Reviewing Africa's urban agri-food supply chain: Sustainability Approach

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Abstract

There is an increase in perishable and processed foods(PPF) consumption in African cities, which requires effective production, processing, and distribution, to meet the growth in food demand. Factors -such as urbanization, population growth, dietary change, and rise in income are drivers for increasing the consumption rate of PPF. The stakeholders of the PPF supply chain (SC) need to intensify the production of good-quality foods amidst the increasing food demands, resource scarcity, high food prices, and adverse climate change. The study aims to examine the sustainability of the PPF supply chain in African cities, including the present state of PFF, using a sustainable assessment of food and agriculture (SAFA) developed by Food and Agriculture organization (FAO) (SAFA guideline, 2014). Lagos(Nigeria) is used as a case study, and four agribusinesses in PPF in this region will be examined for sustainability performance in dimensions namely social, environmental, economic and governance. A conceptual framework for assessing and promoting a sustainable PPF SC in Africa's cities will be developed, comprising assessment, system and solutions.

Keywords: Urban food supply chain, African cities, Sustainability Assessment of Food system,

Main Subject

Introduction

Presently, Africa is undergoing a substantial demographic shift, attributable partly to urban growth and rising population. Cities are home to 3.5 billion residents; by 2030, it is estimated that 60% of the people across globe lives in cities, and 95% of growth in urbanization will occur in developing countries. In 2020, 43.9% of the African population lived in cities, and 56.1% of the population resided in rural communities(OECD/SWAC 2020), which records significant urban migration (Leyerer, et al., 2020). Africa has several cities and megacities with diverse cultures and dynamic, thriving economies (AGRA,2020). Its urbanization growth rate is estimated to be 3.5% annually between 2015 and 2025. By 2050, Africa's population will rise to more than 1.3 billion, and the region's youth are the significant seekers of urban settlement (UN-DESA 2018).This is associated with the belief that urban areas provide better opportunities (Dolislager, et al., 2021), including economic empowerment, quality education, social status, and food security than the continent's rural regions (Cheng, et al., 2022). Amidst the urban expansion, African cities

face malnutrition, poverty, food insecurity, and a lack of infrastructure to support sustainable food production (Newell, et al., 2019). Feeding Africa's growing cities is contingent upon efficient production methods and land, water, and energy availability (Barthel, S. et al., 2019). Creating a food production system within the city region that records increasing food demand, will reduce the negative environmental impacts and promote sustainability (Brown, 2015).

The increase in population leads to the massive demand for food despite the challenges confronted with global food production, such as degradation of natural resources and climate change. According to Obirikorang et al., 2021, regardless of the high-yield crop varieties and innovative techniques provided in the previous agricultural revolution, current methods of agri-food production cannot meet the future estimated world's food demand by 2050 (Valentina et al., 2021). The African cities' food demand constitutes the continent's most extensive and fast-expanding food market of approximately $US200-US$250 billion annually; this huge food market presents an excellent opportunity for the region's agri-food stakeholders (AGRA,2020). The food market within African cities contributes to sustainable development by creating social value and economic empowerment with the space (Guzmán-Pérez et al., 2021). Agri-food remains an essential commodity to build a sustainable and well-nourished population in Africa (Schulterbrandt et al., 2018). Therefore, fostering quality nutrition, food security, and sustainable food production are crucial concerns throughout African cities and agri-food actors (Houessou et al., 202). Agri-food supply chain actors need an integrated and collective approach to provide food sufficiency solutions within African cities (Davies et al., 2021).

The rural workforce is reducing because of increasing urban settlement, and this rural community cannot sufficiently produce food that will meet the increasing demand of the growing urban population (Dolislager et al., 2021). Therefore, African cities need to have food within their landscape, where habitation and food systems co-exist within the same ecosystem (Brown, 2015). The approach to meeting food demand by importation creates huge competition for indigenous agri-food supply chain actors regarding price, food quality, and market share reduction(Davies et al., 2021). It has been recorded that Africa import US$ 72billion worth of food yearly, and north Africa and southern Africa has the highest annual food import in the region, which are 31% and 25%, respectively (AGRA, 2020). Furthermore, the increased prevalence of food imports in Africa demonstrates that the region's agri-food industry faces difficulties meeting food demand. Therefore, achieving food sustainability and sufficiency in African cities requires stakeholders to employ several alternatives and mediums to boost their food production (Houessou et al., 2020).

The busy life associated with urban living makes city residents seek convenience in several products, including food, which results in vast purchases of processed and prepared foods. Processed foods account for 62% in African cities and 49% in rural areas. In addition to urban lifestyle and expanding food demand, the increases in per capita income in many African cities lead to more processed and perishable foods consumption, such as dairy, meat, poultry, and fish. Africa's cities evolving food consumption patterns and dietary changes parallel Bennet and Pierce's 1954(Bennett's law), which states that as people's income rises, there is a transition toward consuming more perishable food (AGRA, 2020). Feeding African cities in line with consumption trends generate massive critical attention among the stakeholders (Armanda et al., 2019). Therefore, more sustainable food production methods within the cities should be developed to meet the demand for food.

In summary, the rate of urbanization, increased food demand, urban lifestyle, and increased per capita income constitute the significant drivers of dietary trends in Africa (Davis et al., 2022). It leads to the agri-food system transformation and presents a need for more sustainable food production methods within the cities (FAO, 2018). Therefore, the objective of this study is to answer the following research question:

RQ: How to promote and develop sustainable production of Perishable and Processed foods in Africa's Cities?

The rest of this paper is organized as follows: section 2 'research background' - provides a summary of the current condition and concerns facing PPF in African cities. Firstly, those questions mentioned above will be addressed using the sustainable assessment method SAFA (Sustainability assessment of food and agriculture), which FAO developed to examine the sustainability performance of agri-food enterprises within urban cities in Africa. The study area will be Lagos, Nigeria, and several Case studies will be selected in this region for examination. Secondly, after assessing the sustainability of the case studies, digital solutions will be presented, and their role in promoting sustainability of PPF within African cities will be explained. Section 3 '"methodology' covers the sustainability assessment of PPF supply chain case studies using SAFA. And the latter part of the paper comprises results, contributions, sustainable approach and references.

Research Background

Perishable Foods

The perishable food supply within the city region is a multi-layered action from primary production to consumption, which also involves the impact of the perishable supply chain on the environment and its social effects on people. According to FAO 2020, 50% of agricultural food products in Africa end up as waste, with the most significant part being perishable foods. Food commodities are categorized as perishable due to a high tendency of deterioration from farm to fork (Awah Manga et al., 2018). The shelf life of perishable foods is the maximum duration of time where this food commodity can be stored to maintain quality and safety under specific environmental conditions. Perishable food products diminish in value, become unhealthy for consumption, and end in waste if not kept within a particular temperature along the food supply chain (Dong et al., 2021). A food product is classified as perishable when it has at least one of the following characteristics: overall quality deteriorates noticeably, its quality diminishes with time, spoils food is unsafe for consumption (López Cifuentes et al., 2021).

The supply chain of most food, especially perishable foods, is becoming complex and more prolonged. This food product is at risk of deterioration and waste due to the high tendency to degrade quality from microbial decomposition. Perishable foods need a specialized handling method from farm to fork, considering the high possibilities of degradation and its social and environmental impact. Research on the sustainability of perishable foods has increased in recent years, but the studies require a region-specific approach due to the global variability in environmental conditions (Golestani et al., 2021). A perishable food sustainability method adopted in Europe will not be suitable for Africa due to variations in environmental conditions. In some African cities that experience extensive road traffic congestion, the intra-city supply of perishable foods can take a long time and affect the quality of foods and increase spoilage (Dube al., 2017). According to the study conducted by Jouzdani et al., 2021, the challenges facing the perishable food supply chain should be approached holistically and consider the specific features of each section, from production to consumption. Several studies identified actors' decision-making as the primary driving force for perishable food supply network design. Supply chain actors need to implement sustainable measures into the perishable foods supply system that encourage better economic returns, improve environmental performances, and promote social stability globally (Miranda, 2019). When designing a supply chain network, the perishability of perishable foods and their impacts on the environment should be considered ((López Cifuentes et al., 2021). A significant challenge facing this sector is maintaining the required temperature to preserve perishable foods across the supply chain. However, industry 4.0 technologies present IoT and Big data solutions for a smart supply chain (SSC), using sensors to monitor the environmental condition, report variation, and provide a suitable decision support system to maintain and reduce loss. Africa food FSC actors see investing in solutions that can monitor the condition of perishable foods as nonessential and prefer conventional methods to preserve

perishable foods along the supply chain (Miranda, 2019*)*. Infrastructure inadequacy and economic inefficiency of stakeholders and smallholder farmers to invest in technologies and solutions to improve the efficiency of the FSC system leads to massive loss and waste (Andam et al., 2018). Therefore, the prevailing waste in Africa's food industry, coupled with the considerable demand for perishable foods in major cities in Africa, poses challenges to the government and stakeholders to meet growing food demand.

The Volume of waste in the African food sector is related to the lack of a controlled environment infrastructure warehouse, and supply chain system that could inform better decision making on the state of condition of agri-food products from farm to the fork. In the most developed world, a cold chain system is used to transport perishable foods; this system utilizes refrigerator methods to preserve the quality of perishable foods, minimize spoilage, and reduce food waste. Several studies have investigated the environmental impact of storage and retail of perishable foods (Sarfo et al., 2021), which associated huge volume energy consumption with the storage of perishable foods due to refrigerators or cold chain systems. In many developed countries, the cold chain industry has experienced colossal growth in its services over the years, and China's hard chain sector is projected to be RMB 500 billion by 2026 (Jouzdani and Govindan 2021). According to Dong and Miller 2021, the increase in the cold chain industry in many developed countries will bring about a more negative impact on the environment by the emission of GHG (Xiong et al., 2022). Therefore, there is a need for alternative food methods and technological solutions to provide sustainable practices in the African urban food sector (Govindan et al., 2017). A short agri-food supply chain system can reduce CO_2 emissions by reducing agri-food transportation in African cities. Urban food stakeholders need to produce food in the city by exploring innovative methods like; greenhouse(for vegetable cultivation) and controlled environmental agriculture, which will significantly reduce agri-food transportation within the cities, increase access to food and reduce GHG emissions.

However, all stakeholders in the perishable SC need a partnership to address the pressing issues facing the sector(reference). There is a need to consider: how can we end hunger and reduce perishable food waste within cities, sustainable production methods, and how can stakeholders increase profitability. This can be achieved by multi-stakeholder collaboration and commitment to achieving sustainable perishable foods. All methods adopted to promote the sustainability of perishable foods answer the call to achieve SDG 2(zero hunger), SDG 12(adoption of sustainable practise), and SDG 13(call to address climate change and ' 'it's effects) goals across the globe. Most importantly, in the urban areas, especially in African cities that record massive post-harvest loss and increasing consumption trends towards perishable foods (Kpossilande et al., 2020).

Processed Foods- Food Manufacturing

Food processing practices can be dated back to the history of human civilization when humans were predominantly hunters and farmers, and essential tools used were bow, arrow, hoe, and cutlass. Food consumption primarily was from hunting and food cultivation. Instinctively, humans discovered food processing and preservation techniques, where heat was applied to prepare food for consumption (Andam et al., 2018). As humans developed, their civilization transformed the structure and the dynamic of its social system by impacting all aspects of human experience (Armanda et al., 2019). The development of the human social system presents more advanced food preparation and processing methods. All industrial revolutions positively impacted how food was cultivated and processed. Each industrial revolution brings unique tools and practices to transform the food industry (Miranda J, 2019).

Furthermore, the fourth industrial revolution characterized by IoTs, Big Data, Artificial intelligence (AI), Machine learning (ML), and Blockchain technologies can revolutionize the food industry (Belaud et al., 2019). The adoption rate of methods present in each industrial revolution in the food industry can differ in different parts of the world, where developing countries like

Africa always adopt practices and technology late. Therefore, this is often caused by low awareness of technology, lack of infrastructure, technology incompatibility, and lack of technology demonstration for potential adopters.(Valentina et al., 2021). The developing countries' food industrial transformation and sustainability are limited to each region's ability to leverage the available technology and solutions (Andam et al., 2018).

There has been a concurrent increase in processed foods consumption in Africa, Latin America, and Asia in the last five decades. This is substantially influenced by similar drivers of dietary transition in developed countries (AGRA 2020). The food processing industry in Africa is a multi-trillion-dollar sector, which is estimated to record seven-fold growth before 2040. Food processing industries are at the centre of the value chain and are significant employment, income, and drivers for local economies in some African countries (Kpossilande et al., 2020). The demand for processed food in the region's urban area is rising. Food supply chain stakeholders are faced with providing better food manufacturing methods with minimized environmental impacts (Valentina et al., 2021). The local food processing business actors strengthen knowledge and technological solutions by presenting sustainable practices and techniques for more sustainable food processing and increasing their competitive advantage to produce highly nutritious food for consumption (Reardon et al., 2021). Several initiatives like Africa alliance for improved food processing (AAIFP) was established by USAID to strengthen local food processors in Africa through technology and knowledge sharing among stakeholders within the FSC. The SAFE solutions for Africa food enterprise) the initiative was established by the joint partnership between TechnoServe and USAID, whose main agenda is to boost the competitiveness of Africa's food processing industry and promote access to highly nutritious food. The launch of SAFE in 2012 in Malawi, Kenya, and Zambia was accompanied by a grant of $6.3 million. There is an increasing action by governments, international bodies, and FSC stakeholders to develop Africa's food processing industry. SDG 12 aims to achieve sustainable food production, and consumption can only be achieved through good manufacturing practices and sustainable methods. The Small local food processing business within African cities is challenged to produce quality and nutritious food products that meet food safety standards and regulatory requirements due to a lack of appropriate infrastructure, technology, and investment. (Videgla et al., 2016).

The study done by Sarfo et al. 2021 examines the relationship between the intake of processed foods and health challenges like obesity and diabetes in rural communities in Tanzania. Household food consumption was carried out by Sauer et al., 2021; recorded food consumption in rural areas to be 47% and processed accounted for 76% of food consumption among urban dwellers (Zhong et al., 2021).

Methodology

This study developed a framework for assessing agri-food, comprising three components; assessment, system, and solutions as shown in figure 3. the methodology approach for this study is to evaluate PPF food system cases in Africa and provide solutions for sustainability

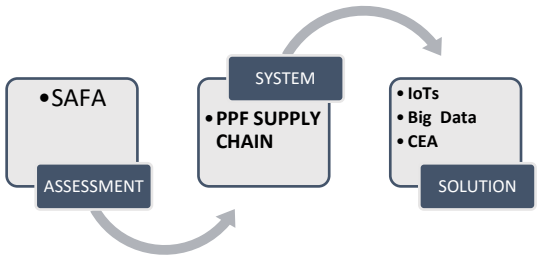

Figure 1-A conceptual framework for sustainable assessment of agri-food system

Study Area- PPF Supply chain in Lagos, Nigeria

Lagos is one of the fastest-growing cities in Africa and an economic hub in the West African region, which records over a 17million residents in 2020, with diverse culture and a thriving economy. Over the recent years, Lagos has experienced tremendous urbanization growth resulting from city migration, population, social status, and better livelihood prospects the city presents to

potential settlers. The youth are significant urban city migrants in this region and from nearby towns, cities, and rural communities.

Data collection

The study employed interview as major method for conducting SAFA assessment with actors in the PPF supply chain**.** The selected stakeholders are managers and production supervisors of the case agri-business selected for the study.

Table 1- case studies of PPF agribusiness in Lagos(Nigeria).

Cases Studies	**Respondent**	**Product**	**Mode of data collection**	**size of org**	**Type**	**Location**
A	Production supervisor	Fish and Meat	Interview	Large	Multinational	Lagos
B	Manager	Tomatoes, cucumber	Interview	SME	Indigenous	Lagos
C	Production Supervisor	Vegetables	Interview	Large	Multinational	Lagos
D	Manager	Vegetables & processed foods	Interview	Large	Multinational	Lagos

SAFA Methods

FAO 2009 created a sustainable assessment of food and agriculture (SAFA) to assess the impact of agri-food operations on humans and the environment(FAO, 2013). SAFA is a comprehensive global methodology for evaluating the sustainability of the agri-food supply chain, which creates an international standard for assessing all facets of sustainability. This methodology was prepared to ensure that agribusiness across the FSC has a firm grasp on the constituent elements that make up the sustainability appraisal of a system and how they deal with the inefficiency and efficiency of the agri-food system. Establishing a comprehensive framework for measuring sustainability in an agri-food system integrates sustainable methods and promotes best practices within the FSC. SAFA assessment is designed to address the sustainability of small, medium, and large-scale agribusiness and stakeholders across the FSC. The SAFA's underlying objective is for the agri-food supply chain to be sustainable in four major areas: economic, social, environmental, and governance. The SAFA's framework comprises 21 themes, 58 sub-themes, and 116 indicators, as shown in figure 7 and table 2. Several studies have pointed out the significant advantage of using SAFA's assessment: flexibility, credibility, user-friendly, and comprehensiveness (FAO, 2013).

SAFA PROCESS

SAFA sustainable assessment comprises four processes of evaluating the agri-food supply chain from farm to form: mapping, contextualization, indicators, and reporting.

Mapping: This is the first step in SAFA assessment, which comprises setting goals and scope for the system to be analysed. This involves visualizing the relationship among components, all processes across the FSC, the measuring element, and establishing the main evaluation goal.

Contextualization: this is the second step; the user needs to review the SAFA's sub-themes and carefully select appropriate themes that align with the sustainability objectives of the agri-food system to assess.

Indicators: These steps involve collecting the necessary information and applying them to the selected hands, and scoring on a 5-point rating of performance based on SAFA's framework guidelines established points.

Reporting: in the final step, the information gathered is inserted into the SAFA's software tools, and the result shows a visual representation of the result in a polygon form. The users must assess

the outcome, self-evaluate the performance and provide solutions for improvement and development.

Table 2- Safa Rating and Score

BEST	**5**	**LIMITED**	**2**
GOOD	**4**	**UNACCEPTABLE**	**1**
MOERATE	**3**	**NOT RELEVANT**	**0**

Result

The arithmetic mean is used by SAFA to determine the score for each theme. As a result, SAFA rounded up the score to the next whole number, for example, 3.1to 4 and 3.6 to 4. The SAFA assessment of the selected case studies covers the governance, environmental, social and economic dimensions. However, this study will evaluate the environmental integrity dimension result and focus on the selected cases' atmosphere and material usage. The environmental dimension of the SAFA assessment for study covers; waste reduction, waste disposal and GHG reduction target, GHG gas mitigation practices across their supply chain.

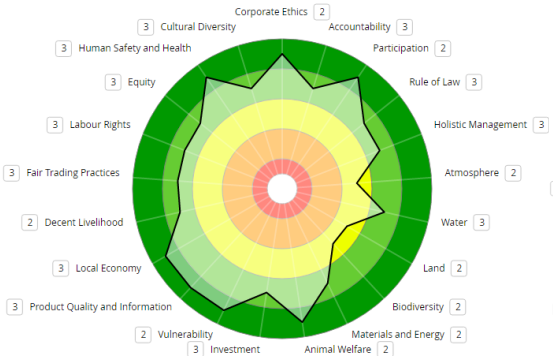

Figure 2- Case A

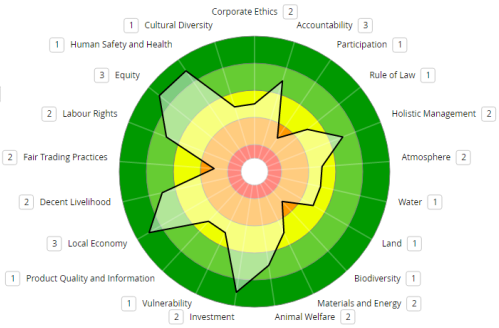

Figure 3-Case b

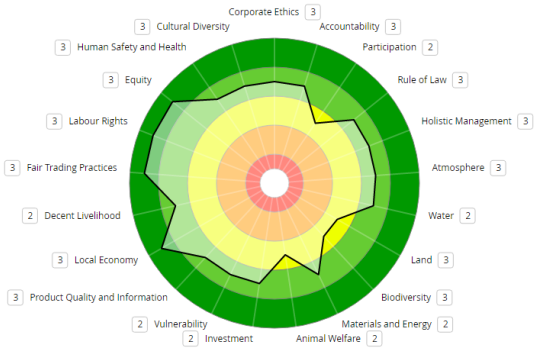

Figure 4- Case C

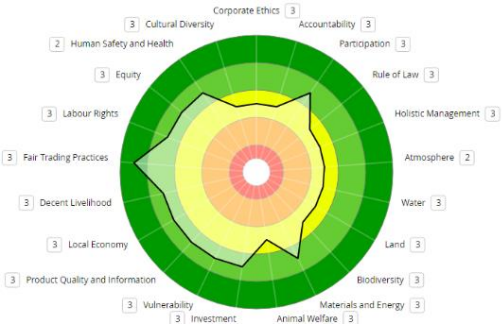

Figure 5- Case D

Environment Integrity

In the environment integrity result, case A, B and D shows a high commitment to GHG emission reduction, while case 2 show a low commitment to GHG emission. Case 2 has the most increased

waste generation with ineffective waste disposal practices. All the instances score the same on the GHG mitigation practices. All four agribusiness face experience economic loss at different stages of the supply chain; the main contributor to access inadequate handling of perishable food products and temperature variation. Central challenges face by most SMEs working in the perishable food Supply chain regarding access to market and inadequate storage infrastructure. Case B and C are multinational organizations in this region; their commitment to reducing GHG by minimizing agri-food system waste is their corporate responsibility plan. All four cases have a similar score for a sustainability plan for their business. Case b shows little awareness about sustainability measures for environmental integrity with limited understanding of possible better sustainability approaches. Several factors like organization size, awareness, solution demonstrations and regulation can influence the rate of sustainable practices within the PPF food system. The best way for improving PPF supply chain sustainability will be solutions that provide real-time information on the condition of perishable foods for stakeholders to make appropriate decisions. Another method will be solutions with a short supply of perishable foods and a Smart PPF supply chain system. Monitoring the condition of perishable foods is critical to improving sustainability.

Research findings and contribution

This study has examined the current state and performance of perishable and processed foods in Africa and the current state and performance of perishable and processed foods in African cities, using Lagos, Nigeria, as a case study. The study discovered how poor handling of PPF contributes to negative environmental impact. The common challenges inadequate infrastructures anda high volume of PPF food waste due to a lack of real-time information on the state and conditions of the PPF supply chain. Stakeholders' ability to make decisions based on real-time data can minimize waste and promote economic growth. However, the study shows how the large and SMEs agribusiness has a different approach to the PPF supply chain sustainability. Most large agribusiness tends to have more concern about PPF sustainability than SMEs. The study proposes an intelligent PPF supply chain and controlled environmental agriculture as the major solution to promote The PPF supply chain. Solution and technological demonstration to all stakeholders in PPF in Africa by leading agribusiness and organizations through social networks or incubators can encourage the adoption of sustainable PPF practices.

Intelligent PPF supply chain using IoTs and Big data

The perishable foods conditions can be monitored along the supply chain using IoTs and real-time data. Monitoring the conditions of this food category will minimize waste and give agribusiness stakeholders real-time data and information and provide better decisions to curb food waste. For this study, we propose an intelligent IoTs driven supply system of perishable foods in African cities, which will cause positive disruption and promote an innovative management model for handling perishable foods. This will create new jobs(off-farm), increase profitability and reduce the negative effect of food waste on the environment.

Controlled environmental Agriculture

Moving food production to a region with a high population and food demand will shorten the food supply chain, reduce emissions, and increase the accessibility of foods in African cities. This idea of the food system in the city areas can be vividly seen as nature presents natural habitat and food system co-existing in the same system. A huge sustainability approach is seen primarily in the natural system, and the principles can be integrated into the urban food system. Hydroponic and vertical farming for the production of vegetables has massive potential in many African cities and increases sustainability. This food production system grows food within cities and creates a system where food production and habitation co-exist.

Digital Platform

Urban life is characterized by increased consumption of processed foods and convenience shopping due to the busy urban lifestyle. Shopping for foods in African cities on digital platforms

presents accessibility to foods, promotes convenience, creates jobs, and creates a new opportunity for innovation in the urban food system. Stakeholders in agri-foods in African cities need to make food available, accessible and convenient for consumers. In developed countries like the UK, most prepared and processed food are ordered through digital platforms, but in developing countries like most in Africa, the use of Digital platforms for food shopping is not yet widespread. Possible challenges for adopting this can be technological infrastructure, but the potential advantage is that 7 out of 10 urban dwellers have access to a phone with the internet.

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