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Assessment of the impact of municipal food waste on food security: A Review

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ABSTRACT

Municipal food waste has emerged as a significant economic and environmental challenge globally. Millions of tons of edible foods are discarded yearly, contributing to a substantial waste problem that exacerbates greenhouse gas emissions and strains municipal waste systems. The rapid growth of the population in urban cities intensifies pressure on food systems, leading to significant food losses at various points in the supply chain, ranging from production to consumption. This study examined these issues using desk-based and comparative methodologies gathering data from policymakers, food producers, retailers, consumers, and Non-Governmental Organisations reports. Perishability, low consumer awareness, weak policy frameworks, poor storage, and processing infrastructure are some key barriers limiting municipal waste reduction. Overcoming these barriers will require coordinated efforts from both the public and private sectors, focusing on consumer education, infrastructure investments, and policy reforms to reduce or eliminate food waste so as to enhance food security and economic boost in urban cities. Health, economic and environmental benefits could be derived from reducing municipal waste. Hence, all stakeholders in the food value chain should take the necessary steps to implement actions to achieve sustainable food production and consumption in African urban cities.

Keywords: Africa, food waste, food security, municipal, environment

RÉSUMÉ

Le gaspillage alimentaire au niveau des communes municipaled s'impose comme un enjeu économique et environnemental majeur à l'échelle mondiale. Des millions de tonnes d'aliments consommables sont jetés chaque année, aggravant les émissions de gaz à effet de serre et exerçant une pression sur les systèmes municipaux de gestion des déchets. La croissance rapide des populations urbaines intensifie les tensions sur les systèmes alimentaires, générant des pertes substantielles à divers maillons de la chaîne d'approvisionnement, de la production à la

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consommation. Cette étude, de nature documentaire et comparative, mobilise des données issues de rapports de décideurs publics, producteurs, détaillants, consommateurs et organisations non gouvernementales. La périssabilité des denrées, la faible sensibilisation des consommateurs, des cadres politiques insuffisants, ainsi que des infrastructures de stockage et de transformation inadéquates constituent des freins majeurs à la réduction du gaspillage. Les surmonter exige des efforts coordonnés des secteurs public et privé : éducation des consommateurs, investissements infrastructurels et réformes politiques visant à réduire, voire éliminer, le gaspillage alimentaire, afin d'améliorer la sécurité alimentaire et de dynamiser l'économie des villes. Des bénéfices sanitaires, économiques et environnementaux substantiels peuvent être tirés d'une réduction du gaspillage municipal. L'ensemble des acteurs de la chaîne de valeur alimentaire est donc appelé à mettre en œuvre des actions concrètes pour une production et une consommation durables dans les villes africaines.

Mots-clés: Afrique, gaspillage alimentaire, sécurité alimentaire, municipal, environnement

INTRODUCTION

In our everyday sustenance, food is an essential source of energy for living and for the support of life for humans, animals, and plants. Human foods come from different types of sources that impact human life and sustain and support healthy living. But situations arise where this food is being wasted due to large supply of it, overproduction, and expiration before consumption date, consumer behavior,food storage system and other factors that contribute to food waste. Food waste is a critical issue in urban areas across Africa. Despite facing challenges related to food insecurity, urban centers contribute significantly to food waste. This problem is worsened by inefficient supply chains and inadequate infrastructure such as poor storage and transportation facilities. Food waste in African cities occur at various stages of the food system, including production, distribution, and consumption. Aschemann-Witzel *et al*. (2017) argue that the lack of proper cold chains and storage facilities play a central role in food loss during transportation and storage.

Food waste is one of the most urgent social, economic, and environmental matters affecting the planet's sustainability. By reducing food waste, the United Nations Sustainable Development Goal 12 related to responsible consumption and production of food level may be achieved (Principato *et al*., 2021; Shabanali *et al*., 2021). Estimations indicate that about one-third of food produced for human consumption is wasted throughout the supply chain globally (FAO, 2011). Food waste is the inedible parts of food left over after consumption and the edible food purchased and discarded by consumers.

Food loss is edible food that is lost or damaged in the production, storage, processing, and distribution phases of the food lifecycle, before it reaches consumers and, typically, cities (FAO, 2020). In this study, is definition of food waste is applied. According to a definition provided by Griffin *et al*. (2009), food waste generally refers to food discarded or lost at any stage of the supply chain, including crops damaged during harvesting, food damaged during transport, or food discarded and mixed with other wastes, i.e,, edible food losses mixed with garbage or leftovers that are not necessarily edible. On the other hand Garrone *et al.* (2014) defined food waste as surplus food that is not used for feeding humans or animals, or surplus food that is not reused or recovered in any form and is disposed off. Until recently, most academic literature and practical interventions to reduce food waste have been focused on consumer food waste in

developed countries (Secondi *et al.*, 2015; Van Geffen *et al.*, 2016; Principato *et al.*, 2019). According to Gustavsson *et al.* (2011), food waste of consumers in Europe and North America amounts to approximately 95–115 kg per year per capita, while in Sub-Saharan Africa and South/South East Asia, it is only 6–11 kg/year. Investigations revealed that the total household waste of fruits and vegetables was 22% in Cameroon, 29% in Saudi Arabia, 20% in Senegal, 38% in Turkey, 39% in Uzbekistan, and 49% in Afghanistan (COMCEC, 2017). Thus, developed countries waste much more food in the consumption stage compared to developing countries (Principato *et al.*, 2019). Hence, ways to reduce food waste and increase food security should be a matter of urgency to gulp the situation. Even though the effects of food waste prevention and reduction on food security are recognized in literature, empirical evidence regarding the relationship between food waste and food security at the household level in developing and emerging countries is scarce and not explicit (Tielens and Candel, 2014). This paper, therefore, aims to create awareness of the relationship between food waste and food security and how stakeholders in Africa can be part of this global campaign on food waste and food security in Africa.

Status of municipal food waste production in some African Countries. Food loss and waste from urban cities is a global crisis that demands our immediate attention, especially in Africa. Food loss has a major impact on the economy, the environment, and the livelihoods of Africans (Dongyu, 2019). In Sub-Saharan Africa, only about 44% of waste is collected, with 53% of total waste in low and middle-income countries (LMICs) generated from food (Turpie *et al.*, 2019; Bessa *et al.*, 2021). Data suggest that sub-Saharan Africa has the highest percentage of food lost after harvest compared to other regions. In Sub-Saharan Africa specifically, most food loss occurs in the field and post-harvest (Houngbo, 2019). The data reveal that in Sub-Saharan Africa, about 13.5 percent of all grain crops and up to 50 percent of all fruits and vegetables are lost post-harvest (Houngbo, 2019), ranging from 28 to 42 percent for cassava, 19 to 42 percent for yams and 7 to 44 percent for sweet potatoes (Affognon *et al.*, 2015).

In addition, food waste contributes to 8% to 10% of global greenhouse gas emissions, exacerbating climate change, while 783 million people still face hunger and food insecurity (UNEP, 2021). Households were responsible for 60% of this total, generating an average of 79 kg of waste per capita per year (UNEP, 2021). UNEP (2021) report provides very rough estimates of the annual household food waste in a selection of African countries: 76 kg/capita in Libya; 92 kg/capita in Ethiopia; 84 kg/capita in Ghana; 100 kg/capita in Kenya; 189 kg/capita in Nigeria; 164 kg/capita in Rwanda; and 78 kg/capita in Zambia.

On the African continent, when calculated based on physical quantities and caloric value, 15.9% and 17.2% of the food produced, is lost (FAO, 2019). Losses in cereals and pulses take place mainly during on-farm postharvest operations storage and during processing and packaging (FAO, 2019).

Africa throws away almost 40% of the food it produces (Chege and Carson, 2017). This issue transcends borders, with global food waste reaching volumes sufficient to feed all undernourished people each year. Fruits and vegetables suffer the most, with losses reaching 50%, the highest globally (Bancal and Ramesh, 2022). A study of food losses across storage, handling and transportation in six Sub-Saharan African countries found that 80.4% of losses happened during storage. Furthermore, the study reported that fruits, vegetables, roots and tubers suffered the highest losses of up to 55.9% due to perishability and poor storage and processing infrastructure (Affongnon *et al.*, 2015).

DRIVERS OF MUNICIPAL FOOD WASTE GENERATION

Understanding the drivers of food waste in Africa is critical for developing policies and strategies to reduce waste, enhance food security, and mitigate environmental impacts. Some drivers of food waste in Africa include:

Urbanization and Changing Lifestyles. Rapid urbanization is one of the most significant drivers of food waste in African cities. According to the United Nations (2022), Africa's urban population is projected to increase from 587 million in 2020 to over 1.1 billion by 2050. As more people migrate to cities, there is a shift in consumption patterns and lifestyle choices. Urban dwellers tend to have more disposable income, which often leads to over-purchasing food that ends up being wasted (Mousa, 2021). Furthermore, the shift to more processed and packaged foods in urban areas increases the likelihood of waste due to spoilage or failure to utilize the food before its expiration date. Changing work patterns in urban areas also contribute to food waste. Many individuals in some urban cities prefer eating out or purchasing ready-to-eat meals rather than cooking at home, leading to food waste in both households and the hospitality sector. Studies in Nigeria and South Africa have shown that food waste in urban households is influenced by the growing demand for convenient foods, which are more prone to spoilage (Oelofse and Nahman, 2021).

Inadequate Food Storage and Preservation. In many African cities, inadequate storage and preservation facilities contribute significantly to food waste. High temperatures, unreliable electricity supply, and the lack of proper refrigeration systems in markets and homes lead to premature spoilage of perishable goods, such as fruits, vegetables, and dairy products. A study in Accra, Ghana, found that poor storage infrastructure was a major factor leading to food spoilage at the market level, with an estimated 20-25% of fresh produce wasted before reaching consumers (Asante and Antwi, 2020). The issue is further exacerbated by poor transportation systems that result in delays and inefficient movement of food from rural production areas to urban markets. For example, in Lagos, Nigeria, food waste occurs due to long supply chains and the use of inadequate transportation methods, such as non-refrigerated trucks for perishable goods (Mousa, 2021). As a result, a significant portion of food gets spoils before it can be sold or consumed.

Consumer Behavior and Awareness. Consumer behavior plays a crucial role in food waste in urban areas. A lack of awareness about the consequences of food waste and insufficient understanding of food management contribute to waste at the household level. Studies show that many urban dwellers in African cities tend to purchase more food than necessary, often influenced by attractive marketing promotions or fear of future price hikes (Mousa, 2021). As a result, food is purchased in bulk, much of which goes unused and is eventually discarded. Cultural preferences and misconceptions about food quality also drive food waste. Oelofse and Nahman (2021) reported that in South Africa, consumers often discard food that is past its best-before date and it is unsafe to eat. Additionally, some consumers throw away food with minor imperfections, such as bruised fruits or vegetables, further contributing to waste.

Inefficient Retail Practices. Retail and food service sectors in African cities are significant contributors to food waste. Many retailers adopt practices that prioritize food aesthetics, leading to the disposal of perfectly edible food that does not meet visual standards (Asante and Antwi, 2020). For instance, retailers may reject fruits and vegetables that are slightly misshapen or blemished, even though they are fit for consumption. Moreover, inadequate inventory management in supermarkets and restaurants often results in surplus food that is not sold or consumed. A study conducted in Nairobi, Kenya, revealed that food service establishments

frequently overestimate consumer demand, leading to overproduction and subsequent wastage (Cheserek *et al.*, 2021). Similarly, restaurants often prepare more food than needed, particularly during buffet services, which leads to large amounts of food being discarded.

Policy Gaps and Regulatory Challenges. Inadequate legislation on food donation and redistribution means that food that could be saved and redirected to those in need is often discarded. Mousa (2021) highlights that while some African countries have food safety regulations, they often do not cover food donations, making it difficult for retailers and restaurants to donate surplus food without fear of legal repercussions.

Moreover, the absence of food waste tracking systems in many African cities means that the extent of the problem is not fully understood, and targeted interventions are difficult to implement. Cheserek *et al.* (2021) emphasize that a lack of reliable data on food waste in urban areas hinders the development of effective policies to address the issue.

Food Losses in Urban Agriculture. Urban agriculture, while seen as a solution to food insecurity, can also contribute to food waste if not well managed. Many cities in Africa are promoting urban farming initiatives to improve food availability and reduce transportation costs. However, poor post-harvest handling practices, lack of access to processing facilities, and the absence of value-addition opportunities can lead to significant food losses in urban agriculture (Oelofse and Nahman, 2021). For example, urban farmers may lack the skills or resources to process or preserve excess produce, leading to spoilage and waste. The drivers of food waste in urban areas in Africa are multifaceted, involving urbanization, inadequate storage infrastructure, consumer behavior, inefficient retail practices, policy gaps, and challenges in urban agriculture. Addressing food waste in urban agriculture requires a holistic approach that involves improving food storage and transportation, raising consumer awareness, enhancing retail practices, and implementing policies that promote food redistribution and waste reduction. As African cities continue to grow, reducing food waste will be critical for ensuring food security and sustainability.

THE ROLE OF HOUSEHOLDS IN MUNICIPAL FOOD WASTE REDUCTION

In recent years, food waste has emerged as a significant concern both economically and environmentally, influencing households and communities a like (Mmereki *et al.*, 2024). Every year, millions of tons of edible food are discarded, contributing to a substantial waste problem that exacerbates greenhouse gas emissions and strains municipal waste systems. Within households, this often occurs due to over-purchasing, improper meal planning, and a lack of awareness regarding food preservation methods (Aragie *et al.*, 2018). The implications extend beyond mere waste; families face financial repercussions as they unknowingly throw away money spent on food that remains uneaten. Furthermore, as consumer habits shape broader societal norms, reducing food waste at the household level not only fosters a culture of sustainability but also serves as a critical step in addressing the larger systemic issues of food security and environmental conservation (Sheahan and Barret, 2017). Recognizing the profound role households play in this dynamic can empower individuals to implement more responsible consumption practices. Some strategies that could be employed by households in reducing food waste include:

Planning and organization strategies for households to reduce food waste. Through the creation of weekly meal plans, families can better anticipate their food needs and purchase only what is necessary, significantly decreasing the likelihood of spoilage (Sheahan and Barret, 2017). Additionally, utilizing a shopping list helps to avoid impulse buys and reduces the chances of acquiring redundant items that may

go unused (Mmereki *et al.*, 2024). Storing food correctly is another crucial aspect; for instance, understanding how to manage expiration dates and using the first-in-first-out method can help ensure older items are consumed first (Aragie *et al.*, 2018). Moreover, educating family members about portion sizes can lead to more mindful eating, minimizing leftovers that often go uneaten. These strategies promote a culture of resourcefulness within the household, reinforcing the idea that every effort towards reducing waste contributes to broader environmental and economic benefits.

Education and awareness within households in food waste reduction. Addressing food waste within households significantly hinges on education and awareness. Many consumers are unaware of the profound impact their food disposal habits have on both their finances and the environment. For instance, a lack of understanding about food labels and storage techniques often leads to unnecessary waste, as individuals discard perfectly good food due to confusion over expiration dates especially when consumers misinterpret the terms “sell by” or “best by” or “use by” or “best before” as label dates (Cliceri *et al.*, 2025). Grassroots initiatives can enhance awareness and motivate behavioral changes in food waste management, emphasizing a collective responsibility in this domain.

Role of government and policymakers in municipal food waste reduction. Government interventions in agriculture have evolved considerably over time. After World War II, numerous countries introduced agricultural subsidies aimed at boosting domestic food production and achieving self-sufficiency. Governments have yet to fully address the issue, leaving waste management largely in the hands of private enterprises and civil society organizations (Nahman and de Lange, 2021). Governments worldwide recognize the need for practices that balance environmental conservation, economic viability, and social equity in the pursuit of food security (Agarwala *et al.*, 2022).

Governments can introduce policies that regulate food waste across the supply chain. For example, France's legislation against supermarket food waste, which mandates the donation of unsold edible food to charities, has been a model for other countries (European Parliament, 2022). Charities (food banks, NGOs, and Civil Society Organizations) are crucial actors in promoting a more circular approach to food, although they have limited capacity to address the root causes of food waste (Fattibene *et al.*, 2020).

Public awareness initiatives are vital for changing consumer behavior regarding food waste. Governments can collaborate with local NGOs to run campaigns that teach residents how to store food properly and reduce waste at home (FAO, 2023). In the same vein, schools with school feeding programs can be a strong driver for food waste reduction at the urban level, while contributing to the overall socio-economic development of shorter food supply chains, and educating younger generations (Fattibene *et al.*, 2020). Governments are increasingly acknowledging the need to involve a variety of stakeholders, including local communities and the private sector, in developing and implementing food security strategies. For example; waste management companies are essential enablers for both designing and implementing urban food waste policies and fostering significant waste-to-energy transformation programs often involving public transport or electricity generation, by fully unlocking the potential of the bio-economy. Trade policies that ensure fair and stable international markets contribute to global food stability and reduce food waste. Government interventions that prioritize resilience, such as climate-smart agriculture and resource management, play a key role in maintaining stability in the face of environmental and economic challenges (Agarwala *et al.*, 2022).

Providing tax incentives to businesses that donate surplus food can significantly increase food redistribution efforts. This approach has been successful in cities like New York, where food recovery programs are supported through tax credits and grants (NYCC, 2023). Future policies should focus on sustainability, inclusivity, and resilience to effectively manage the complexities of the food system in the 21st century (Agarwala *et al.*, 2022).

The role of food producers, processors and distributors in reducing municipal food waste

Food waste is measured throughout the supply chain in cities via the roles of various stakeholders. Hence, it is important to understand where and why food loss and waste occur in the supply chain and the role of food producers, processors, and distributors in reducing food wastage. The primary causes are on-farm waste or damaged harvests and over-planning by the producers (IFPRI, 2017). Producers can reduce food wastage by ensuring produce is harvested at the right maturity and using the appropriate harvesting equipment to maximize yield while minimizing crop damage. Also, producers can engage customers such as wholesalers or retailers in the cities to communicate the implications of order changes. In the processing stage, waste is usually caused by quality issues and size variations. Processors can reduce food wastage by applying technical solutions such as reengineering production processes and product design to reduce waste, using product sizes and packaging that reduce waste by customers, and standardizing date labels to reduce confusion among the end users of the product, improving training to reduce errors during processing.

DEFF and CSIR (2021) suggested some steps that processors can take to reduce food wastage including:

- Measure food losses and identify the causes
- Train staff to prevent food losses
- Process optimization through identifying hotspots and introducing quick-win solutions to prevent wastage.
- Put measures in place to allow for rapid retrieval, reworking of products, or reintroducing primary materials.
- Finding solutions for production interruptions.
- Effective stock rotation and controls.
- Coordinating production with clients and suppliers.

Food distributors can reduce food wastage by using technological interventions to optimize the transport of food and storage. For example, barcoding is being used to track food transportation journeys. This would enable food distribution managers to know where a product has been, for how long, and in what temperatures and conditions. This would enable retailers to accurately label and handle food to maximize shelf life, while also providing traceability in the event of a recall. Technologies such as block chain, the Internet of Things, and Artificial Intelligence can significantly enhance the efficiency and traceability of food supply chains, reducing waste and improving food safety in Africa (Itohan *et al.*, 2023). Food losses and waste at the distribution part of the supply chain are the highest-value food losses due to the input required to get it to this stage in the supply chain.

DEFF and CSIR (2021) suggested some steps that processors can take to reduce food wastage including:

- Support local producers to keep transport distances for distribution to a minimum.
- Avoid uneven road surfaces where possible to reduce bruising of fresh fruit and vegetables.
- Optimise ordering systems, cold chain management, and stock rotation.
- Avoid overstocking. Ensure the shelf is not always filled to the brim.
- Donate surplus food to organizations such as Food Forward South Africa.

Barriers to municipal food waste reduction strategies Africa's urban centers face a pressing concern: the escalating issue of food waste caused by rapid urban growth and widespread food insecurity. However, numerous obstacles impede the successful execution of food waste mitigation initiatives. Food waste in urban Africa is complex, as these regions face reconciling food insecurity with alarming levels of food waste. This increasing issue impacts food security, the environment, and economic development, leading to substantial losses in resources and increased greenhouse gas emissions.

Existing studies on food waste reduction strategies in Africa highlight the need for both policy intervention and public engagement. In Kenya, Njenga *et al*. (2021) emphasize the role of consumer education in reducing waste, while research from Nigeria (Akinbode *et al.*, 2018) points to weak enforcement of food waste policies. South Africa offers a positive example, where policies focused on both supply chain efficiency and consumer behavior have led to measurable reductions in food waste (Nahman and de Lange, 2021).

This section examines the main obstacles hindering food waste reduction in urban areas of Africa, with a focus on five African countries: Nigeria, Kenya, South Africa, Ghana, and Egypt. By analyzing cross-case patterns, the barriers faced by each country were compared to uncover both shared and unique obstacles.

Infrastructural Deficiencies. Participants from all countries highlighted the lack of sufficient cold chains and storage facilities as a major obstacle. For instance, a retailer in South Africa complained about losing a lot of food due to inadequate refrigeration from the farm to the market. Fruits are often wasted due to spoilage during transportation from poor infrastructure.

Consumer Awareness. In Kenya and Ghana, a recurring issue was the lack of public awareness about the consequences of food waste. A study in Nairobi (Kenya) showed that people often buy more than they need without understanding the waste of their actions (Feedback Global, 2015). A study in Ghana revealed the failure of individuals to realize that discarded food could be recycled to other products (Faizal *et al.*, 2024).

Policy Gaps. Both Nigeria and Egypt show weak policy enforcement, with many expressing frustrations over the lack of clear waste management strategies (Chisika and Yeom, 2025; Okoruwa and Onuigbo-Chatta, 2021). The paper revealed that Nigeria have policies on paper, but without enforcement, they are meaningless (Okoruwa and Onuigbo-Chatta, 2021).

Benefits of reducing municipal food waste

Environmental Benefit. Avoidable consumer food waste (ACFW) is a global environmental issue causing significant damage to global key resources especially in urban areas. It is usually dominated by commodities such as beef, dairy products, rice, and wheat. A recent study has found that, a 50% reduction in avoidable consumer food waste could save up to 198 metric tons (Mt) of carbon dioxide (CO_2) emission, 30 grams cubic meter (GM^3) of blue water, and 99 million hectares (Mha) of land (Antoine *et al.*, 2024). Reduction of ACFW by this amount globally will help in alleviating the pressure facing urban areas in terms of increased land dryness which will help in achieving the United Nations Sustainable Development Goals of 2030. This is also achieved by the proposed United Nations Sustainable Development Goal 12.3 per capita global food waste at the retail and consumer levels to be halved by 2030 in urban areas.

Health Benefit. Reducing food waste in urban areas provides numerous health benefits both directly and indirectly. Hence, disease incidences and prevalence caused by

environmental food contaminants are either eliminated or reduced. Furthermore, food waste reduction tends to increase the health safety in the population which enables more people to have access to high-quality foods free from contaminants. Therefore, food waste reduction in the urban areas will not only improve food security but also provide optimum solutions to malnutrition disorders and hunger cases and provide more access to high-quality healthcare access for the people living in the regions (Aldaco *et al.*, 2020; Stanciu *et al.*, 2022). Effective strategies in food waste management will also help in reducing the disease prevalence in the areas resulting in significant costs in disease management and prevention.

Economic Benefits. Food waste reduction in urban areas contributes immensely to the circular economy that enables the development of secondary markets by adding more value from by-products where wasted food can be converted into compost, bioenergy, or even animal feed. Local diversion of waste foods from landfills can further support the sustainable industries that use food waste as a raw material which consequently boosts the local economy. A recent study found that establishing and maintaining household food waste (HFW) from large economic investment and appropriate utilization of the system could result in enormous amounts of energy and material recovery thereby creating significant financial revenue (Yang *et al.*, 2022). Food waste reduction initiatives provide effective socio-economic empowerment such as lower household food expenditure, thereby, saving cost caused by food waste.

CONCLUSION AND RECOMMENDATIONS

Food waste reduction strategies in urban areas are associated with a significant number of benefits through the effective provision of an enabling environment suitable for agricultural activities that will ensure food security and economic boost in Africa. Food waste reduction helps in preventing nutritional disorders due to poor quality food in circulation and eliminating hunger in urban areas. Effective food waste reduction strategies in Africa also help in achieving the target set out by the United Nations Sustainable Development Goal by 2030. The following actions can be recommended:

Infrastructure Investments: African governments should prioritize the development of cold chains to preserve food during transport and storage.

Consumer Education: Launch Public awareness campaigns in Africa to educate consumers on the importance of reducing food waste.

Policy Reform: African Governments need to create stronger policies with clear enforcement mechanisms to support waste reduction strategies. Furthermore, governments should provide incentives for waste reduction.

Future research should explore the use of digital solutions, such as mobile applications, to track and reduce food waste. Additionally, further studies should examine the potential for public-private partnerships in addressing these barriers.

DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest in the paper.

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