare costs.

IV. METHODOLOGY

This research review highlights Africa's food, nutrition and water security status. It examines the evolution of food, nutrition and water security, the status of global food, nutrition and water security, factors affecting food security, effects of food insecurity, land tenure and food, nutrition and water security, how biotechnology can be adapted to improve food, nutrition and water security, and food safety and value addition in Africa. The qualitative research review is based primarily on literature review from secondary data sources. It must be noted that since the review is qualitative in completion, the research methods have been used to gather primarily non-numerical data and find meaning, opinions, and underlying reasons that vary from various sources. It is based mainly on, concerned with, and verifiable by observation and experience. Amartya Sen's theory of entitlement is explored based on the conceptual categories of endowment set, entitlement set and entitlement mapping to justify entitlements as a set of commodity bundles that can be transformed to deal with food security.

Search strategy: Literature was identified through targeted searches of Google Scholar, Scopus, Web of Science, and institutional repositories (FAO, World Bank, African Union, UNECA, WFP, IFAD, WHO) using combinations of the following terms: "food security Africa," "nutrition security," "water security," "food insecurity drivers," "climate change and food security," "land tenure and food security," "biotechnology and food security," "food safety and value addition," and "entitlement theory food security." The search was restricted primarily to English-language sources published between 1980 and 2026, with priority given to peer-reviewed literature and authoritative institutional reports.

Inclusion and exclusion criteria: Sources were included if they addressed food, nutrition or water security in Africa or comparable developing-country contexts, or if they contributed conceptually or methodologically to the review (e.g., entitlement theory, measurement approaches). Sources were excluded if they were not available in English or if they focused exclusively on high-income contexts without comparative relevance. Grey literature was included where issued by recognized institutions (e.g., FAO, World Bank, African Union, UN agencies), and access dates are provided for web-based sources.

Synthesis approach: The literature will be drawn from journals, handbooks, working papers, published and unpublished theses, and publications from global scenarios of food, nutrition and water security, including conferences, seminars and government documents drawn from the world, including Africa. The paper defines concepts of food, nutrition and water

security. It examines food availability, access, utilization, stability and water security. Factors affecting food, nutrition and water security in Africa, which include climate change, low investment in irrigation and agricultural research, outbreak of pandemics, poor agricultural policies, war and political instability and corruption, are examined, and recommendations on how African countries can step up to deal with these issues are brought to light.

Operationalizing entitlement theory: Sen's entitlement theory is used in this review as an analytical lens to examine access-related dimensions of food security. Specifically, the endowment set (legally owned resources such as land, labour, and knowledge), entitlement set (feasible commodity bundles obtainable through production, exchange, or transfer), and entitlement mapping (the rate at which endowments can be converted into entitlements) are used to interpret why food may be available at national level yet inaccessible at household level. This framework guides the discussion of land tenure, poverty, and market access as access-related determinants of food security rather than merely as background context.

V. LITERATURE REVIEW

5.1 Food, Nutrition and Water Security Concept

Food, nutrition and water security is a primary concern to policy makers, academics and practitioners all over the globe [20]. Food, nutrition and water security is vital as successive food shortages and the food price crisis from 2007-2008 brought attention to the substantial importance of food security to ensure political constancy [21]. Food, nutrition and water security exist when everyone at all times has economic and physical access to adequate, secure, and nutritious food that fulfils their dietary needs and food preferences and is aided by an environment of appropriate sanitation, health services and care, permitting a healthy and active life [22]. The four core dimensions of food security include food availability, access, utilisation and stability, and for food security and nutrition objectives to be realised, all four dimensions must be fulfilled concurrently [22]. The dimensions of food, nutrition and water security consist of:

- **Food availability:** This remains the predominant aspect used in food security analysis and measurement, and mechanisms used to measure food availability encompass the production of crop indices, livestock ownership indices and food balance sheets [23]. The Food and Agricultural Organisation obtains its undernourishment values from national food balance sheets, which pertain to a country's food supply and assumptions of intra-national food distribution [24]. Productivity estimates are easy to obtain at global, regional and national levels, partly explaining the persistence of the availability-based focus [23].
- **Food access:** Access to food is impacted by access to resources, social and physical environment, government trade policies, and income levels [25]. Food access has a solid institutional component consistent with Sen's 1981 treatment of entitlements and evidence that entitlements failure leads to food insecurity [25]. Food access is often measured using a proxy, entitlements-based indicators such as food consumption, food price monitoring, income or assets [26].
- **Food utilisation:** The availability and accessibility of food in a household does not mean that the household is food secure unless the food is nutritious, safe and socially acceptable to the members of the household [25]. Determinants of food utilisation include the ability to use the available food physically, for instance, having proper cooking utensils, culturally regulated feeding hierarchies, cuisine patterns, adequate housing and the ability to use the available food biologically, for example, the absence of diarrhoea or other diseases that impede the biological food use and infections [27].
- **Food stability:** When a person has enough food intake today, that individual is still regarded as food insecure if they have insufficient access to food periodically, risking a deterioration of nutritional status [28]. Adverse weather conditions, political instability or economic factors such as rising food prices and unemployment impact food security and nutrition status [28].
- **Water security:** This encompasses various needs and conditions and these include water for drinking, economic activity, ecosystems, governance, financing and political stability [29]. Water security is not just about how much natural water a country has but also how well the resource is managed [29].

5.2 Definition of Terms

Food security alludes to the state where everyone has physical and economic access to safe, sufficient, and nutritious food and water all the time to meet their food choices and dietary requirements for an active and healthy life [30].

Nutrition refers to the intake of food required to meet the body's dietary needs, and it impacts the development process at every stage of the life cycle from conception to death [31].

Food insecurity is a lack of regular and stable access to healthy, safe and affordable foods that promote optimal health and well-being [32].

Malnutrition denotes deficiencies, excesses or imbalances in a person's intake of energy or nutrients. Malnutrition is divided into two categories: undernutrition, stunting, wasting, underweight and micronutrient deficiencies. The second category refers to obesity, overweight and diet-related non-communicable diseases such as cancer, heart disease, stroke and diabetes [33].

Stunting represents the impaired growth and development children endure from poor nutrition, repeated infection and inadequate psychosocial stimulation [34].

Wasting signals low weight for height, often indicating recent and severe weight loss. It occurs when a person has not had food of adequate quality and quantity or has had frequent or prolonged illnesses [35].

Hunger is an uncomfortable or painful physical sensation brought about by insufficient consumption of dietary energy, and it becomes chronic when the person does not consume a sufficient number of calories regularly to lead an everyday, active and healthy life [36].

5.3 Evolution of Food, Nutrition and Water Security Concept

The notion of food, nutrition and water security started more than 45 years ago when there were food shortages worldwide [37]. At first, it focused on ensuring that there was enough food and that the prices of essential foods were stable worldwide and in each country. This happened because agricultural commodity prices were volatile in the early 1970s [37]. This was caused by disarray in the monetary systems, financial marketplaces, and various other unfavourable conditions [37]. The attention to supply constraints resulted from the changing structure of the global food economy, which is thought to be the cause of these economic problems [37]. Hunger, food crises, famine and water emphasised the development of the definition of food security, which considers the most critical needs and actions of people who might be affected [37].

In 1994, the United Nations Development Program Human Development Report examined human security, and seven critical issues were highlighted: food, economics, environmental, communal, political, personal, and health security [38]. Food insecurity is a problem that ranges from the household to the international level, even though it is primarily addressed nationally by policymakers [39]. At the household level, food security measurements consider individual dietary preferences; thus, food insecurity is a problem affecting the whole world [39].

The subsequent moment occurred when the World Bank published the foundational report entitled Poverty and Hunger in 1986 [40]. The report emphasised a difference between chronic, temporary, and acute food insecurity associated with poverty and human-made or natural calamities [41]. This assertion resulted in introducing a temporal scale to measure food security. This was considered when expanding the idea of food security to include the parameter availability of sufficient, safe and nutritious food to people at all times for a dynamic, healthy life [42].

The second edition of the notion took place in 1994 in response to the Human Development Report issued by the United Nations Development Program, which examined the prerequisites for human food security [43]. After the World Food Summit 1996, a very organised and systematic work was endorsed. The organisations' members were tasked with monitoring the progress toward decreasing the number of malnourished people in developing countries by 2015 [43]. It was also in the middle of 1990 when the term food security was replaced by nutrition security to elaborate on the current scenario.

5.4 Theory of Entitlement (Amartya Sen)

The entitlement approach is based on conceptual categories, namely the endowment set, entitlement set, and entitlement mapping, and this theory is of utmost importance to Africa as it highlights what individuals need to possess to attain food security [44]. The endowment set combines all those legally owned resources by a person conforming to established norms and practices [45]. The resources include tangible assets such as land, animals and equipment and intangibles such as knowledge, skills and labour [45]. The entitlement set is the set of feasible compositions of goods and services that a person can legally obtain using the resources of his endowment set [44]. The utilisation of the assets to get final goods and services may be either in the form of transfer, production, exchange or transfer. Entitlement mapping is simply the link between the endowment set and the entitlement set, defined as the rate at which the resources of the endowment set can be turned into goods and services [45].

Sen's entitlement theory considers entitlements as a set of commodity bundles that can be transformed to deal with food security in a household [46]. Systems comprising human beings, resources and structures should be developed because they complement each other to aid synergies for sustainable food security in a community [46]. It, therefore, means that when the necessary resources and structures are put in place, Africa will have the capacity to deal with food insecurity, primarily due to climate change, rapid population growth, poor agricultural policies and programs, conflicts and corruption. The entitlement theory also looks at how communities can become food secure, explicitly looking at food access [46].

Amartya Sen has presented a global logical model for examining all famines (the entitlement approach) and simultaneously a new hypothesis of causation that specific famines are described by decreases in access to food for identifiable populace groups regardless of available food at the national level [47]. Food might be available at the national level; however, at the district level, people might be starving because they cannot access food because of prices, availability (volumes), and distance [47]. Sen's entitlement theory approaches food security from an access point of view and further spells out the barriers, such as the law between food availability and access [45]. The theory also postulates that although food can be available, in some instances, it is not available to everyone; this can be witnessed by the abundance of food in supermarkets whilst people are food insecure. The entitlement theory helps to finish the food chain from the producer to the consumer [47].

5.5 Food Security and Nutrition Measuring Methods

Food security, nutrition and water security measures that are used include the following methods:

- **Food and Agricultural Organisation method:** This method estimates dietary energy consumption per capita at the country level [48]. Per capita energy consumption is calculated through the food balance sheets used in the household income and expenditure surveys. The proportion of the undernourished population is marked as that part of the distribution lying below a lower limit energy requirement level [48]. The minimum calorie intake is further adjusted for the sex and age distribution of the country's population, assuming the minimum acceptable body weight for all sex age groups and activity levels for adults [48].
- **Household Expenditure Survey Method:** The household expenditure survey method is a direct method to obtain information from the households, and the respondents must make available information about their expenditures on food and other necessities, especially the amount of money they spend on purchasing essential and nutritionally adequate diets [49]. Accurate data is obtained by getting information about the quality of food items consumed within and outside the household [50]. The household expenditure survey method estimates an average daily per capita calorie consumed, adjusting for access to culturally appropriate food [50].
- **Dietary Intake Assessment:** This method uses different techniques, including food frequency questionnaires, food records provided by an individual or observer, and the recall method, which can be done after 24 hours, seven days, or 30 days [51]. This technique relies on participants' memory, while the food records depend on recording food consumption data. These adjusted estimations roughly calculate nutrient intakes [51].
- **Anthropometry:** This method uses the measurement of individual human characteristics, and the generalised information is collected on the areas of food provisioning, preparation and consumption practices according to the cultural settings of the respective areas [52]. Information gathered extends to the body size, weight, body proportions and food composition [53]. These indicators help measure the impacts of food security and nutrition and health on individuals' nutritional status [54]. This method is also helpful in constructing scales of past food supply, current food stores and adequacy of future food supply [52].
- **Food Insecurity Experience-based measurement scales:** This method is based on respondents' perceptions or experiences and a series of questions that rely on qualitative and subjective assessments [50].
- **Rapid Rural Appraisal:** This approach is almost identical to participatory and rural appraisal but is more action-oriented, including focus groups and in-depth interviews [53]. The information collected through rapid rural appraisal helps develop quantitative measures for determining the food security status [53].

5.6 Global Food, Nutrition and Water Status

Geopolitical and climatic events are influencing the food systems' resilience [10]. The global food supply faces two crucial impediments: a drop in imports from Ukraine and, to some degree, from Russia and knock-on effects that could further constrain global supply [10]. The current import deficit has been mainly due to a reduction in the capacity to move siloed grain

out of the Black Sea Region because of the Russia/Ukraine conflict [55]. Domestic food price inflation remains high globally as of December 2023 [9]. Inflation higher than 5% is experienced in 61.9% of low-income African countries, South Asia and some Central Asian countries, 76.1% of lower-middle-income countries in Latin America and some Central Asian countries and 57.4% of high-income countries in Europe and North America [9].

Global import volumes have declined, and the world's grain mostly comes from six growing regions, including Ukraine and Russia, which produce roughly 28% of the wheat and 15% of corn exported globally [9]. Reports highlight that there has been an immediate reduction in import volumes due to blocked Black Sea ports and mines along the shipping routes [55]. Wheat and maize supplies that needed to exit Ukraine via rail or truck transport faced logistical bottlenecks, including different rail gauges used in Ukraine versus neighbouring countries [55]. Supply was tightened by countries that attempted to shield domestic markets with trade restrictions in 2022, and roughly forty new export bans and export licensing requirements were introduced between the beginning of the war and May 2022 [9]. These measures put additional pressure on available food stocks, pushed prices up, and threatened food security for the world's poor [55].

As mentioned earlier, there is a gap that we feel water is not being recognized. In this paper we have included it as a crucial aspect of food and nutrition security. Water security is a powerful notion [56]. Water is important to food security as well as crops and livestock (United Nations World Water Development, 2012). Agriculture requires large quantities of water for irrigation and of good quality for various production processes. Access to adequate food in the rural areas of many developing countries depends heavily on access to natural resources including water that are necessary to produce food [57].

Water security predictors are similar to food security and these include socioeconomic and demographic characteristics including education, size of family, poverty, income and assets [58]. Although wealthier families are likely to be more water secure because they have the resources to spend on purchasing water and storage systems, water insecurity has been observed across the wealth gradient; that is, not all households are able to buy themselves out of water insecurity [59]. Given the high incidence and severity of water issues and the links between water and nutrition, water security is vital to human nutrition and health [56]. Water security is essential for food security. The impact of water shortage on food security is clear-cut; unsafe water and sanitation can lead to malnutrition and exacerbate existing problems [60]. No matter how much food a malnourished child eats, they will not get better if the water they are drinking is unsafe or unavailable [60].

5.7 Food Systems

Food systems have become the central theme among food actors and scholars to frame, comprehend and adequately address food, nutrition and water security [61]. The food systems approach encompasses the actors within the food supply chain and the governance procedures that shape their roles [62]. The components of the food system include food supply chains, food environments, consumer behaviours and diets, individual factors, the outcomes including nutrition and health, environment livelihoods and wages and fairness and justice for all people and the drivers, many of which are exogenous to food systems [63]. Food supply chains are the elements that connect the production of food, food storage, loss and distribution, processing, packing and retail [64]. The types of foods produced by supply chains provide food to environments where people buy and order food [64].

These environments vary from informal to highly formalised environments, and the types of food influence the architecture of these environments, including their offer, affordability, properties, promotion, and advertising. Individuals' purchasing power, knowledge, aspirations, resources, and culture shape consumer decision-making and behaviour, influencing diets [65]. These components affect many outcomes, including health, nutrition, wages, income, the environment, climate cultures and societal equity [66]. Political, programmatic and institutional actions can be impacted and regulated by food system components outcomes and drivers, all of which affect progress toward the Sustainable Development Goals [67]. Food, nutrition and water security pillars intersect with food systems, and risks, shocks, and vulnerabilities consistently threaten the resilience and various outcomes of food systems [67].

If food systems do not function well, it will be difficult to achieve food, nutrition and water security, yet even if food systems are well functioning, food insecurity can still occur [68]. Food systems are embroiled in an intimate societal interdependence with many other systems, which also influence food, nutrition and water security [68]. Food security requires functioning health systems, educational systems, energy, water and sanitation [63]. The definition of food security and nutrition refers to the necessity of a whole systems approach. The physical and economic access alone denotes that built environments, urban and rural development and infrastructure, livelihoods and economics influence food, nutrition and water security outcomes [61]. A good illustration is the COVID-19 pandemic, where there was growing evidence to suggest that while food supplies

were protected mainly during the pandemic, food insecurity escalated for various reasons, including loss of income and the global economic slowdown [68]. The long-term outcomes of the loss of income and employment are profound; food prices have risen and are 3-25% higher in some parts of the world than in 2020 [61].

5.8 Nexus Between Food Insecurity and Poverty

A vital relationship exists between poverty and food insecurity; poverty creates unstable and unfavourable conditions that may fuel food insecurity [69]. Poor people often face financial limitations that hinder their access to safe, sufficient, and nutritious food [70]. Poverty can contribute to worsening food insecurity by jeopardising the standard of food intake and sustaining hidden hunger, which is the deficiency of crucial vitamins and minerals [71]. Poverty leads to financial limitations that, in turn, contribute to the consumption of low-cost, healthy staple foods, especially carbohydrates and fats, rather than nutritionally rich food [69].

In some instances, energy levels spike with the consumption of carbohydrates and fats, but nutritional quality becomes compromised [71]. This results in reduced nutritional quality and nutrient deficiencies [71]. Poverty plays a substantial role in regulating access to and preference for foods, and this is clear in studies that demonstrate that when people living in poverty get a chance to expend relatively more on food, they often go for better-tasting food rather than good-quality food [71]. Nutritional status profoundly impacts human capital because improved nutritional status is crucial for eliminating poverty, as good health is required to boost productivity levels, contribute to economic growth and enhance a country's overall welfare [72]. When there is inadequate nutrition, human capital starts to decline because malnutrition negatively impacts an individual's physical and mental development, intellectual abilities, productivity and economic potential [69]. Consequently, economic stability is jeopardised, making a country more susceptible to poverty.

Poverty contributes to food insecurity, referred to as resource-constrained or poverty-related conditions [69]. Although the populace affected by poverty and food insecurity overlay, not all people living in poverty are food insecure, and this problem also exists in people living above the poverty line [72]. Poverty contributes to creating conditions of micronutrient deficiencies and hidden hunger and these factors exacerbate the issue of food insecurity and make individuals more susceptible to infections [72]. The infections further reduce nutritional and health status, aggravating food insecurity and reinforcing the cycle of poverty [69].

5.9 Factors Affecting Food, Nutrition and Water Security in Africa

Climate change: African countries are at risk from the effects of global warming owing to their poor financial, scientific and technological capabilities to adjust to the dangers caused by climate change and their reliance on climate-sensitive and weak economic sectors, which include rain-fed agriculture [73]. The majority of countries in Africa rely heavily on agricultural production and food security, and some parts of the continent have been drier over the last century [74]. The African continent is set to face a sharp rise in temperature compared to the rest of the world, compromising food security [74].

Climate variability is seen as a threat and a barricade to sustainable global growth and development practitioners and policymakers [75]. Recent data shows an increase in worldwide hunger and malnutrition and rising instances of extreme weather in Africa [75]. Some African countries could see a decline of 50% in crop productivity by 2030 and a 90% drop in income by 2100 due to significant climate change and variability [75]. Some research indicates that national and household food security in less developed nations, especially in Africa, has decreased due to climate change [74]. Climate extremes will affect the obtainability of food in Africa by decreasing the viable arable land appropriate for crop production [76]. This could lead to an increase in the prevalence and number of undernourished individuals in Africa.

COVID-19 (2019-2022): The COVID-19 pandemic also increased the budget deficit to a regional average of minus 6.4% in 2021, further restricting fiscal space (Reliefweb, 2023). Governments were forced to borrow massively, increasing the ratio of government debt to GDP in many nations where ratios were already high in countries like Cape Verde 157%, Sao Tome & Principe 88%, Ghana 81.8% and Senegal 73% in 2021 [77]. Higher global food and energy prices combined with the lasting effects of the COVID-19 pandemic strongly impacted the economic performance of the sub-region in 2022 [77]. Soaring food prices significantly threaten food security by reducing the purchasing power of about 600 million people in Africa, especially vulnerable groups [78]. This is mainly due to the dominant share of food expenditure of households in West Africa, which is 43% of the total, with households in Burkina Faso, Gambia, Mali, Nigeria, Senegal and Sierra Leone spending more than 50% [77].

High population growth: Population surge in Africa with dwindling agricultural produce is a growing concern for policymakers [79]. The current population in Africa is around 1.4 billion, with an average rate of growth accounting for 3.2%, the highest in the world [80]. According to the prediction, Africa's population will reach approximately 2.5 billion by 2050 [80]. High population growth in certain African regions will make it harder to eradicate problems of food insecurity, inequality, hunger and malnutrition [81]. It has been observed that the growth in the human population and its effect on hunger have been the topic of concern as food insecurity is more prevalent in nations with larger populations [80]. A rising global population is a notable factor in spreading hunger in every part of the world's poorest region [81].

Low investment in irrigation agriculture and research: African countries cannot reach their full potential because of decades of under-investment, under-use and neglect of their public infrastructure (Onwujekwe & Ezemba, 2021). The World Bank evaluated in 2000 that 85-90% of agriculture in Africa depended on rainwater for survival and that agriculture accounted for 35% of the region's gross domestic product, 40% of exports and 70% of its employment [12]. Agricultural output may not be more sustainable with an annual rainfall of less than 700mm [82]. While global scientific investments and the number of scientists have increased in the past few years, no African country now devotes 1% of its GDP to research and development [83]. According to a report [82], 80% of the countries that invested less than 1% of their gross domestic product in scientific research are in Africa, and this suggests that poor spending on the continent has been relatively low since 2014.

War and political instability: According to the FAO Report on Food Security in Africa 2018, conflicts in various parts of Africa have left many in urgent need of food assistance, especially in Nigeria, where the ongoing insurgency exposed as many as 2.9 million to severe food insecurity between June and August 2018 [84]. The insurgency in Nigeria, for example, has displaced over 1 million, killed over 10,000 and had implications of causing price increases in other parts of Nigeria, disrupting farming in other parts of the country, thereby remodelling the agricultural value chain and resulting in a drop in food production [84]. In the Central African Republic, the conflict has significantly affected food production and a spike in food prices, and at least 1.6 million people urgently need food aid [79]. One outcome of food insecurity attributable to wars and conflicts is the stunting and wasting away of children [84]. The Food Security Information Network reports that 3 million children in Ethiopia are wasting away [84]. At the same time, in the Lake Chad Basin, the Democratic Republic of Congo and South Sudan, 12 million children were wasting away [79].

Poor agricultural policies and programmes: Most African countries have unsound agricultural policies addressing food, nutrition and water security in the long term [85]. Self-sufficiency for significant food commodities is decreasing in Africa, and without action, Africa's food import bill, which stood at \$43 billion in 2019, could rise to \$110 billion in 2025 [86]. The primary reason for this scenario is unstable political regimes and governments that can develop these policies [79]. Other policies enacted are outdated; for example, food export restrictions and trading bans have isolated Nigerian markets giving local farmers little motivation to grow their production for subsequent seasons while at the same time exposing the people to price volatility as a result of diminished supplies [79]. Many African countries also have fragile governments, poor credit organisations, weak training institutions and the propagation of technologies that would help improve food security [79].

Corruption: Africa has some of the highest levels of corruption in the world, and corruption signifies a more profound and widespread sickness, and it is widespread in Sub-Saharan Africa [78]. Like other forms of economic stability, bribery widens the income gap between the wealthy and the underprivileged, fuelling widespread poverty and food insecurity in Africa [87]. Corruption and the misuse of public finances have intensified social division and armed conflict in several African countries [88]. While many African governments claim to be concerned about ending malnutrition, few have taken the time to quantify the extent of the issue [89]. A study on corruption and food insecurity found that poor rural people in African countries are susceptible to corrupt practices [88]. The study also ascertained that poverty-stricken people in Kenya were shown to pay bribes more frequently and with a more significant proportion of their income than the middle and upper classes, thus pushing them into a catastrophic state of food insecurity [88].

5.10 Effects of Food Insecurity

Food insecurity, which broadly denotes a condition of disrupted dietary patterns and food intake, is a risk factor for nutrition insecurity, a condition marked by inadequate consumption of healthy foods [90]. Diet-related ailments such as diabetes, obesity, coronary artery diseases and certain types of cancer have become some leading causes of morbidity, mortality and healthcare expenditure in many African countries [90].

Food insecurity can lead to more physical illnesses in the long term as well as mental and emotional problems, which make learning challenging, and those who have suffered food insecurity as a child are reportedly more likely to miss school or try to

work through hunger, which limits performance [91]. Absorbing information is more complicated when a student is distracted by hunger pains, regardless of age [92].

In most African countries, persistent malnutrition leaves children weak, exposed and less able to fight common childhood diseases, for instance, diarrhoea, acute respiratory infections, malaria and measles [84]. Food insecurity in children also impacts their parents' ability to work. When children cannot go to school, parents may have to stay at home with them, which can mean they are not contributing to the economy, resulting in lost productivity [93]. Access to a stable food supply is critical for children's healthy physical and cognitive development [94].

Adolescents and adults suffer adverse consequences of food insecurity and malnutrition, which ultimately leads to decreased energy levels, delayed maturation, growth failure, damaged cognitive ability, diminished capacity to learn, reduced capability to fight infections and illnesses, shortened life expectancy, increased maternal mortality and low birth weight [84]. Food insecurity may also result in political turmoil, just as food-insecure individuals may manifest feelings of disaffection, powerlessness, stress and anxiety, and they may experience reduced productivity [85]. Household dynamics may become disorganised because of preoccupation with obtaining food, leading to anger, pessimism and irritation [85].

When food is not reliably available to families, it can have long-term effects on the broader economy [93]. Food insecurity stunts physical development, shrinks productivity, wastes money, and harms educational outcomes, reducing overall lifetime earnings for those who experience it [93]. For individuals, the malnutrition and sickness that food insecurity can cause lead to more absences from work and these illnesses, particularly when chronic, also require massive resources for treatment [95]. Food insecurity is also linked to low wages and neighbourhood segregation, and to participate at total capacity in the workforce, employees need enough nutrition [96].

5.11 Land Tenure and Food, Nutrition and Water Security in Africa

Given that land plays an essential part in the livelihoods of the more significant part of Africans, food, nutrition and water security, and poverty reduction cannot be attained unless issues of access to land, security of tenure and the capacity to use land productively and in a sustainable manner are addressed [97]. In Africa, access to farmland is a significant determinant in defining households as food insecure [98]. Food, nutrition and water security pillars are intimately tied to sustainable agriculture [99]. They are complex and interconnected with land [99]. Food, nutrition and water security remain aspirations, and tenure security is elusive for many African people [99]. The sound governance of land tenure is core to ensuring food, nutrition and water security, and sustainable development [100]. Strengthening land tenure governance through tenure security and equitable access to land can promote sustainable agriculture and food systems [101].

Adequate land and resource governance systems that provide improved access, control, and rights to land and other natural resources are necessary for achieving food, nutrition and water security [102]. Land property smallholder farmers dominate food production in developing countries yet constitute the largest share of food-insecure people and account for most of the world's poor and hungry [103]. Limited land access and insecure tenure rights may weaken food, nutrition and water security in Africa, where over 70% of people depend on land and natural resource exploitation for livelihoods [104].

In Nigeria, one of the constraints to food security is the lack of secure title of agricultural land [105]. Less than 3% of Nigerian households are estimated to hold formal land titles and rent-seeking, and the high cost of processing land registration constrains legal titles, reviving customary land tenure and initiating informal land proper documentation [106]. The Voluntary Guidelines on the Responsible Governance of Tenure of Land in the Context of National Food Security and the Frameworks and Guidelines on Land Policy in Africa were established to guide the governance of land tenure to achieve food security [107]. Despite the importance of these guidelines, there is a lack of literature on the effect of land tenure among smallholder farmers across various food security outcomes [107]. Secure land tenure rights can enhance household food security's availability, access and utilisation [108].

5.12 How Biotechnology Can Be Adapted to Improve Food, Nutrition and Water Security in Africa

Low crop production is the main reason for poverty and food insecurity in Africa [109]. Biotechnology can increase crop yield by introducing high-yielding varieties resistant to biotic and abiotic stresses, reduce pest-associated losses and increase the nutritional values of foods, which is a critical factor in African countries [109]. In modern agriculture, biotechnology plays vital roles in advancing cropping systems, soil science, plant physiology, seed technology, crop management and animal husbandry, all of which are pivotal to improving the quality and quantity of food production [110]. According to [111], among

the numerous possibilities for crop improvement, genetic modification of crops deserves special attention. It could be a life jacket in this ocean of food insecurity.

Genetically engineered crops can reduce food insecurity to a minimum [111]. Genetic modification enables farmers to achieve a more significant and better agricultural yield, counting on its limitless potential for crop improvement [112]. Although it is still a subject of public debate, super plants offer a feasible alternative for addressing world hunger [112]. However, the capacity of biotechnology to act as a tool to aid in solving the issue of food security still needs to be fully exploited [109]. Developing transgenic crop varieties with higher nutritional content or higher amounts of folate can offer adequate quantities of essential micronutrients that are typically deficient in diets in the developing world [113].

There have been notable advancements in the utilisation of biotechnology to create food crops with enhanced nutritional value, such as reduced amylose, phytic acid and gluten contents and increased oleic acid and gamma-amino butyric acid contents, among others [114]. These advancements aim to reduce detrimental nutrient elements and provide essential nutrients such as vitamin A and iron to poor populations across the globe who are worst hit by food insecurity [114].

From a scientific point of view, genetically modified organisms (GMOs) have considerable benefits for farmers, consumers and the environment [115]. GMOs have resulted in increased yields, an increase in farmer's profits and enhancing food quality and nutrient composition critical for tackling malnutrition and associated diseases [116]. Regardless of their benefits, GMOs are met with heavy criticism and at least 26 countries including China, France, Germany, India, Italy, Mexico and Russia have partially or fully banned them [117]. It has been noted that at least 60 countries have also put significant restrictions on GMOs [117]. The reason for this opposition to GMOs is because of the perceived weak agricultural benefits compared to their potential risks [118]. There is also a noted lack of trust and confidence by the public in regulatory processes behind GMOs [118].

5.13 Food Safety and Value Addition in Africa

Sustainable agriculture is based on a commodity value chain approach from primary products through processing and marketing [119]. High post-harvest food losses due to poor post-harvesting handling practices, inadequate food processing and storage facilities, weak supply chains, and limited value addition are significant challenges constraining agricultural development and food and nutrition security in Africa [120]. In recent years, consumer buying behaviour has changed, and more people are consuming processed food than ever before. The need for processed food will increase in the coming years [121].

Value addition increases the worth of agricultural produce, stimulates agricultural production, stabilises the food supply and ensures adequate intake of nutrients, including micronutrients, by vulnerable groups [120]. Value addition reduces food systems' risks to nutrition and health by ensuring a safe, wholesome food supply and controlling food-borne diseases caused by bacteria, viruses, parasites, and chemical contaminants [119]. The processing of food can be done at two levels: at the commercialised level, trade-oriented processing and at the household level, where home food preservation will be carried out [121].

The embracement of value-added products such as canned fruits and vegetables, fortified foods and processed grains in Africa will enable them to have longer shelf lives, thereby ensuring a more stable food supply [122]. Value addition also enables the development of nutritious products, thereby addressing malnutrition and promoting healthier diets [122]. Africa's staple crops, such as rice, cassava, maize and millet, offer immense potential for value addition, and these products create products like rice bran oil, maize flour, millet-based snacks and cassava chips [122]. This will enable Africa to meet the growing demand for processed staple foods [122]. Africa's favourable climate and diverse agroecological zones make it an ideal region for horticulture and fruit production, and processing fruits into juices, concentrates, jams, and dried fruits adds value and extends their shelf life [122].

VI. RECOMMENDATIONS

- The African Union, regional economic communities, and member states must come to terms with and acknowledge the magnitude of the continents' food insecurity challenges and their risks and vulnerabilities. Policies on food, nutrition and water security in Africa and actions must impact resilience and sustainability directly, and they should focus on provisional strategies and responses focusing on livelihood saving with long-term strategies to build resilience and address the root causes of food, nutrition and water security.

- African governments can and must cooperate to address the geopolitical tensions that lead to global crises and the causes of climate change.
- Measuring food security and nutrition methods must be used without delay to confirm the state of food insecurity in Africa.
- Trade liberalisation and import diversification could help stabilise regional food supply and prices; for instance, Zambia's big maize harvests could have helped offset shortfalls elsewhere in Southern Africa if not for a ban on exporting the crop. Access to larger markets can incentivise investment in agricultural production networks and value chains. Trade liberalisation can also help spread knowledge, such as how to plant drought-resistant crops and encourage competition.
- African governments should also consider setting up incentives such as lifting value-added taxes, duties, and other taxes imposed on food businesses to facilitate the supply chain to function appropriately without substantial interruptions. Governments should also consider extending concessional loans or loan guarantee facilities to food actors who need them to ensure the food supply chain runs smoothly.
- African governments must incorporate sustainability, climate resilience, and agroecology into their agricultural sector strategies and develop recommendations for achieving these goals. Sustainability plans should describe the agriculture systems that benefit communities, small-scale food producers, and the environment and emphasise various approaches, including developing drought and flood-tolerant crops, weather information and robust extension services.
- Nutrition-sensitive agricultural interventions can be adopted, and these improve various nutrition outcomes in mothers and children. Communicating the significance of nutritious diets in extension services while providing biofortified seeds can increase utilisation and overall nutritional status. Home gardening positively affects the availability of nutritious foods and dietary diversity.
- Nutrition assistance efforts should be based on solid nutritional science, centred around the goals of preventing and treating, when necessary, diet-related illnesses, promoting the consumption of safe, healthful, and nutrient-dense foods, discouraging the consumption of processed, unsafe, and unhealthy foods, and educating people on nutritional health and improving dietary quality.
- Improved post-harvest handling, storage and processing technologies reduce food losses and strengthen food security and nutrition by increasing availability and stability.
- African countries need to strengthen their anti-corruption laws and regulations and set up independent commissions to track down corruption in all sectors.
- There is need for African governments to improve water infrastructure as water conservation and efficiency are vital components of sustainable water management. Solar desalinization and smart irrigation systems are great examples of clean technology for water efficiency and control.
- Implementation of rainwater harvesting systems to collect and store rainwater for drinking or recharging underground aquifers.
- Building wells to extract underground water from underground aquifers.

VII. CONCLUSION

Africa suffers more than any continent due to climate change, yet they have not contributed significantly. Most African countries have limited awareness of food security, nutrition and water issues. Water insecurity in Africa is likely to intensify under the ever-increasing water demand and rise in global temperatures. Substantial action from all relevant parties is required to tackle this massive problem of water insecurity. As a result, people tend to be reluctant on this matter, making food insecurity more prevalent. Research and development budgets must be increased from 1% of the gross domestic product to improve agricultural production. Land under irrigation also needs to increase from the current 6% to at least 20% to achieve food security in Africa, especially with the rising population. African states are in serious debt, and some developed countries use

food insecurity as a bribe. Food security, nutrition and water consequences are profound; without coordinated action, Africa risks becoming desolate in the next few decades.

Limitations of the Review: This is a narrative review based on published literature and publicly available institutional information; it does not present new experimental or survey data. The evidence base is weighted toward institutional reports and selected peer-reviewed studies, with limited systematic coverage of some sub-regions. A formal systematic search strategy was not employed, and the possibility of selection or publication bias cannot be excluded. The use of entitlement theory is interpretive rather than formal modeling. Some claims (for example, regarding future desolation or the role of developed countries) are broad and would require scenario analysis or additional evidence to substantiate. Despite these limitations, the review provides a structured synthesis that can guide policy and future research.

Future Research Directions: Priority research should include: (1) systematic reviews and meta-analyses of food, nutrition and water security interventions in Africa; (2) scenario analyses of climate change impacts on food systems; (3) comparative studies of land tenure reforms and food security outcomes; (4) field evaluation of biotechnology and biofortification under African conditions; (5) assessment of value addition and post-harvest loss reduction; and (6) integrated water–energy–food nexus studies at national and regional scales.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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