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RECEIVED 24 March 2023

ACCEPTED 28 June 2023

PUBLISHED 19 July 2023

## CITATION

Assan N (2023) Socio-cultural, economic, and environmental implications for innovation in sustainable food in Africa.  
*Front. Sustain. Food Syst.* 7:1192422.  
doi: 10.3389/fsufs.2023.1192422

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# Socio-cultural, economic, and environmental implications for innovation in sustainable food in Africa

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The debate over innovation in sustainable food in Africa is multifaceted and complex since it is impacted by an array of issues, including social, cultural, religious, and environmental implications. The diversity of cultures on the continent, as well as religion, influence the foods that people eat. The architecture of agro-ecological zones influences food production and, as a result, the sort of innovation in sustainable food. Africa, in particular, has immense potential for the development of multiple sustainable food innovations, whether in terms of food, culture, or tradition. By sustainable food innovation, it may be possible to improve Africa's food systems from the demand side while also mitigating the effects of climate change. For Africa, it is the food crisis that simply cannot be allowed to go to waste, hence the need for innovation in sustainable food solutions in its own context. Africa's long-standing food crisis, recently worsened by the COVID-19 pandemic and, increasingly, by climate change and heavily weighed on gender disparities in agriculture and food production, threatens to have dire consequences, especially on achieving the SDGs in Africa. Innovation in sustainable food is at the forefront of all Africa needs for its survival at every current stage of population evolution; this applies whether in industrialized or impoverished nations, rural or urban, village or metropolis, etc. It is false to believe that the only sources of innovation in sustainable food are cutting-edge research or the most recent developments in genomic science. The discussion gives an opinion on the socio-cultural, economic, and environmental factors and their implications for innovation in sustainable food in Africa.

## KEYWORDS

innovation, sustainable food, gender, climate change, indigenous knowledge systems, traditional food, food security, Africa

## Introduction

The food crisis in Africa makes it impossible to let food go to waste, necessitating the development of innovative, sustainable food solutions tailored to the continent's specific needs. The persistent food crisis, which has lately been made worse by the COVID-19 epidemic and increasingly by climate change while also being strongly affected by gender inequality in agriculture and food production, is an existential threat to attaining the SDGs, especially in Africa. Whether in rural or urban, village or metropolis, etc., innovation in sustainable food is at the forefront of what Africa needs for its survival today. It is false to believe that the most

recent developments in genomic technology or cutting-edge research are the only sources of innovation in sustainable food. But, communities in Africa must accept the need to evolve due to the results of various advances in innovation in sustainable food if the continent is to solve problems with food access, safety, and health.

Rinkinen and Harmaakorpi (2018), describes innovation as a process of reestablishment of science and technology for the benefit of the economy and society. It alludes to both a procedure and an outcome. Ramirez et al. (2018) implore that it may be managed in four key ways: product, process, marketing, and organization. Contrarily, food innovation refers to the culmination of all creative and technological initiatives dedicated to the production, distribution, sales, consumption, and waste management of food. As thus, one of the primary ways that food businesses can optimize food efficiency while maintaining a competitive edge in the global market is via food innovation (Kaleka and Morgan, 2017). Food innovations include changes to local food production practices such as handling, harvesting, preparing, and processing and storing of agricultural commodities after harvest. A transformation African food systems may be a result of innovation in sustainable food processes. Africa's emphasis on sustainable food innovation thus has the potential to have a significant effect on the productivity and profitability of the smallholder agriculture sector as well as the creation of new locally based added value.

There is a critical need to focus on innovation in sustainable food since the pace of population growth in African countries is much higher than the quantity and quality of food required to maintain the population (Figure 1). According to reports, sub-Saharan Africa is home to 204 million of the 814 million malnourished people in the globe (HLPE, 2013). Low agricultural output, poverty, and inefficient food distribution are the main causes of hunger. Due to the difficulty most low-income households in Sub-Saharan Africa have in obtaining nutritious food of high quality, innovation in sustainable agriculture is required to advance safety, health, and food access. There is a critical need to focus on innovation in sustainable food since the pace of population growth in African countries is much higher than the quantity and quality of food required to maintain the population (Figure 1). According to reports, sub-Saharan Africa is home to 204 million of the 814 million malnourished people in the globe (HLPE, 2013). Low agricultural output, poverty, and inefficient food distribution are the main causes of hunger. Due to the difficulty most low-income households in Sub-Saharan Africa have in obtaining nutritious food of high quality, innovation in sustainable agriculture is required to advance safety, health, and food access.

Innovation as a concept is contentious because it promotes constrictive modernization ideas that worsen social and environmental issues in the Global South while still promising prosperity and progress (Ludwig and Macnaghten, 2020). George et al. (2012) take a look at inclusive innovation, which emphasizes outcomes and calls for the creation and implementation of fresh concepts that aim to provide opportunities that increase social and economic success for marginalized groups of society. On the other hand, the idea of inclusive innovation is still contested and ambiguous but has gained acceptance as a reflexive value that goes beyond a straightforward push for modernization (Opola et al., 2020). Inclusion is about more than just the results; it's also about the agency of marginalized actors in the innovation processes itself, according to Foster and Heeks (2013) and the UN (2018). In this approach,

marginalized actors produce inventions that are both inclusive and exclusive to them.

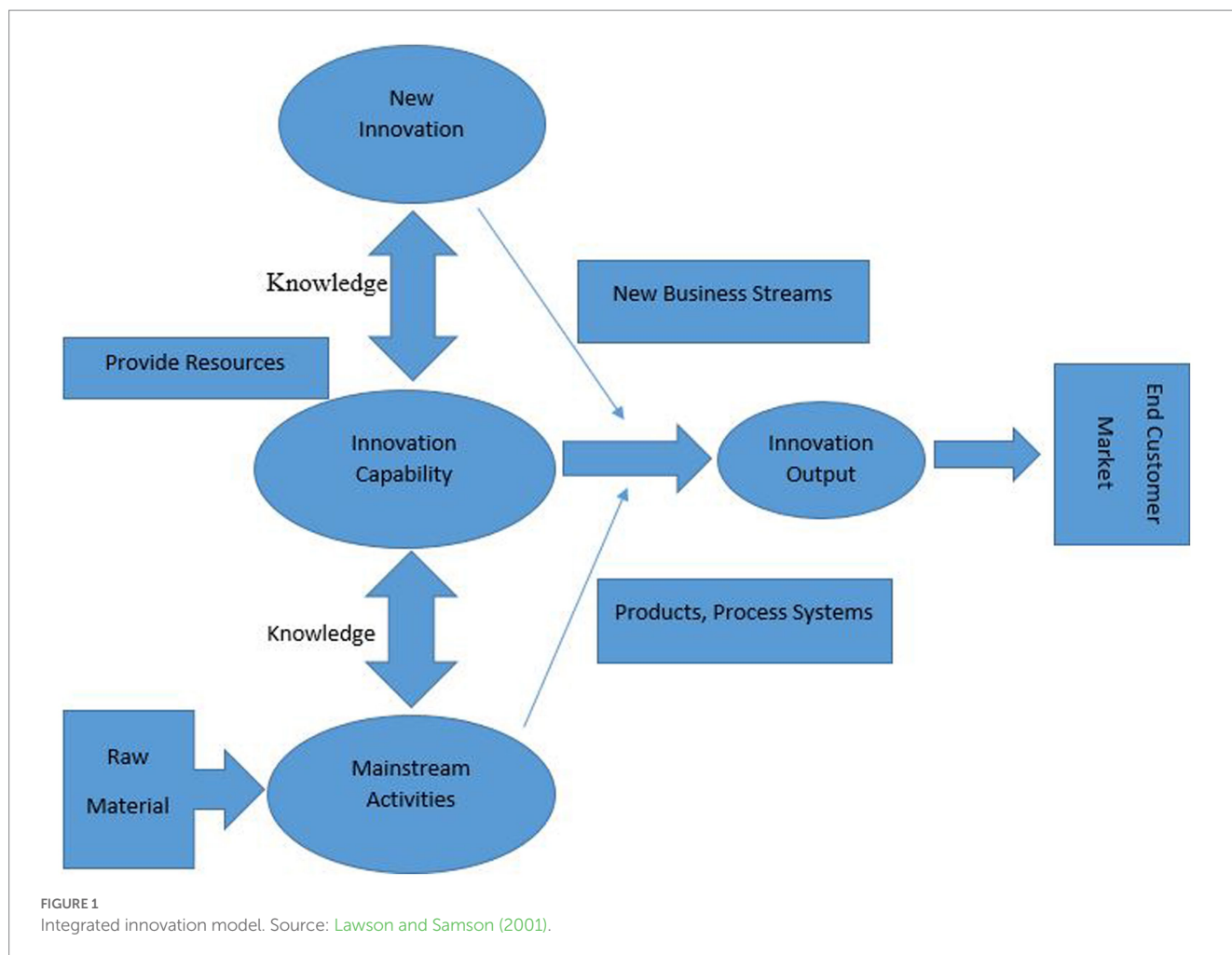
The capacity to maintain or improve living circumstances without endangering or depleting natural resources for current and future generations is what Goffman (2005) defines as sustainability. As a result, "sustainable food" might be defined as the development, production, distribution, and consumption of ecologically conscious food items. It is critical to remember that sustainability encompasses the entire food chain, not only organic food and formal farmers' markets. Sustainable foods refer to foods that are produced or farmed in such a manner that their adverse impact on the environment and the communities that generate them is minimized.

For Africa, innovation in sustainable food should take the form of a process in which smallholder food producers, in addition to bringing new or existing products and processes, incorporate the elements of resilience to shocks or environmental sustainability while considering food security and nutrition, economic development, or sustainable natural resource management (FAO, 2019). For Africa, the discourse on innovation in sustainable food is multidimensional and complex because its effectiveness is reliant on a variety of variables such as social, cultural, religious, and environmental connotations.

## Innovation in sustainable food from a global perspective

The food sector plays a significant part in the present-day discourse of the 2030 Agenda for Sustainable Development (FAO, 2023) and directly supports several SDGs, including SDG12 ("Responsible consumption and production"). These SDGs also include SDG2 ("Zero Hunger"), and SDG3 ("Good Health and Well-Being"). In developed nations, the system for farming and food production has undergone gradual shifts and is currently going through rapid transformations. Until late, advances in technology in food industry have profoundly completely transformed the entirety of agri-food production and supply chain networks. This is on the backdrop that the African continent has struggled to make gains in this respect owing of diverse constraints and this are sociocultural, economic and environmental in scope. The trends in innovation in sustainable food in developed countries has been rapid due to advancement in science and technology. In order to make food less hazardous, more nourishing, or more appealing, innovative methods of production, processing, or packaging have emerged in the sustainable food industry. With food innovation, industrialized countries have pioneered and commercialized novel food products, processes, and services.

A key vital approach to answering sustainability components and evolution in the agri-food sector system may be the deliberate application of innovation in food. This approach could serve as inspiration for the growth of agriculture in a way that is easily accessible, resilient, and environmentally friendly while the world's population keeps increasing. Valoppi et al. (2021) assert that the capacities of the planet to reabsorb its endowment and responsibly generate food are steadily eroding, and as a result, it will need novel food systems in order to feed the existing and future populations of the world because bioresources required for production are vanishing by 2050, when the projected population will exceed 97 billion. Global food security will be a major issue (Berners-Lee et al., 2018).



One of the first objectives of working toward food security is to mitigate the loss and disposal of food (Kuiper and Cui, 2021; Santeramo, 2021). The FAO anticipates that 13 billion tons of agricultural produce will be lost or wasted right through the food chain each year, from production to sales at retailers and by consumers. Wieben (2017) emphasizes the relevance of innovation in sustainable food with the increase in global population, which is anticipated to reach 97 billion people by 2050. Van Dijk et al. (2021) predict that the demand for food is likely to continue to rise, factoring in climate change.

Investigations by scientists have come up with innovative methods in the last few decades to mitigate food loss and waste and enhance sustainable food production and provision. Identify new ingredients, create new food frameworks, and digitize the food system (Dalkas and Euston, 2020; Siegrist and Hartmann, 2020; Zampollo, 2020). Unlike developing countries, a lot has been achieved in terms of innovation in sustainable food in developed countries, which has occurred simultaneously with science and technological advancement (Gholamipour-Shirazi et al., 2020; Hirvonen et al., 2020; Roos, 2020; Torres-Tiji et al., 2020; Zarbà et al., 2020). Because of current scientific and technological advances, this treatment may be completed successfully. Partners are employed in the food business, looking for new and inventive ways to supply customers with attractive, cost-effective, and nutrient-rich goods as well as

ecologically responsible institutional equipment procedures, supplies, processing, and packing goods that have recently seen a significant transformation thanks to innovation approaching decades. Improvements in sustainable methods of food production are possible to predict.

With the aid of new technology and other advancements, tried-and-true processing techniques are making a comeback in the modern food sector. With the rising popularity of fermented foods and beverages, one approach in particular has experienced a significant comeback: precise temperature controls. Cutting-edge analytical tools and other equipment Technology has now made large-batch fermentation even safer and simpler, enabling it to safely satisfy the rising demand for these goods. In order to produce, prepare, or package food in a way that is safer, healthier, more nourishing, or tastier, science and technology are utilized to create innovative methods of doing so. Innovation in the food industry is crucial to addressing social issues, including how to assure a sustainable but abundant supply of food. The core principles of food innovation in nations with advanced economies have emerged in an assortment of ways and have been utilized to provide inventive and ecologically conscious food solutions. The industry of food innovation is always being produced, striving for invention, preparation, and distribution. As a result of technology and science, innovation has occasionally made it possible to create totally new food categories. We can access

fresh, nutritious foods through the combination of novel components and manufacturing approaches.

Today, it is feasible to purposefully generate extremely small-scale matter, and nanotechnology can help change the nutritional value of food and animal feed. [Ashfaq et al. \(2022\)](#) state that foods that include nanoparticles as well as packaging materials of a very minuscule size must be labeled in order to alert consumers to their existence. [Rothen-Rutishauser et al. \(2021\)](#) describe a substance with several uses. Titanium dioxide (TiO<sub>2</sub>) is frequently employed as a cosmetic or food additive. Its widespread use, particularly in nanoscale items, raises questions regarding its safety. According to [Katrin et al. \(2022\)](#), packaging is vital in order to guarantee that food reaches its destination in a perfect state from the point where it was produced to the point of consumption, despite the fact that the vast majority of modern-day food supply chains have always used throw-away packaging material. Environmental concerns pertaining to packaging waste have gotten much worse over the past several decades. The authors present an overview of contemporary packaging innovations and developments that tackle the expectations of the bioeconomy, the circular economy, and digitalization, in addition to summarizing the obstacles to the creation of more environmentally friendly food packaging.

The opinions of consumers are changing as a consequence of the latest progress in combating climate change, and they are now putting pressure on industry to make some green improvements in quality. A type of nano-packaging employs microbial alterations in either physically or chemically the food item's safety quality, and if it will shortly become compromised, it may all be assessed via nano that goes into the packaging, examining manipulation of individual atoms and molecules to limit the use of pharmaceuticals in animals, which might assist in avoiding the emergence of resistance to antibiotics both in animals and in people ([RIKILT & Joint Research Centre, 2014](#); [Huang et al., 2015](#)).

The creation of unique foods and advancements in processing and packaging made possible through innovation have benefited consumers ([Ashfaq et al., 2022](#)). Functional foods that include bioactives are gaining popularity as an alternative to traditional pharmaceuticals since they are more affordable, safe, and accessible. [Chatterjee et al. \(2013\)](#), [Olaiya et al. \(2016\)](#), and [Konstantinidi and Koutelidakis \(2019\)](#) modern advances highlight the application of artificial intelligence in food production. [Mavani et al. \(2022\)](#), in response to consumer requests for healthier food alternatives, devised ecologically conscious alternative food options.

Food innovation should be based on eco-friendly, low-input technologies. This scenario will translate to low prices, and innovations should create new supplies in a responsible way, hence replacing traditional foods with novel food products that are starting to appear, resulting in embedded specialized words. These alternative food alternatives fall under this category, including sluggish food motion, locally sourced organics devoid of pesticides, and natural One example of how food innovation boosts output and efficiency is the management of food safety using AI. Worries about food safety and security have also increased ([Vågsholm et al., 2020](#)). Innovative advances in food safety, packaging, and processing ingredient research are laid out by [Mishra et al. \(2020\)](#) in their most recent book. Their predictions are that the globe will have to deal with the task of feeding an estimated 9 billion people by the year 2050. Innovations in food research are crucial in order to tackle that issue. A focus was placed

on the possible health advantages of different supplements, the bio-absorption of metals and their beneficial effects on biological systems, as well as decreasing the loss of food's nutritional value.

[Hassoun et al. \(2023\)](#) highlight the idea of food processing 4.0 as a leading example of innovation in sustainable food. This term refers to the way that food is processed in the modern digital era using industry 4.0 technologies to increase the nutritional value and safety of processed foods. Cut production costs and time, manage energy and resources sustainably, and reduce food loss and waste in the industry. 40 technologies have attracted a lot of interest recently and have transformed a number of industrial industries, including the field of food processing.

In the work of [Husain et al. \(2021\)](#), AI could possibly substantially enhance packaging, extend the lifespan of foods, integrate foodstuffs, and further enhance food safety through the development of a more open method for managing a supply chain. The food sector relies solely on drones. Robotic farming and smart farming as a result of AI and ML Therefore, securing global food security could be contingent on our ability to properly understand the magnitude and relevance of AI in the farming and food sectors. The main objective of this project is to develop an AI methodology for reviewing and enhancing initiatives for the food industry's commitment to food quality and safety. AI provides an efficient solution to improve food quality. The technology, when implemented, makes the task so simple and sustainable ([Spanaki et al., 2021](#)).

Non-thermal technologies are advancements in food processing methods that have little to no impact on the sensory qualities and key nutrients of food items ([Jadhav et al., 2021](#)). Non-thermal technologies that have been tested in the food sector include high hydrostatic pressure, pulsed electric fields, ultrasound, and cold plasma ([Pizarro-Oteiza et al., 2020](#); [Thirumdas et al., 2020](#)). It is now possible to employ non-thermal technologies to partially or entirely replace the well-known and widely used traditional food processing and preservation techniques ([Hassoun et al., 2020](#); [Denoya et al., 2021](#); [Echegary et al., 2022](#); [Sruthi et al., 2022](#)).

The fundamentals of culinary innovation in developed nations have emerged in a variety of ways and have been utilized to provide inventive and environmentally friendly food substitutes ([Harrington and Ottenbacher, 2013](#)). The food industry is continuously striving for new inventive methods to produce, prepare, and distribute food as a result of scientific and technological advancements. Food creativity has occasionally made it possible to produce brand-new food categories. We can get access to new food products by combining new components and manufacturing techniques. The goal of contemporary innovation is to improve the nutritional value of food by adding additional macro- and micronutrients while still maintaining food security and safety. Not all food manufacturing and processing techniques are environmentally friendly; however, owing to advances in food technology, currently produced food procedures are becoming more environmentally sensitive. Putting more emphasis on sustainability requires protecting the environment and ensuring that food production will be possible for many years to come. Modern food innovation focuses on increasing productivity and reducing expenses, which lowers prices for customers.

[Valoppi et al. \(2021\)](#) gave an overview of the entire process of food design, employing innovative approaches to tackle issues that support the food industry's digitization. Utilization of new ideas in blockchain, cutting-edge aerial reality, AI, and virtual reality. Ingenuity in the food



industry only intensifies as technological advancements proceed. The focus is on cutting-edge technologies for the coming years, such as cutting-edge food products that offer sustainable options for our growing population. As the world population continues to increase, global food innovation is getting more attention. Long-term health is a significant issue that is being addressed in the creation of sustainable food by reducing food loss and waste, promoting effective resource use, and slowing the loss of biodiversity. The circular economy, or one that integrates seamlessly into the food chain, offers answers for the need for global food sustainability (Jurgilevich et al., 2016).

In an effort to boost nutrition, the circular economy's resilience reduces food waste while promoting efficient resource use. Additionally, it can halt the extinction of biodiversity. According to Jurgilevich et al. (2016), food loss and waste are often characterized by a decline in food supply chain efficiency, quantity, or quality. Only a few instances of how the FAO (2019) defines food loss along the whole supply chain include the harvest, slaughter, and sale procedures. On the other side, there is food waste at the consumer and retail levels. There is a great deal of disagreement over what constitutes food, but based on the FAO's definition, foods that are used to make animal feed and non-edible accessories like bones, feathers, and peel are not regarded as spoiled or lost food. A reduction in garbage loss and waste will ensure that the world's sustainable provision of food is made possible by innovative sustainable techniques.

Poor nations place much focus on food safety and adequate nutrition in foods, both in terms of macro- and micronutrients, while moderately and upper-income nations place the greatest priority on minimizing the risk of chronic illness in addition to functional and ecologically sound foods (Cencic and Chingwaru, 2010; Govindaraj, 2015; Azaïs-Braesco et al., 2017). The idea of food has evolved from the correct amount of nutrients that are necessary for survival on a daily basis (Floros et al., 2010) to a tool for mitigating diseases that are associated with nutrition, such as non-communicable illnesses such as type 2 diabetes, coronary conditions, obesity, and cancer, for bettering human mental and physical well-being. Siró et al. (2008), and to slow down getting older. Rockenfeller and Madeo (2010) argue that the needs and preferences that consumers have should be considered seriously, whereas, designing novel food products notwithstanding, access to novel and improved nutritious foods with extra benefits could potentially be hampered by individual financial status beyond the borders of a nation.

## Innovation in sustainable food from an African perspective

The population of Africa is expected to increase from an estimated 118 million people at the beginning of the 20th century to 788.5 million people in 1997 and 1.5 billion people by 2025 (UNPN, 1996; UNER, 1999). By 2025, 60% of the population is expected to be hungry in the region (Nana-Sinkam, 1995; FAO, 1996). The rapid growth is less of an issue than the lack of the region's economic expansion to keep pace with population growth. After all, Africa still has a massive undeveloped natural resource base and agricultural potential. Africa requires answers to the problem of food insecurity, which the rising population will make worse.

The continent needs to increase agricultural output while reducing food losses and waste in the agricultural value chain (Sengupta and

Hari, 2023) to meet demand for food for the growing population. In order to solve food insecurity, Africa must manage its agricultural and food systems in a sustainable manner in terms of innovation in sustainable food. Hence the food waste and losses that occur at all levels and along the whole agricultural value chain, thus they must be reduced. According to preliminary estimates, up to 1.3 billion tonnes of food are lost or wasted each year (FAO, 2011a), which is equal to 24% of all food calories generated for human consumption (Lipinski et al., 2013). The complete value chain is represented by these sums. Of these, farm-related, storage-related, and handling losses total more than 520 million tonnes, or close to 8% of all food calories produced. Poorer nations experience particularly substantial losses on the farm and during storage, which surpass 1 billion tonnes, or approximately 12% of all the calories generated in Africa.

Sustainable food innovation falls within the category of innovation for agricultural systems, which lately has been concentrated mainly on production with the aim of transforming agricultural practices and rural economies across Africa. Agriculture innovations are new inputs, the machines and methods that are used in agriculture production processes in order to increase production, yield or quality (Akkoyunlu, 2013). Therefore, the purpose of innovations in agriculture in Africa is increasing the food production, and in recent time, the production of safe food, too. African perspectives on agricultural innovation are mostly seen as a part of agricultural advances aimed at improving food production and, more lately, at producing safe food (Ehui, 2019). It is accurate to say that, despite recent initiatives to boost investment, Africa continues to produce insufficient amounts of food and value-added goods, and that, as the 2018 African Agriculture Status Report demonstrates, agricultural output has mostly stagnated since the 1980s.

Agricultural food innovation is a spring board to economic growth and might assist in utilizing natural resources more sustainably and effectively, hence reducing hunger and poverty (Aerni et al., 2015). Even though the effects of adopting agricultural innovations have been the focus of in-depth research, the link between these metrics of farm output and household wellbeing in sub-Saharan Africa is still unclear (Ogundari and Bolarinwa, 2018). Africa has two huge possibilities to modify and strengthen its agriculture economy. First of all, new, crucial tools for boosting sustainable agriculture are provided to African countries by advances in science and technology. Second, measures to create regional markets will provide extra incentives for agriculture marketing and production. This is the primary objective of the Agricultural Innovations in Africa (AIA) program (The New Harvest, 2009). In-depth research has been done on the factors influencing adoption as well as the impact of technology adoption on recipients' wellbeing (Justice and Tobias, 2016; Kekonnen, 2017; Ayenew et al., 2020).

Small farmers' productivity can be improved through simple agriculture and food innovation, which on the other hand reduce environmental impact. Hence this entails enhancing the profitability of agriculture while increasing its sustainability. Scientific developments in agroecology, genetics, and biotechnology are in favor of this theory. While there are many jobs that may be accomplished using the knowledge currently accessible, whether it comes from outside sources or indigenous sources, innovations are required due to the challenges presented by the natural environment. According to Juma et al. (2013), it is predicted that African agriculture would become more intensive, increasing food output by 80% to meet

demand. In order to produce high-quality goods while maintaining production resources (sustainable intensification), continental agricultural advances should entail a shift from purely exploiting natural resources to technical innovation (Boskovic et al., 2012). With the intention of improving farmer standards and expanding production options, agriculture and agricultural science and technology are actual issues and centered on innovation and the concept of innovation systems. The history of agricultural innovation and research, however, suggests that this process is relatively sluggish (Hall, 2007).

Undoubtedly, it has been predicted that climate change (drought and other natural catastrophes) would significantly lower agricultural productivity, which will further motivate efforts to implement innovative technology (Alarcón and Bodourogrou, 2011). The fact that over 900 million people are underweight, with the great majority living in developing nations (98%) highlights the importance of using cutting-edge technology in such nations' agriculture. Agricultural innovations result in increasing the production of almost all crops, as well as the growth of yield in livestock production. In the study by Mapila et al. (2011), after innovation the technology of production, significantly higher total income of examined crops for \$812.34 is achieved in 2008, comparing to 2007. Even though agricultural biotechnology is embedded in seeds and may be particularly useful for addressing the agronomic and environmental issues in less developed areas, relatively little effort is put into research in this area in developing nations (Graff et al., 2003).

Poor nations have the potential to innovate their production technologies in agriculture, but they are mainly dependent on modern technologies from the developed countries. Principally, Africa should address issues to do with their educational systems, science and technology, institutions, increase financial and human investments for establishing local technological possibilities and learn from the experience of other innovative regions. Although the continent has achieved significant progress in agricultural innovations, such as post-harvest technologies this is still not satisfactory and more attention should be given to smallholder farming sector which is the backbone of food production (Bjornlund et al., 2020). One of the potential explanations for the lackluster impact of implementing agricultural innovations in sub-Saharan Africa is the absence of efforts to create and spread an integrated package of new and beneficial technology that includes enhanced management practice, according to Otsuka and Muraoka (2017). Agricultural growth can reduce the poverty in developing countries, through stronger role of the research and generating the knowledge, which will result in innovation (Asenso-Okyere and Braun, 2009). In agriculture, innovations include new knowledge or technologies related to primary production, processing and commercialization, which leads to the growth of productivity, competitiveness and living standards of farmers and other (Boskovic et al., 2010).

Over the past few decades, postharvest technology has made considerable strides, and as a result, a variety of useful technologies have been developed in many nations, including a number of poor nations in Africa. The innovations in sustainable food that are taking place in Africa are continually changing, but they have not been well studied and recorded (Zwane, 2020). Post-harvest food technology is one area of sustainable food innovation that has advanced. Inadequate food production pipeline inefficiencies that result in food waste and have a substantial negative impact on the environment, productivity,

and the availability of food may be resolved by post-harvest technologies that are appropriate (Kitinoja et al., 2011). The edible components of plants and animals raised for human consumption that are eventually not consumed by the population are referred to as food losses and waste. They signify a decline in the quantity, quality, or nutritional content of food meant for human consumption (FAO, 2011b).

African scientists have emphasized the need for local governments and continental organizations to adopt effective policies and technology-driven interventions to reduce post-harvest losses stifling food security in the region (AATE, 2021). Post-harvest technologies play a critical role in innovation in sustainable food, and this need has been expressed by African experts (AATE, 2021). Africa needs policies and technology to increase food security since it cannot afford post-harvest losses. Scaling up both conventional and contemporary post-harvest management strategies is essential, and the use of agricultural biotechnology may completely alter the scenario by reducing post-harvest losses. Africanized and appropriate food solutions and opportunities can be innovated? However, it should be acknowledged that since time immemorial despite not being documented and possibly having little monetary value, food innovation ideas still make these people's lives better in poor agrarian communities in Africa.

In terms of basic food production, the rural population, which is mostly found in less developed nations, has enormous resources. They also predominantly inherit sound agricultural practices that have been passed down through the years among family members and neighbors. The usage of resources, however, is lower than we could reasonably anticipate (Boskovic et al., 2013), as a result of the low level of knowledge that follows new technologies, contemporary trends, and breakthroughs in this field. Due to the increased efficiency of the use of natural potential in the primary production sector, any innovation that is made in this regard would be of utmost importance. According to AATF (2021) a broad range of methods are available, from the simple (direct sun-drying) to the industrial (medium and large-scale facilities or factories to process and add value to agricultural products) to the latter. To fulfill demand, it is necessary to create and scale up locally produced, cheap technology. This has a substantial positive impact on nutrition and societal development while also increasing the management and quality of food crops.

Rural population, which is mainly in less developed countries, possesses huge resources in domain of primary food production, as well as mainly good inherited agricultural practice, which have been transferred for generations within the family and neighbors. However, the level of knowledge, which follows new technologies, modern trends and innovations in this area, is still weak, therefore, the utilization of resources is less than we should expect it realistically (Boskovic et al., 2013). Thus, every innovation, directed in the said direction, would be of great importance, especially those, which refer to innovation the knowledge, due to more efficient utilization of natural potential in the primary production sector. At the local level, resource-constrained rural African communities are setting the standard for effective, cutting-edge sustainable food practices, which is particularly true. The degree of innovation in sustainable food is influenced by a number of societal, economic, and environmental factors. Climate change, gender, indigenous knowledge systems, culture, and traditional food commodities are just a few of the sociocultural, economic, and environmental aspects that have an impact. Herrero et al. (2021) suggest that elements' impact on the level

of innovation in sustainable food is complex since they interact and do not have a simple effect.

For Africa innovation in sustainable food is taking place at the village level in all facets of life, including new food products, processes, and food services (Badiane et al., 2022). Value should be added to local/traditional foods produce through local models and products (Materia et al., 2021). The African approach to innovation in sustainable food may be different from that of the developed world, despite the fact that it entails the creation of novel food processes, food products, and food services. The fact is not just bridging the gap between Africa and more developed countries so that Africa can develop sustainable food innovation for its people. But it is all that innovation in sustainable food should contextualize the socio-cultural, economic, and environmental ramifications for African sustainable food systems. Unintended innovation in suitable food might disrupt the African food systems landscape which might be catastrophic for Africa if this happens. The argument for a different perspective on innovation in sustainable food in Africa is that the resource poor smallholder farmers drive food production and are also the major players in food supply chain thus we must focus our efforts on innovation in sustainable food which are acceptable in this sector (Zwane, 2020). On the other hand, African food production and supply is gendered, hence this must not have overlooked whenever discussing innovation in sustainable food. The presumption is that smallholder farmers who are the major food producers and suppliers should be the cogent of innovation in sustainable food if it is to have an impact on continental benefits such as nutritious food, healthy products, and secure products.

Traditional knowledge in addition to other socio-cultural and economic and environmental factors peculiar to African may influence the form of innovation in sustainable food, particularly in rural communities. According to Chigudu and Toerien (2018), the cultural diversity of Africa is exemplified by the region's distinctive traditional food, which are occasionally impacted by agro ecological variables. African countries stand out for the diversity of their social structures and regularly experience challenging socioeconomic and demographic conditions. Kittler et al. (2012) urges that food culture is characterized as the traditions, customs, behaviors, cultural beliefs, ideals, habits, conventions, and norms associated with producing, preparing, procuring, cooking, consuming, serving, and celebrating food. The distinctive nature of continental cultural diversity will have a particular impact on innovation in sustainable food. It is reasonably to suggest this differentiated nature of cultural diverse will also influence innovation in sustainable food in a different way. It is crucial to highlight that because much of Africa's food value chain is informal, the African food business is not very sophisticated, as smallholder farmers tend to take the lion's share of food services. The goal of this discussion is to examine some of the proponents who may have an impact on African innovation in sustainable food.

The diversity of food cultures on the continent and possibly even religion have an impact on the foods that people eat hence influencing innovation in sustainable food. The configuration of agro-ecological zones determines the food commodities produced, and thus the nature of innovation in sustainable food. When it comes to food, culture, or legacy, Africa, in particular, has enormous potential to derive differentiated innovation in sustainable food. Rural Africa is undoubtedly experiencing a rapid rise in food innovation at the moment, if the definition of food innovation is the development and

commoditization of alternative food products, processes, and services. The goal of this discussion is to examine some of the proponents who may have an impact on African innovation in sustainable food. The more likely drivers of innovation in sustainable food in Africa are, but are not limited to, the following: climate stressors that have impinged on the value chain of food systems, food prices, and the high rate of orphaned traditional crops. African innovation in sustainable food will not take the form of the industrialized countries food pathways.

According to Goffman (2005), sustainability is "the ability to maintain or increase living conditions without harming or depleting natural resources for present and future generations." Survival, resiliency, and efficiency are aspects of "sustainability," in addition to the environmental, economic, and social factors that contribute to sustainability. As a result, "sustainable food" might be defined as the development, production, distribution, and consumption of ecologically conscious food items. It is critical to remember that sustainability encompasses the entire food chain, not only organic food and formal farmers' markets. Sustainable food offers societal benefits such as nutritious food and healthy, secure products these proponents may be described in a different context for Africa and developed nations. Sustainable consumption and production by smallholder food producers is a practical way to achieve a sustainable status through innovative food that addresses rural communities as well as the environment targeted on the traditional food production systems and consumption patterns.

Climate-smart food production practices and conscientious food consumption could reduce rural communities' environmental impact and improve their quality of life. Food, production, and how it is transported from the point of production to the point of consumption are some of the activities in the household sector that have the greatest environmental impact in the food value chain. Food production is inextricably linked to the usage of water and land, and agriculture accounts for the majority of the environmental effects of the food production and consumption chain. Non climate smart the usage of water and land, and agriculture have dire consequences on the environment however seems the organic form of small scale farming practices if maintained may rescue the environment. The problem is that modern agriculture has imposed non-environmental friendly farming practices on small scale farming in Africa, that focus on too much reliant on chemicals and pesticides and other soil additives that have damaged the environment contributing to degraded lands which are non-productive.

Rural households continue to value the pursuit of farming activities and that subsistence production is important to improve household food security (Baiphethi and Jacobs, 2009). Much of the attention on food innovations should be given to this sector. According to Godfray et al. (2010), there is a chance for enhanced technology for small-scale food storage in a network of small-scale dealers, millers, and farmers. Agro-processing for sustaining smallholder farmers (SHFs) can add value and improve SHFs' quality of life, according to Mahlogedi and Thindisa (2014). However, they also note that this would require enough human and social capital from the SHF. In Africa, the greatest easily available path to food security is local and subsistence food production innovations. Due to resource constraints, Africa's smallholder farmers lack technology in terms of picking the appropriate recyclable package, the ability to buy as few food packages as feasible, recyclable bags, and consumer safety and information. All of this is in addition to global plans such as: agro-environmental



policies have an impact on sustainable food innovation. Innovation in sustainable food for African smallholder food producers should encompass the development alternatives to local food and other energy and resource-intensive foods, as well as creating more sustainable food production processes. Food processing, packing, and storage, as well as transportation and waste disposal, are all environmental concerns (Tiwari and Khawas, 2021). Hence, improving community behavior in food consumption planning, expanding organically produced foods, and controlling the use of pesticides and toxic chemicals are crucial for Africa's innovation in sustainable food.

Prodanović and Bokovi (2017) observed that the primary obstacles to innovation in underdeveloped nations include bureaucratic hurdles, start-up expenses, a lack of skills, finance, and bad regulations. The primary cause of hunger in Africa is rural poverty, not food shortages, and without a radical transformation which encompasses innovation in sustainable food, Africa will never be able to afford more food for the growing population. Sadly, focusing on supply has not led to effective responses to many of the complex and linked problems that Africa's food system challenges. Too often, such efforts smack of a kind of "if farmers grow it, consumers will buy it" reasoning that does not deliver useful results in the long run. We've been studying Africa's food systems for over a decade, and our studies show that a shift in focus is essential especially to also give emphasis on what happens to the food when it is produced.

It is well acknowledged that the development of agriculture depends on the accessibility and uptake of relevant novel technology. Through a better role for research and information generation, which will lead to innovation, sustainable food methods can assist agricultural expansion, reducing food shortages and poverty in Africa (Asenso-Okyere and Braun, 2009). The impact that genetically modified organisms could have on the poor in emerging countries. The debate and hostility that these studies have sparked makes it common to overlook viable alternatives that can help accomplish some of the aforementioned goals of food safety and environmental sustainability (Prasad, 2007).

## Indigenous knowledge and innovation in sustainable food in Africa

Indigenous knowledge, according to Matsika (2012), is existing traditional and local knowledge that has developed as a result of the experiences of the local community in coping with situations or contexts that constitute a threat to the people's daily lives. According to Warren (1991), information that is exclusive to a certain culture, society, or ethnic group. It is often localized as a result of long-standing management and conservation approaches for biological resources that are crucial to society. As a result, it is a complex collection of knowledge, skills, and technology that is specific to a certain region (Ndangwa, 2007). This research lends credence to the premise that indigenous knowledge is data that locals in a certain location possess that is not part of the established scientific community (Otto, 2008).

Indigenous knowledge has the potential to be used in innovation for sustainable research and development in Africa. Indigenous knowledge-derived innovation in sustainable food among rural African communities results in the long-term prosperity of smallholder food systems. This provides a concrete means of putting

African food producers in charge of their own ideas in sustainable food future programs. In African food systems, indigenous innovations such as those in sustainable food are more likely to be driven by traditional knowledge systems. As a result, traditional knowledge becomes critical for any innovations related to sustainable food in order to achieve cumulative growth, both economically and socially.

White House Office of Science and Technology Policy (OSTP) and Council on Environmental Quality (CEQ) released the first-ever Guidance for Federal Departments and Agencies on Indigenous Knowledge at the White House Tribal Nations Summit (2022) to quote "Had our traditional cultural practices and ceremony not been outlawed and had our information keepers been listened to over the centuries, we probably would not find ourselves in the position we are today – with the losses and extinction and contamination we face as our global community. This is a valuable component of being able to face not only climate change but the preservation and protection of all of our resources (OSTP and CEQ, 2022)." Indigenous knowledge spans a wide range of topics, including unique food features and attributes, the availability of resources in food production, their management and usage, and their methods of food processing or altering them for sale/use in food systems. Traditional knowledge is the foundation for rural communities' eucharis and balance with their environment, which includes food production, supply, and consumption. As a result, any assessment into how indigenous food systems differ from industrial economies and how we may use these concepts to build sustainability within the food systems of rural communities is crucial for innovation in sustainable food methods.

The progression of sustainable food innovation can contribute to the much-needed compassionate understanding and integrated vision required to connect and consolidate the diverse efforts toward food production and supply, resulting in a positive outcome for food systems. Remarkable indigenous food innovations would be developed that could be transformed into marketable products, thereby enhancing household food welfare and even revenue. They could provide a substantial impact for Africa's rural agrarian economies as they transition towards an innovation-driven sub-economy.

Most frequently, a lack of respect for traditional knowledge has resulted in innovations in sustainable food interventions that are externally motivated, resulting in an attempt at unsustainable development in this subject. Indigenous knowledge is information accumulated by a group of individuals who have lived somewhere for a long time (Trung et al., 2007). Communities have developed a wide range of skills, perspectives, and behaviors to take advantage of and protect biological diversity and food systems (Davis, 1998). The indigenous knowledge of biodiversity, conventional ways of life, inventions, practices, and procedures, in addition to knowledge, skills, and inventions can be exploited for innovation in sustainable food.

Africa has maintained its own historic territorial food management techniques and the food systems that have fed them for millennia while preserving the preponderance of the planet's existing terrestrial biodiversity. The concept of inclusive innovation has become widely embraced in the agricultural domain and promises to overcome traditional innovation paradigms by emphasizing more balanced, sustainable, and just human-environmental relations. Indigenous and local knowledge play an increasingly important role in debates about inclusive innovation, highlighting the diversity of relevant actors and marginalized perspectives. At the same time, the



positioning of indigenous and local knowledge in innovation processes remains ambiguous and contested.

We assert that better archiving, greater understanding, and political endorsement of indigenous knowledge can promote the reorganization of food systems and, thus, innovation in sustainable food. Food innovation that disregards traditional knowledge systems is likely to be unsustainable, while ignoring local responses to local food problems may be costly for rural communities, which are typically resource constrained. Indigenous knowledge of the environment, resource utilization, and conservation should be fully respected in order to promote innovation in sustainable food.

Africa can build on the strengths of its indigenous knowledge systems related to food for innovation in sustainable food as part of the SDGs. The successful exploitation, promotion, or usage of African indigenous knowledge to spur innovation in sustainable food has enormous potential for resolving some of Africa's interconnected development challenges outlined in the SDGs. There are some documented success stories of traditional knowledge and practices in their utility and significance in strategic sectors across the continent, such as resource management, biodiversity conservation, etc., among others for sustainable development. Therefore, their role in innovation in sustainable food might not be an exception.

Traditional knowledge has the ability to transform food systems and dispel the myth that it has not contributed much to knowledge, history, or civilization. It can act as a conduit for sustainable food innovation. It is also intended to stimulate academic debate and study on the best ways to make traditional knowledge and practices more scientific and value-free in innovation for sustainable food. Indigenous food systems, according to [Vijayan et al. \(2022\)](#), guarantee ecological and socioeconomic sustainability but are overlooked in science and policy. They concluded that better documentation, deeper understanding, and legislative recognition of indigenous knowledge can contribute to the transformation of food systems, hence spurring innovation in sustainable food.

Indigenous knowledge systems support heritage food systems, and their innovations, based on millennia of collected wisdom, are not only critical for food security and food sovereignty but also for cultural identity, spiritual well-being, and land stewardship, resulting in sustainable food innovation. Indigenous knowledge drives the local food systems, which are centered on several generations of thought with the goal of ensuring future food security and innovation. They not only support locally adapted indigenous and traditional foods (livestock and crops), but also wild foods and crop and livestock wildlife collection that they employ to supplement their domesticated agricultural crop and livestock products.

Farmers who have few resources rely significantly on traditional knowledge to manage their land wisely and use the variety of crop and livestock genetic resources that are available at the local level ([Pretty, 1995](#)). As a result, farmers have gained a deep understanding of the advantages and applications of specific plants and animals, which is crucial for innovation in sustainable food. Farmers have also accumulated local knowledge on the particular crop or animal husbandry. Through testing, seed preservation, and informal network exchange, they have historically been the managers of agricultural and livestock germplasm and its diversity for generations. Their specialized understanding of the benefits and various applications of plants and animals for food security, health, and nutrition, as well as their passion for food innovation, are extremely important.

Understanding indigenous knowledge discloses significant ecosystem insights for the creation of alternate, self-sufficient, economically viable, ecologically sound, and socially just food production and supply systems to achieve food security and, thus, innovation in sustainable food in the resource-poor farming sector. Integration of traditional knowledge seems essential to addressing this irresolvable challenge of innovation in sustainable food. This is grounded in the belief that rural communities in Africa have consistently had a framework in place for exploring and promoting food innovation.

Nevertheless, the “missing piece” in rural innovation on food methods may deviate from the traditional “diffusion of inventions” idea, which may explain why indigenous creativity of this kind has not been widely acknowledged and used by development facilitators ([Matthews, 2016](#)). If we are able to comprehend the old system in Africa better, our perspective on how food innovations are spread may entirely change. More crucially, it has the ability to put into practice the notion of relying on farmer-led food innovation to spur long-term transformation in African food systems.

Instead of forcing externally driven innovation in sustainable food, let us have a farmer-led path to the future we desire for them. By doing so, the challenge of sustainable food innovation may be permanently solved, and a greater sense of ownership throughout the entire process may result. This will serve as the cornerstone for development organizations to collaborate with farmers in support of what they are already doing to recognize and promote their own sustainable food innovations, thus opening the door to the future of Africa as imagined innovation in sustainable food by local communities.

## Gender differentiate roles and equality for innovation in sustainable food

Gender equality is critical to ensuring sustainable food innovation in Africa. Women are generally charged with food production and preparation for their families and are involved in all stages and phases of food processing, which are crucial to innovation in sustainable food. Food production is primarily carried out by women in Africa, particularly where subsistence agriculture is prevalent, with little involvement from men ([Boserup, 1970](#)). Women comprise the largest percentage of the workforce in the agricultural sector but do not have access to and control over all land and productive resources ([Mugede, 2013](#)).

Cropping, harvesting, and threshing, as well as duties related to the preparation and marketing of food, are all jobs that women in agriculture perform. They also take care of small livestock ([Karl, 2009](#)). Across the board, women prepare food for their families and take part in all stages and procedures of the food processing process. Women were involved in post-harvest activities such as storage, processing, and marketing, according to the [SOFA Team and Doss \(2011\)](#); these activities may be connected to innovation in the creation of sustainable foods. On the other hand, 90% of the women worked in some capacity related to food processing ([Baba et al., 2015](#)). The food preparation methods outlined above are among those that can be targeted for innovation in sustainable food.

Since women make up a significant portion of the food production workforce, advances in sustainable food innovation may help advance

gender equality and all women's rights. It's possible that there are gender inequalities in the creation of sustainable food technologies. There are many ways that creating gendered perceptions of sustainable food innovation is possible. For instance, if the relationship between gender and food innovation is seen as mutually constitutive, society's norms and relations—which are influenced by environmental changes—will shape and organize food innovation.

Differentiated roles and responsibilities in the food production and supply value chain may influence the type of innovation in sustainable food along gender lines. We expect more innovation in sustainable food processing to be led by women because this is their domain. This means, on the one hand, that the types of food innovation utilized in various historical, political, and cultural settings, their design, and their meaning are generated within gender relations, and as a result, they reflect pre-existing gender inequalities as in the prescribed function and responsibility in food systems. On the other hand, by providing alternative tools and procedures for food production, supply chain innovations shape such gender interactions.

More than 60% of smallholder food production systems in Africa are managed by women, hence the food system in that continent is reportedly heavily slanted in favor of women (FAO, 2011a). This is a positive feature of riding on innovation in sustainable food. They play an important role in African agriculture, performing the majority of the work to produce, process, and market food (Anderson et al., 2021). They argue that in order to better address women's priorities and challenges, there is an urgent need to strengthen African women's voice in agricultural food systems as well as the development of innovation in the sustainable food agenda.

The innovative sustainable food agenda in African food systems needs to be driven by women. This will be done as part of an effort to address the triple challenges of providing food security and nutrition for a growing population, preserving the livelihoods of millions of rural poor people who labor in the food supply chain, and doing it in an environmentally sustainable way. Nevertheless, because sex-disaggregated data in innovation and sustainable food knowledge is lacking, these favorable synergies are frequently undetectable. Closing the knowledge gaps in gender and agriculture and food systems is a crucial step towards achieving this vision. Women, particularly in rural agrarian economies, play an important role in combating hunger and malnutrition and making food systems more productive and sustainable, and can thus contribute to the development of sustainable food innovation.

Gender-specific goals are set for innovation in sustainable food. The tasks and responsibilities of women in food systems, the barriers they confront, and how they can play a significant part in the transformation of food systems (crops and animal-related foods) have all attracted a lot of attention in recent decades. There is proof that improving food security and nutrition as well as creating just, resilient, and sustainable food systems for all will result from establishing gender equality and women's empowerment in food system innovations. This implies that innovation in sustainable food may be gendered as well; thus, innovation in sustainable food is the way in which people or communities introduce new or existing commodities, processes, or organizational ways for the first time in a specific situation in a bid to improve effectiveness, attractiveness, resilience to shocks, or environmental sustainability and thereby contribute to nutrition and food security, household welfare, or a sustainable use of household commodities. Women are key actors in every part of

innovation in sustainable food in Africa's food systems, as farmers, commodity processors, traders, and consumers.

The nutritional and financial well-being of women's families would be enhanced by mechanisms that allow them to produce more food, which would encourage them to engage in sustainable food innovation. To support women's food production, which will lay the groundwork for fostering innovation in sustainable food, there is a need for capacity building, technical assistance, and the promotion of gender-responsive approaches in food production and gender-sensitive agricultural policy. Ogunlela et al. (2009) make references to a few writers while highlighting the urgent need for an African agriculture and food production strategy that takes a gendered approach. This call is made because, despite the fact that women play a crucial role in the African agricultural sector, they have been largely overlooked by policymakers, who have done so at great expense to the continent's agriculture and gender equity.

Despite women being on the forefront of agriculture and food production and its allied processes, in most cases, they underrated in scientific and technical research institutions, which may result in derailing their contribution to innovations because women's distinct perspectives and food and farming needs (Wakhungu, 2010) in food systems are not taken into account. This is despite the fact that women are fundamental to and critical to African food production and supply chains. In agriculture, approximately 62 percent of women are engaged. Women do the majority of the work in food production, processing, and marketing. Women are significantly underrepresented in agricultural research and development when it comes to creating research agendas, determining priorities, decision-making, and leadership. It is important to remove gender-specific obstacles and opportunities that prevent the development of innovative, climate-resilient, and gender-responsive food systems. In their capacities as stakeholders in food production and supply, as food processors, and through household chores, women significantly contribute to the food economy.

## Climate change, climate smart agriculture, and innovation in sustainable food

Population growth and climate change are already putting strain on food security and production, but the long-term effects are anticipated to be much more profound. The Intergovernmental Panel on Climate Change (IPCC) Report states that it's possible that there will be fresh climate disturbances for decades or perhaps millennia to come (IPCC, 2007). These shocks will have an impact on many different ecosystem practices, especially food production. As a result, it's critical to sustainably retain and effectively preserve the food we produce. Due to climate change, there is a need for food innovation that addresses diversifying the food system, adopting sustainable diets, reducing food loss and waste, and creating more efficient methods of food production and processing.

Climate change, which has decreased food productivity, is especially affecting African food systems. So, on a continent where the climate is changing and becoming more unpredictable, innovation in sustainable food is essential. Africa's fragile food and agricultural systems have become a major cause for concern. Understanding the conceptual framework for sustainable food innovation that takes into

account the vulnerability of food systems and assessment from a systems viewpoint is essential with a view toward the transition strategy for innovation in sustainable food.

A vicious cycle of low food productivity, poverty, and poor food distribution and access increases the vulnerability of small-scale food producers, who primarily rely on rain-fed food production. This may exist due to the neglect of small farmers' food producers in the face of climate change challenges. These small-scale food producers, whose production is primarily for the local market and therefore essential for community food security and sustainable food, are suffering from a limited capacity for adaptation in the face of increasing instability in rainfall and temperatures, which is affecting their production and survival.

An African perspective that can examine how new food products, processes, and services might evolve and influence the system's capacity to fulfill social needs, particularly food and nutrition security in a changing climate. [Figure 1](#) attempts to showcase the social, cultural, economic, and environmental considerations in a conceptual framework for the discussion of innovation in sustainable food. In order to maximize Africa's potential for food production for the benefit of its expanding population, there is recognition of the need to mitigate the effects of climate change.

Due to the fragility and lack of resilience of its agricultural systems, the lack of food security, and nutritional issues, Africa needs to innovate in the field of sustainable food. The effects of climate change are being felt by vulnerable groups in both urban and rural Africa, underscoring the necessity of utilizing innovation in food sustainability on the continent. African food systems are fragile due to climate change, necessitating the development of innovative, sustainable food systems. The production, harvest, distribution, and consumption of food all fall under a wide range of responsibilities, so it is easy to see how climate change may affect each of these areas. Extreme weather will have an impact on the harvest and post-harvest losses due to the susceptibility of small-scale food producers, generating a shortage of some essential ingredients and affecting the local food chain.

Given the consequences of climate change on food systems in general, there is a need to instill shock resilience or environmental sustainability and thus contribute to nutrition and food security, household welfare, or the sustainable use of household commodities in resource-poor communities in Africa. Climate change has a greater impact on African food systems, which has led to low productivity. In a continent that is vulnerable due to an unpredictable changing climate, innovation in sustainable food is essential. The vulnerability of farming and food systems therefore becomes a major concern. It is crucial to explore the conceptual framework for food vulnerability analysis and assessment from a systems viewpoint with an eye toward the transition strategy for innovation in sustainable food. A.

African approach that can examine how new food products, processes, and services might grow and influence the system's capacity to fulfill social needs, particularly food and nutrition security in a changing climate. Social, cultural, economic, and environmental considerations are addressed in a conceptual framework for the discussion of innovation in sustainable food. In terms of food innovation and security, Africa is engaged in a livelihood struggle for its population, notably in the context of global warming and rising populations. The demand for corrections is now more pressing than ever.

According to [IIED \(2020\)](#), industrialized food and farming systems are essentially unsustainable. They account for over one-third of global greenhouse gas emissions and nearly 60% of global biodiversity loss. They are depleting the natural resources required to sustain agricultural output, such as water, soil, and genetic resources. Farmers in developing countries with limited resources are frequently labeled as "backward" or "unproductive," but research reveals that they are very productive, sustainable, and equitable. These systems protect biodiversity, offer healthy food, are climate resilient, and emit low carbon. Yet, it's not just about lowering risks; it's about thinking long term and managing the risks in its supply chain. Communities must defend their interests with regard to their food supplies in order to reduce the effects of climate change. What must therefore be done?

Small-scale food producers will be much less able to maintain nutrient-dense, nutritious, and safe food if they do not take early action to contribute to climate change mitigation through sustainable food innovation. When temperatures rise, there is a greater likelihood that fungus-produced compounds similar to aflatoxin as well as other dangers, including viruses, bacteria, and protozoa, will compromise food production and supply networks. Floods and other severe weather conditions are hampering supply chains, causing crops and post-harvest food products to decay and raising the possibility of food losses. To maintain the safety of the food system, communities routinely employ a wide range of distinctive food processes and procedures, and climate change may have an impact on these.

Climate change-related harvest shocks put local food supply networks to the test. As a result, some communities will depend more and more on food handouts, potentially rendering them more vulnerable to food shortages to feed their own growing populations. Such a mismatch raises risks for the local agricultural food supply network. It is essential that local governments promote sustainable innovation through proper policy frameworks that enable innovative food types or more sustainable production. Aside from the fact that climate change may cause food shortages, the risk assessment process should always prioritize food safety. But we may also look at the consequences of sustainable food innovation through the prism of environmental sustainability.

Building resilience and fostering innovation in sustainable food systems that not only meet the continent's demands for food and nutrition but also adapt to climate change is one option Africa may use to manage the overlapping dangers it confronts. The development of sustainable, resilient African food systems that can tackle the problems posed by the present and foreseeable crises through innovation in sustainable food requires community-based scientific research and innovation. Innovation in sustainable food can help mitigate the effects of climate change by improving how we produce, prepare, package, store, and consume food.

## Culture, traditional foods, and economics of food in innovation in sustainable food

Culture has influenced food for a very long time in the history of human civilization. There is an intercession of food, region, and culture. Traditional and indigenous foodstuffs are an important component of Africa's food system, but they are becoming increasingly marginalized and threatened as a result of massive dietary transitions,



rampant food imports, and significant migration throughout the continent. Regrettably, neither the food scientists nor the policymakers have created a conducive setting to promote innovation in sustainable food related to traditional and indigenous foodstuffs. Innovation in sustainable food focusing on traditional and indigenous foods will help influence ideas that can support positive food system transformation, particularly in changing climates in Africa. The population of Africa is diverse, reflecting a cosmopolitan, multi-ethnic society. Communities may have certain dietary habits and practices, and families may withhold or cook food in a particular way based on religious or cultural beliefs. As a result, reflecting cultural diversity and variance in the food produced and supplied in individual community settings is vital, as is innovation in sustainable food. This argues that respect for the contributions made by various cultures and nationalities to the range of food traditions enjoyed across civilizations should serve as the driving force for sustainable food innovation.

Food taboos may act as an impediment to innovation in sustainable food, which may have an effect on the health and nutrition of rural areas in Africa. Diversities in culture have an impact on certain food traditions, food kinds (mainly traditional cuisines), and lifestyles, which determine how innovative sustainable food is. According to their cultural identity, groups, communities, or societies have different likes and demands, and the term “culturally favored foods” refers to healthy foods that are safe for consumption and satisfy those needs. The idea of diversity can be applied to both culture and cuisine. The “state or reality of being various or diversified” might be considered diversity in this context. Hence, “diversity in food” can mean a few different things: For one, the representation of all food and culture or the array of nutrients needed for a full, well-rounded diet in a specific culture or society, or the variety of food-related crops grown or animals raised on a farm.

Food culture’ can be defined as habits, rituals, practices, belief systems, values, lifestyle, traditions, and customs centered around growing, producing, procuring, cooking, eating, serving, and celebrating food. Family history, lineage, heritage, and ethnicities; geographic divides and climates; and social and political situations such as poverty and war all heavily influence the food culture. The food culture is influenced by individuals, small networks, and institutions, such as families, or large ones, such as societies, the food industry, and geopolitical settings or countries. All the above have a bearing on the extent of innovation in sustainable food in various communities.

In order to promote a positive change in the food system in Africa, sustainable food innovations should take advantage of the crucial role that traditional and indigenous foods and food systems may play. Food pyramids are an exceptionally important tool for visualizing the entire diet and opportunities for sustainable food innovation in Africa. Dietary patterns are built around the foods indicated at the hierarchical food pyramid of each community. Surprisingly, nutritious foods are prevalent in ancestral diets. The food traditions of Africa are influential and important; they were and are an aspect of food history. Understanding the culturally preferred food ways of local communities is an essential window into history that innovation in sustainable food could be based on. Integration of food innovation through appreciation of food cultural differences in food lifestyles and the more sustainable the innovation will be being an important step toward individual and collective cultural humility and food innovation in sustainable food.

Major points of consideration in culture, traditional food, and innovation in sustainable food in Africa are that food innovations are sustainable if they target the types of foods embraced by a community’s culture. This is inclusive of cultural food habits and traditions (such as religious observances) related to food. In many civilizations, one’s choice of dietary habits can be influenced by one’s identity; however, this has largely been examined in light of the maintenance of cultural identity among migratory groups (Reddy and van Dam, 2020). African food habits represent varied cultures of everyday pluralism as well as views toward traditional healthful food practices, and these factors drive community innovation in sustainable food.

Traditional food should be targeted as an important part of innovation in sustainable food in Africa. Although far from being achieved, innovation in sustainable food systems can be a stepping stone for the whole African food system in order to support transformation. Smallholder farmers are not motivated to churn innovation in sustainable food beyond the subsistence level because they lack market access that can connect them to local, regional, and international markets through a number of means while complying with trade regulations.

In the smallholder farming sector, innovation in sustainable food is limited because there is a lack of enhancement in investments in the application of certification and standards and addressing food safety and animal welfare. The lack of investment in food processing by small-scale food producers is the major cause of high food losses during production, storage, and transport. The lack of consideration of socio-economic, equity, and gender implications to build more sustainable value chains within changing food systems has been a drawback in innovation in sustainable food. Small-scale agriculture and food production have failed to embrace the development and use of information technologies and digitalization to achieve increased production and minimize food losses during production, storage, and transportation.

## Towards an innovation in sustainable food conceptual framework

The goal of innovation in the sustainable food system is to revitalize the African food system, create balanced nutritional and food security, and promote sustainable agriculture and food production. It is a complex socioeconomic network. Productivity and environmental sustainability should both include innovation in sustainable food. The conceptual framework is built on the many sociocultural, economic, and environmental aspects that were described in the sections above. We need to adopt a multifactor lens approach to understand innovation in sustainable food approaches, which entails simultaneously taking into account a number of different but connected elements (sociocultural, economic, and environmental factors) and should result in more effective and sustainable local solutions.

Policymakers can more accurately determine the implications and unintended repercussions of various food policies on innovation in sustainable food production by taking systemic effects into account. This will enable them to adapt those policies as needed to produce more sustainable food solutions. A sustainable level of food supply from smallholder farmers alone cannot address all the economic, social, health, and environmental imbalances in Africa’s food system.



The smallholder food production sector is a complex system that is influenced by multiple factors. Only a multifaceted agricultural and food production strategy can effectively handle the system's complex food issues, including rural food shortages as well as safety, health, and access issues. Africa must strategically engage in developing agriculture- and food-related enterprises, particularly downstream, to meet the continent's expanding industrial demand for smallholder agricultural and food commodities. An integrated innovation model that considers all value chain activities is shown in flow diagram form in [Figure 1](#).

Small-scale farming dominates Africa's lush and diverse agriculture and food production sector, which has the ability to support virtually any integrated innovation model for the production, distribution, handling, storage, processing, packing, and retailing of packaged goods. The model includes all processes, from the production of raw materials—where small-scale food producers are the dominant players—feeding into large-scale operations all the way up to the consumption of goods. Small-scale food producers will benefit from support as they move from subsistence farming to associated large-scale industrial and food services, where they can earn greater wages, expand their purchasing power, and increase food demand.

For Africa's growing industrial demand for smallholder agricultural and food commodities, strategic investments in creating agriculture- and food-related industries, especially downstream, will act alongside the many gradients that affect creativity in perspectives on sustainable food ([Figure 1](#)). These sociocultural, economic, and environmental modes and their corresponding interactions provide the heuristics needed to analyze and navigate the complex relations among climate change, indigenous knowledge systems, gender, culture, and traditional foods in the context of innovation in the sustainable food domain. Understanding the complex logical relationships of factors influencing innovation in the sustainable food sector is made possible by the conceptual framework.

Gender, indigenous knowledge systems, sociocultural norms, and traditions have an impact on innovations in sustainable food because of how they affect African agriculture and food production ([Figure 2](#)). Another top focus should be closing the gender gap in agriculture in Africa. Half of the poor smallholder farmers in sub-Saharan Africa are women. If they are given more economic power, their productivity and earnings will increase, and they will discover ways to innovate sustainable food in order to reduce child malnutrition. The fundamental primary causes of vulnerability and food insecurity in rural communities in sub-Saharan Africa and, more likely, innovation in sustainable food include gender differences in agriculture and food production as well as inequities in climate change awareness and solutions.

The glaring gender disparities in climate change knowledge are largely attributable to a range of multifaceted, though often subtle, community and societal challenges women routinely face that cut across institutional, social, and cultural dimensions. Therefore, it is imperative that institutional gender sensitization knowledge accessibility be developed to initiate the task of attitude change within the male-dominated public information domain. The long-standing conventional way of handling climate change issues has been to just offer an aggregate view of climate change impacts without paying attention to gender dynamics. This needs to change because the gender component has proven to be an essential variable for analyzing

the roles, responsibilities, constraints, opportunities, incentives, costs, and benefits of climate change knowledge accessibility.

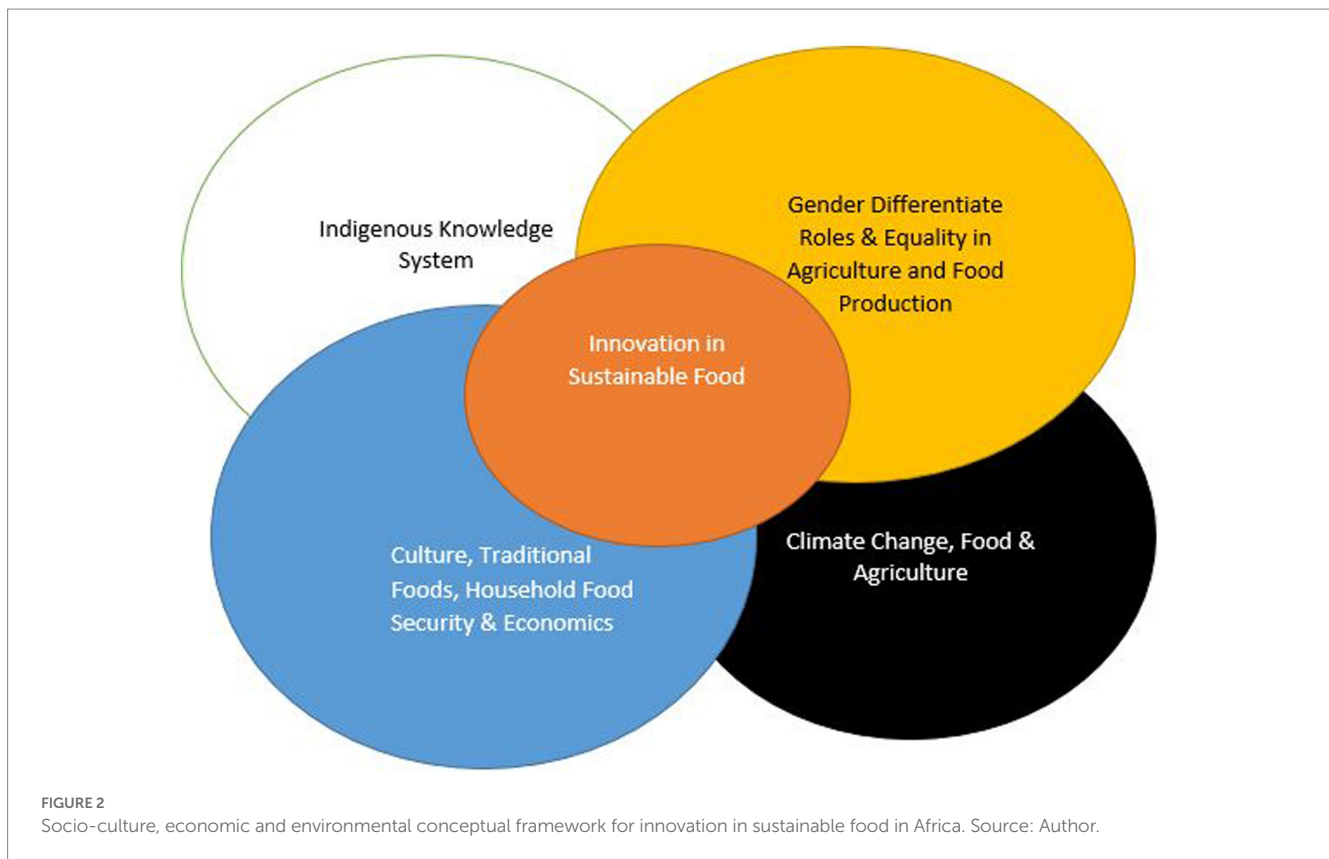
Climate change is recognized as a global crisis for food systems, but responses tend to focus on scientific and economic solutions rather than addressing the vitally significant human and gender dimensions. Because of gendered social roles, women are on the front lines of climate change impacts, such as food production impacted by extreme weather events, yet they are the least acknowledged. This might have consequences in the quest for innovation in sustainable food. How then do we move toward more people-centered, gender-aware climate change policies and processes that promote innovation in sustainable food?

How do we both respond to the different needs and concerns of women and men and challenge the gender inequalities that mean women are more likely to lose out than men in the face of climate change and innovation in sustainable food? In order to address the larger issues of voice, representation, and involvement in food innovations in rural areas, the matrix integrates enhanced gender participation, climate change mitigation, the utilization of indigenous knowledge, and respect for traditional foods.

Indigenous knowledge is a broad and priceless system of information that is adaptable and continually changing, based on abilities, skills, and problem-solving strategies that evolve through time depending on environmental circumstances ([Battiste and Henderson, 2000](#)). Innovation in sustainable food developed through indigenous knowledge have a long shelf life within communities and are more likely to benefit the current and future generations of residents of particular communities. A lot of people have thought about employing indigenous knowledge as a backup plan to promote various food-processing methods in impoverished rural areas around the developing world. It is crucial to increase awareness of the value of indigenous knowledge about the sustainable use and management of food commodities in order to reduce shortages of both crop-based and animal-based food as well as improve rural livelihoods. Hence, it is also critical to focus on communities' food-related indigenous knowledge systems and their contribution to enhancing food nutrition and security as an effective part of a strategy for innovation in sustainable food. This is against the background that much of food processing, such as food preservation, storage, and packing, in rural communities is done in a traditional way for the majority of the communities.

An appreciation of local food indigenous knowledge processes and an understanding of their use role and importance may be a prerequisite to supporting innovation in the sustainable food front in African communities. Indigenous knowledge practices and experiences are the basis for all innovation in sustainable food developments in resource-poor communities and further sustainable food systems. Effective use of indigenous knowledge in food processes that are economically feasible, socially accepted, and at low risk for smallholder food producers is crucial to innovation in sustainable food.

A key part of Africa's food system is traditional and indigenous foods; however, due to widespread dietary changes, unrestricted food imports, and significant migration throughout the continent, these foods are becoming marginalized and in danger. Regrettably, neither the food scientists nor the policymakers have created a conducive setting to promote innovation in sustainable food related to this group of commodities. Innovation in sustainable food focusing on traditional and indigenous foods will help influence ideas that can



support positive food system transformation, particularly in changing climates in Africa. Sustainable food innovations should capitalize on the essential role that traditional and indigenous foods and food systems can play in encouraging good food system transformation in Africa.

The agriculture and food production industry has purportedly grown rather interested in the idea of inclusive innovation (Peddi et al., 2023). It claims to replace conventional innovation paradigms by placing an emphasis on more equitable, long-lasting, and well-balanced human-environmental partnerships. Indigenous and local knowledge are gaining importance in debates about inclusive innovation, highlighting a variety of relevant players and underrepresented voices. It should be emphasized, nevertheless, that the role of indigenous and local knowledge in creative processes is still up for debate. A conceptual framework that defines the numerous facets of smallholder food production must be developed in order to comprehend innovation in sustainable food in Africa. This enables the identification of the endogenous, exogenous, or interacting factors behind the development of sustainable foods. It is important to emphasize that sociocultural, economic, and environmental factors can have a variety of effects on the development of environmentally friendly food innovation since they are dynamic rather than static.

Understanding the complex relationships between the several elements of the food system, such as production, harvest, distribution, and consumption, provides the foundation for sustainable food innovation. The world needs to address social issues like how to responsibly produce enough food to feed everyone. This is required due to how climate change is affecting food production systems. To name a few instances of innovation in the sustainable food process,

growing food, reducing food waste, experimenting with diets, and enhancing the marketability of agricultural products (including crop and animal products) along the agri-food value chains are all important aspects of the process.

More so, farmers' self-awareness, social networks, and other local information-dissemination agents are the driving forces for innovation in sustainable food process outcomes narratives. About innovation in sustainable food, the following key considerations may need to be addressed for Africa:

- i. How do small-scale food producers view innovation's benefits in sustainable food systems, encompassing interventions and practices?
- ii. What shapes how small-scale food producers see the importance of sustainable food innovation to the development of successful sustainable food systems?
- iii. What are the sociocultural, economic, and environmental drivers of innovation in sustainable food in resource-poor rural smallholding agriculture's food narratives?
- iv. To what extent are innovations in sustainable food known in resource-poor rural smallholding agriculture's food narratives?

The effectiveness of innovation in sustainable food may fluctuate depending on the context. Innovation in sustainable food through increasing production diversity may not be a universally applicable way of improving diets and nutrition, owing to the fact that production diversity may be considerably more significant in situations where access to food markets is limited. The interplay between components of food systems that influence diets—quantity, quality, diversity, and safety—underpins sustainable food innovation.

However, dietary trends may contribute as change agents for future innovation in sustainable food processing.

Food culture-influenced dietary habits have an impact on the nutritional and physical health consequences of rural communities. This goes hand in hand with the desire for sustainable food innovation. Due to the increased demand for food brought on by population growth, sustainability in food production and consumption, and enabling elements such as anticipated participant behavior in the food system that should be added via local institutional initiatives, these links may have an immediate impact on food systems or they may have an indirect impact by affecting crucial food system components like innovation and sustainable food. On the other hand, biophysical and environmental, economic, sociocultural, and demographic forces remain critical.

Innovation in sustainable food is more likely to have a positive impact on dietary diversity, nutrient adequacy, and nutrition outcomes. Innovation in sustainable food systems, accompanied by nutrition-sensitive production systems that incorporate nutrition-related behavioral change communication, will be a driver of sustainable food systems. This could imply that innovation in sustainable food-enhancing diets in the local population is dependent on numerous socio-cultural, environmental, and gender perspectives of food systems and requires context-specific interventions. Empirical evidence is required to prove the connection between sustainable food innovation and production diversity, as well as to explore the connections between sustainable food innovation and household dietary diversity, with a focus on particular aspects of the food system. Future agriculture, food, and innovation research utilizing cross-sectional data from households or communities should be expected to aid in the creation of research hypotheses in sustainable food.

## Implications

In developed nations, the system for farming and food production has undergone gradual shifts and is currently going through rapid transformations. Until late, advances in technology in food industry have profoundly completely transformed the entirety of agri-food production and supply chain networks. This is on the backdrop that the African continent has struggled to make gains in this respect owing of diverse constraints and this are sociocultural, economic and environmental in scope. The trends in innovation in sustainable food in developed countries has been rapid due to advancement in science and technology. In order to make food less hazardous, more nourishing, or more appealing, innovative methods of production, processing, or packaging have emerged in the sustainable food industry. With food innovation, industrialized countries have pioneered and commercialized novel food products, processes, and services.

For Africa agriculture and food production, as well as related activities such as sustainable food innovation, are heavily influenced by sociocultural, economic, demographic, and environmental factors that affect their functioning and performance in Africa. Smallholder farmers are the cogent of agriculture and food production on the continent hence are the target sector for innovation in sustainable food. A key vital approach to answering sustainability components

and evolution in the agri-food sector system may be the deliberate application of innovation in food. This approach could serve as inspiration for the growth of agriculture in a way that is easily accessible, resilient, and environmentally friendly while the world's population keeps increasing.

Innovation in sustainable food as one of the keys to enabling food systems transformation. The strategic deployment of innovation can be a central and significant enabling factor for agri-food system transformation, and act as an engine of ensuring inclusive, resilient and sustainable rural development. Food innovation is the development and commoditization of new food products, processes, and services. Innovation in food also has an important role to play in tackling societal major challenges such as how we can ensure a sustainable yet plentiful food supply to feed a growing global population. Right now, it's happening rapidly. Food related industry are looking for ways to make healthy, nutritious offerings that are not only enticing, accessible, exciting, and unique, but also sustainable.

Smallholder farmers are the cogent of agriculture and food production on the continent hence are the target sector for innovation in sustainable food. The socio-cultural, economic, demographic, and environmental factors such as culture, gender, climate change, indigenous knowledge influence agriculture and food production hence the need to consider them in innovation in sustainable food. It is therefore prudent to conclude that to ensure innovation in sustainable food in Africa, especially at the household level, we need to rethink the way we support the core of food production on the continent, which is smallholder food producers, and realize that women also play a critical role on this front. We need to support food production in this sector and integrate them into food value chain thus high chances for innovation in sustainable food. Therefore, the empowerment and support of small-scale farmer food producers must be a priority to increase the likelihood of innovation in sustainable food.

It is impossible to assemble a comprehensive overview of the most notable food innovations that have developed over time in Africa due to a paucity of records, a geo-differentiated nature, and cultural diversity. It is more likely that unnoticeable changes in processed food production, packaging, and storage, along with an array of intriguing new ingredients, have been developed over time. Rural communities are increasingly allowing themselves to adapt their traditional food products on an ethnic, cultural, or community basis. The awareness of the socio-cultural, economic, and environmental facets of various communities is fundamental to the need for comprehensive, inclusive innovation in sustainable food in rural areas.

The socio-cultural, economic, and environmental wellbeing of communities, particularly those who are most at risk in the food system, must be protected and respected by any innovation in sustainable food. It is imperative to promote community and societal innovation in sustainable food with agreed-upon innovative food-related regulations that safeguard the rights of communities from small-scale food producers and vulnerable groups like women and children.

Appropriate food production and climate change policy can be aimed to reward smallholder farmers and enable their food consumption by putting climate, nature, and resilience at the center of food systems to enhance climate-smart food production, promote

equitable livelihoods, and create resilience to vulnerabilities, shocks, and stress in food production, thereby stimulating the creation of new products, food processing, packaging, and services.

Food industry innovation strategies must be founded on the complete technology in the food system and cognizant of both technical, social, and environmental changes in order to provide food that fulfills the nutritional, personal, and social requirements and wants of all populations.

## Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

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## Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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