Journal of Food Security, 2021, Vol. 9, No. 1, 1-7
Available online at http://pubs.sciepub.com/jfs/9/1/1
Published by Science and Education Publishing
DOI:10.12691/jfs-9-1-1

Urban Dynamics of Food Loss and Waste: Challenges and Opportunities for Improving Food Security in Kisumu, Kenya

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Received October 28, 2020; Revised November 29, 2020; Accepted December 08, 2020

Abstract The 21st Century has witnessed a rapid growth in global population characterised by an increasing proportion of urban dwellers. While feeding this growing urban population is a challenge, estimates indicate that one-third of all food produced in the world gets lost or wasted. This study, premised on the FAO conceptual framework of food loss and food waste, sought to identify the linkages between urban dynamics and the causes of food loss and waste along the food supply chain. The study involved data mining, review, thematic analysis and integration of both primary and secondary data from three research projects conducted in Kisumu by Kisumu Local Interaction Platform (KLIP). The study found that Kisumu city and the wider county is deficient in food production; more than 65% of the city population resides in informal settlements, with inadequate infrastructure and services; and food insecurity is prevalent. Though accurate quantitative data was not available on the food lost at the various stages of the supply chain, food losses were noted at the all stages. Food losses at production and post harvest handling stages were caused by flooding, pests, and contamination. Food losses during processing were minimal due to fewer food processing industries in the city. Most food products from small scale producers were transported via public road transport, often without proper packaging leading to physical damage and contamination. At the market stage, inadequacy of food storage and preservation facilities led to food losses. At the consumption stage, food waste was low due to poverty as households generally buy smaller amounts of food on a day to day basis. However, some food is wasted in restaurants patronized by middle and upper income segments of the population. Reducing loss and waste across the food value chain can contribute to improving food and nutrition security.

Keywords: *urban food security, food supply chain, food loss and waste, urban dynamics, Kisumu*

Cite This Article: Paul Otieno Opiyo, Stephen Gaya Agong, Frankline Otiende Awuor, and Munira Gilani, "Urban Dynamics of Food Loss and Waste: Challenges and Opportunities for Improving Food Security in Kisumu, Kenya." *Journal of Food Security*, vol. 9, no. 1 (2021): 1-7. doi: 10.12691/jfs-9-1-1.

1. Introduction

Food Loss (FL) is defined by Food and Agriculture Organization of the United Nations (FAO) as the decrease in the absolute quantity and/or quality of food resulting from decisions and actions by food suppliers in the chain, excluding retailers, food service providers and consumers. It refers to any food that is discarded, incinerated or otherwise disposed of along the food supply chain from harvest/slaughter/catch up to, but excluding, the retail level, and does not re-enter the chain for any other productive use, such as food, feed or seed [1]. On the other hand, Food Waste (FW) is part of the FL which refers to the removal from the Food Supply Chain (FSC) of food (whether processed, semi-processed or raw) which is fit for consumption, by choice, or which has been left to spoil or expire as a result of negligence by the actor, predominantly, but not exclusively, the final consumer at the household level. It thus refers to the decrease in the quantity or quality of food resulting from decisions and actions by retailers, food service providers and consumers [1].

According to FAO, food security exists at the individual, household, national, regional and global levels "when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" [2]. From this definition, four main dimensions of food security can be identified: food availability, access, utilization and stability. For food security objectives to be realized at all the levels, all the four dimensions must be fulfilled concurrently [2]. However, the global efforts to attain food security are undermined by unabated food loss and waste. Nearly one third of all food produced globally for human consumption is lost [1,3], despite the food and nutritional security challenges facing the fast growing global population.

The rapidly growing global population is characterised by an increasing proportion of urban dwellers. Fifty five per cent of the world's population lived in urban areas in 2018; and it is projected that by 2050, 68 per cent of the world's population will be living in urban settings [4]. While feeding this growing urban population is a major developmental challenge of the 21st century, rough estimates indicate that one-third (approximately 1.3 billion tons) of all food produced in the world for human consumption gets lost or wasted [3].

Notably, food and green waste comprise more than 50 per cent of all municipal waste, which is commonly the single highest budget for most local governments. In low-income countries, food expenditure in cities may be as high as two thirds of total household expenditure, while agro-industry accounts for more than 50 per cent of value addition due to manufacturing. Urban dwellers, even in countries with large rural populations, consume up to 70 per cent of food supply. Reducing food loss and waste is widely seen as an important way to reduce production costs and increase the efficiency and effectiveness of the food system, improve food security and nutrition, and contribute towards environmental sustainability [1,3,5].

The United Nations estimates that close to half of the worlds urban dwellers are in relatively small settlements of less than 500,000 inhabitants [4]. These secondary cities usually have inadequate institutional and financial capacity to cope with the challenges of rapid urbanization. In Africa, it is estimated that thousands of new towns and cities will emerge as it crosses the 50% urban threshold shortly after 2030 [6]. Kisumu, the third largest city in Kenya is a classic example of such secondary cities in Africa.

Food security has often been viewed as a rural issue, with governments and other stakeholders mainly focusing on increasing food production with less attention to food quality. The focus in urban areas has traditionally been on preventing food contamination and spread of diseases. [7,8]. However, there is more to urban food and nutrition insecurity beyond food production or contamination and spread of diseases. There are several urban dynamics including infrastructure and services, socio-economic, socio-cultural and governance factors that have an influence on the food system (Figure 1). This paper aims to identify the linkages between these dynamics and the causes of food loss and waste along the FSC, and proposes interventions in the system to minimize FLW and improve food security. An ocular and critical analysis of urban dynamics of food loss and waste is premised on a framework (Figure 1) adopted from FAO definition and conceptual framework of food loss and food waste [5,9].

This improved framework indicates that food loss and waste occur at various stages of the supply chain. Food loss mainly occurs at the earlier levels of the supply chain from production, post harvest handling and storage, processing and packaging, and distribution; while food waste occurs at the retail and consumption levels. FLW is caused by un-harvested crops, pests and diseases, contamination, spoilage, damage, expiry, overstocking, oversized portions, customer preferences, bulk purchases and menu behaviour. These causes of FLW are influenced by urban dynamics including infrastructure and services; socio-economic; and socio-cultural factors. An attempt is made in this current study to use the food value chain approach in identifying the linkages between these urban dynamics and FLW as well as their implications for urban food and nutrition security.

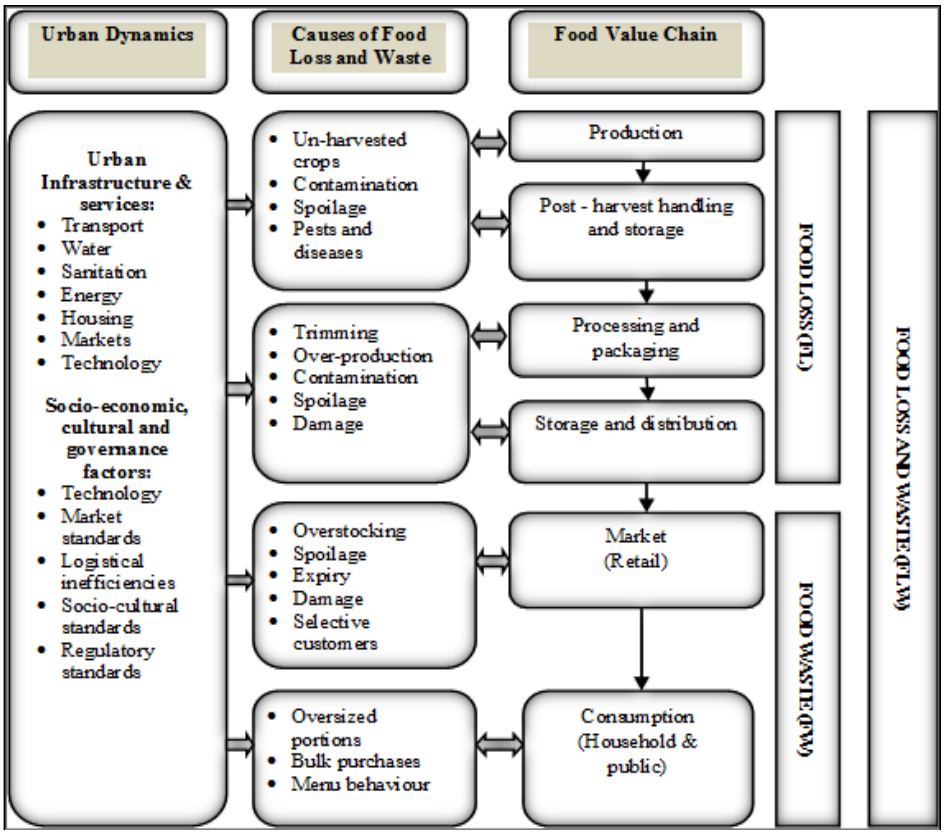

Figure 1. Urban dynamics of food loss and waste along the food supply chain (adopted and modified from FAO)

2. Materials and Methods

Secondary data collated from different sources such as the FAO and three previous research projects done by Kisumu Local Interaction Platform (KLIP) from 2016 - 2020 have been integrated bringing into perspective both primary and secondary data in addressing the objective of this study. The previous projects undertaken by KLIP include: Consuming Urban Poverty (CUP) project, formally called 'Governing food systems to alleviate poverty in secondary cities in Africa'; Nourishing Spaces (NS), formally called 'Food systems governance for prevention of non-communicable diseases (NCDs) in Africa'; and Mistra Urban Futures - Realizing Just Cities. These projects employed both qualitative and quantitative methods of data collection. This current study thus involved mining and reviewing data and analysis of published literature on food loss and waste. Thematic analysis was applied to identify and draw linkages between the causes of food loss and waste along the food value chain; urban infrastructure and services; and socio-economic dynamics.

The study adopted a descriptive, analytical and explorative approach to discuss the main causes and sources of FLW. The study further emphasizes on reducing FLW as one of the actions to achieve food and nutrition security and improve the sustainability of global and local food systems. The findings of the study are presented and discussed in the following sections.

3. Results and Discussions

3.1. Kisumu City's Food Security Challenges

Kisumu City is located at the shores of Lake Victoria which happens to be the second largest fresh water lake in the world. According to the latest census conducted in 2019, the city population stood at 507,402 inhabitants [10]. Kisumu has a huge potential for fishing and associated blue economy enterprise. The majority of the residents of Kisumu are ethnic Luo, who were predominantly fishermen. However, fishing industry around Kisumu has been negatively affected by dwindling fish stock due to overfishing, the invasive water hyacinth and environmental pollution [11]. The city is surrounded by rich agricultural lands suitable for food crop production. The farming areas to the east of the city are dominated by commercial sugarcane plantations and rice paddy fields, while the rest of Kisumu County practices small scale farming of maize, legumes, vegetables, and livestock keeping for subsistence. Kisumu grew from a centre for barter trade in agricultural produce in 1901 to become the sub-national administrative and commercial hub of Western Kenya.

A 2016 survey established that about 31% of household members aged 20 years or older were unemployed [11]. This has implications on household food security in the city as majority of residents depend on food purchased from the market [11]. Furthermore, estimates from the 2019 census indicate that more than 65% of Kisumu city's population live in informal settlements, with inadequate infrastructure and services [10]. The daily food requirements of majority of residents (75%) are obtained via informal traders [13]. The city has high prevalence of food insecurity and nutritional challenges. The CUP project 2016 household survey found that nearly 86 per cent of households had a Household Diet Diversity Score (HDDS) of six and less, indicating nutritional deficiency. Measured using Household Food Insecurity Access Prevalence Scale (HFIAP), the same survey established that 26 per cent of respondents were moderately food insecure while 45 per cent were severely food insecure [13].

Like other urban areas in low income countries, Kisumu is challenged by the double burden of malnutrition - the coexistence of under-nutrition and overweight/obesity or diet-related non-communicable diseases in the communities and households [12,14]. All forms of malnutrition manifest in the city at various scales: Under-nutrition, which includes wasting (low weight-for-height), stunting (low height-for-age) and underweight (low weight-for-age); are common among children, particularly in poorer neighbourhoods. However, conditions of micronutrient-related malnutrition, which includes micronutrient deficiencies (a lack of important vitamins and minerals), or micronutrient excess; and overweight, obesity and diet-related non-communicable diseases (such as heart disease, stroke, diabetes and cancers) are fast growing in the city. This transition is taking place amidst food loss and food waste at the local and national levels and increasingly questionable food safety and quality.

3.2. Food Loss and Waste along the Supply Chain

Food supply chains are complex as they include different level actors, from those who produce and aggregate; to those adding value to the product (processing and packaging); and those selling into the next level (wholesale and retail) [9]. Food losses occur along the supply chain when there is decrease in the quality and quantity of edible food mass throughout the supply chain that specifically leads to edible food for human consumption. As articulated already, food waste occurs when there is a decrease in the quality and quantity of food due to decisions and actions by retailers, food service providers and consumers.

3.2.1. Food Loss at Production at Post Harvest Handling

Rough estimates indicate that 54 percent of the world's food losses and waste occurs 'upstream' during production, post-harvest handling and storage [3]. Data was not available on quantities of food lost 'upstream' in Kisumu. However, there are food losses at production stage in the farmlands neighbouring the city often caused by flooding, pests and diseases, and contamination. For example, the National Irrigation Board (NIB) estimated that about 1,500 acres of rice was destroyed by floods in Ahero Irrigation Scheme within Kisumu County in 2020 [15]. In the same year, the Kenya News Agency reported that rice worth KES.800 million at Ahero and West Kano Irrigation Schemes was destroyed by floods [16]. In 2018, six hundred rice farmers, members of Ahero Multipurpose Co-operative Society lost an estimated 950 bags of rice worth KES 10million due to destruction by birds [17].

Poor on farm and in home storage facilities often causes food loss to pests and rodents, and sometimes to weather elements. Fresh products like fruits, vegetables, meat and fish straight from the farm or after the catch can be spoilt in hot climates due to lack of infrastructure for transportation, storage, cooling and markets. Post-harvest losses of fruits and vegetables are far higher than those of cereal crops. Estimates of horticultural losses in Kenya have been reported to be as high as 50 percent, mainly due to poor storage and handling practices [18]. Kisumu climate is hot and humid making fresh products to get spoilt unless kept in suitable preservation facilities. For example, inadequate handling facilities and delay between catch and distribution contribute towards fish spoilage. On landing the fish are dumped on the sandy beaches and the most preferred fish preservation method at the landing sites is sun-drying, done directly on the ground or on top of old fishing nets, exposing fish to contamination [19].

Naturally occurring aflatoxin in maize is a long-standing problem in Kenya, accelerated by humid storage conditions. The country is considered a world hotspot, with incidents of acute toxicity recorded in 2004 and 2010. Maize is Kenya's main staple used to prepare *ugali*, a cooked starchy paste the key ingredients of which are maize flour and water. Maize is also used to prepare another traditional dish, *githeri*, which is a mixture of maize and beans, cooked whole. In 2019, several maize meal brands were taken off the market due to unsafe levels of aflatoxin [20].

3.2.2. Food Loss at Processing and Packaging Stage

Food is lost during processing because of spoilage down the production line. Errors during processing lead to final products with the wrong weight, shape or appearance, or damaged packaging, without affecting the safety, taste or nutritional value of the food. In standardized production lines, these products often end up being discarded [21]. Labour disruptions and mechanical breakdowns also lead to losses of perishable foods.

Food losses during processing are minimal in Kisumu due to fewer food processing industries. There are sugar milling companies in the satellite towns of Kibos, Chemelil and Muhoroni. The city has two maize milling plants and one fish processing factory. Other food processing enterprises are involved in small scale food preservation and packaging targeting the local market [22]. The small scale food processing industries do not have adequate capacity to process and preserve fresh farm produce to be able to meet market demand. Part of the problem stems from the seasonality of production such as that seen in mangoes and avocadoes; and the cost of investing in processing facilities that will not be used year-round. Most by-products of these small scale industries are usually recovered for use as animal feeds.

3.2.3. Food loss at Distribution Stage

The current trends in globalization have precipitated unforeseen distant food miles with various food products being transported to consumers in all parts of the world. Transportation is done by plane, train, trucks or ship among others. Not all the transported goods will in the end be purchased by consumers. Some food is lost due to mechanical damage, caused by vibration during transportation. The increasing distance between primary production sources and food consumption areas results in the necessity of transporting food products over greater distances.

Kisumu is generally deficient in food production and food is brought into the city from distant production sources within Kenya and neighbouring countries. The 2016 CUP project revealed in the reverse value chain analysis (RVCA) of five key food commodities that maize is brought into the city from TransNzoia, Uasin Gishu, Narok and Bomet counties in Kenya and Busia (Uganda). Tilapia and Nile perch are brought into the city from Siaya and Busia, while dried fish is brought as far as from Lake Turkana in northern Kenya and Uganda. Cabbages and kales are brought from Bomet, Kisii and Nakuru counties. Sorghum and cassava for making porridge are obtained from Busia, Kisii and Migori counties. Most eggs are brought in from Nakuru and Uganda [22]. Maintaining the physical condition of the products requires proper packaging and containerization, which is hardly available to most transporters bringing food into Kisumu. Some eggs are lost due to breakages, fish and vegetables are lost as a result of contamination and spoilage, and some maize is exposed to moisture, leading to natural growth of aflatoxin. Large volumes of tomatoes are usually discarded at Kibuye market due to mechanical damage resulting from of poor handling during packaging and transportation.

There are few specifically designed food transportation trucks in Kenya, mainly operated by large scale distributors. Most food commodities from small scale producers are transported via public transport, often without proper packaging leading to physical damage and contamination. For example, fresh milk requires continuous refrigeration from production to consumption, which is hardly available to small-scale producers. Another important factor is the number of accidents/collisions involving the means of transportation especially the vehicles carrying goods. Accidents, collisions or other incidents are common on Kenyan roads, making it impossible for transporters to continue with their journeys with the resultant huge losses and wastage of food.

3.2.4. Food Loss and Waste At Market Stage

Supermarkets usually order a variety of food types and brands from the same manufacturer to get beneficial prices. Consumers also expect a wide range of products to be available in supermarkets. A wide range of products (especially brands of the same product) does however increase the likelihood of some of them reaching their "sell-by" and expiry dates before being sold, and thereby wasted. When shopping, consumers expect store shelves to be well filled. Although certainly beneficial for sales statistics, continually replenished supplies mean that food products close to expiry are often ignored by consumers.

Data collected by CUP project in 2016 and Nourishing Spaces project in 2018 indicates rapid growth and expansion of supermarkets in Kisumu in the last two decades. In the year 2000, there were only three supermarkets in Kisumu, and all were in the city centre. By 2010, the number grew to seven supermarkets and by 2018 there were eighteen supermarkets in Kisumu. Supermarkets are characterized by large range and

quantities of products on display. Retailers assume that consumers like full shelves and full shelves give the consumer the chance to choose which product is of highest quality and fits them best. Retailers therefore stack the shelves as full as possible, leading to food loss and waste, particularly for fresh produce as the bottom products carry the weight of all the products on top of them. The bottom products will bruise/damage more easily and will not be bought and in the long run get spoilt.

Supermarkets often respond to consumer demands for aesthetic quality. Food that would normally be fit for human consumption is rejected by supermarkets due to their appearance. This was observed in Kisumu, particularly with fruits and vegetables. Supermarkets demand high aesthetic quality of fruits and vegetables and those not meeting the standards are rejected. Further because these foods are highly perishable, some of the foods rejected by supermarkets end up in waste bins. Fresh food traders interviewed at Kibuye market indicated that they normally do not supply supermarkets in Kisumu due to their inability to guarantee stable supply of foods that meet the stringent aesthetic standards.

Kisumu has inadequate fresh food storage facilities in the municipal markets, and among informal retailers who dominate the foods retail sector. A survey of both formal and informal food traders done by CUP project in 2016 established that spoilage (51 per cent of cases) was the second highest cost incurred by food retailers after transportation. The same survey also revealed that fresh food (at 58 per cent) accounted for a greater proportion of all foods sold by the respondents [22]. Fresh foods require water and appropriate storage and preservation infrastructure to prolong shelf life and maintain hygiene. The CUP study noted that about 54 per cent of respondents lacked electricity, 75 per cent lacked refrigeration facilities, 57 per cent lacked sanitary facilities, and 70 percent lacked piped water [22]. The inadequacy of these infrastructure and services contributes to food loss due to spoilage and contamination.

Another study done in September and October 2018 involving participatory 14-day cleaning of Kibuye market and weighing of waste collected by traders confirmed that municipal waste from the market was mainly spoilt fruits and vegetables. It was noted that tomatoes, onions, pineapples, mangoes, melons, among others was part of the organic wastes removed from the market on a daily basis. The study established that an average of 1,214 kg of vegetables, 477kg of fruits, and 157kg of maize is collected from the market to the dumpsite daily, excluding some food waste that was recovered to feed animals [23].

3.2.5. Food Loss and Waste at Consumption Stage

Like other cities elsewhere in contemporary developing countries, food wasted at consumer level is minimal in Kisumu. A contributing factor is that consumers generally buy smaller amounts of food products at the time, often just enough for the day's meals. Poverty and limited household incomes make it unacceptable to waste food. A majority of Kisumu households buy food on a day to day basis from the informal traders due to low incomes and inadequate storage and preservation facilities [12]. However, food waste was noted in some eateries and restaurants patronized by middle to high income people. Some of these restaurants serve buffets at fixed prices, which encourage people to fill their plates with more food than they can actually eat. The common practice of keeping buffets fully stocked during business hours (rather than allowing items to run out near closing) creates even more waste. Some of the uneaten foods from restaurants are recovered to feed domestic animals like pigs and dogs, but some still end up in waste dumps.

At the household level, people have adopted different strategies to minimize food loss and waste. As noted earlier, majority of households in Kisumu city live in informal settlements with inadequate access to energy, water, sanitation and kitchen facilities. Interviews done under the Nourishing Spaces project established that such households purchase food for daily consumption. Additionally, the fear of losing food to spoilage encourages stocking and consumption of less perishable, usually ultra processed foods rich in sugar, salt and fat; contributing to rising incidences of non-communicable diseases in the city [14]. The middle and high income households who have food storage and refrigeration facilities are faced with the challenge of frequent electricity outages, sometimes lasting several hours or days leading to degeneration and loss of food under refrigeration at home.

Kitchen culture and inadequate culinary skills also contribute to food wastage. Some foods lose their nutritional value due to improper cooking and improper storage. Some people often forget, or due to personal preferences do not eat leftovers and end up throwing them away. Confusion over the meaning of date labels such as "sell by," "best if used by," and "expires by" also contributes to food waste as some people prematurely discard food which is ideally still fit for consumption.

4. Conclusions and Recommendations

Reducing loss and waste across the food value chain contributes to improving food and nutrition security of low-income consumers, minimizing environmental impacts of agriculture, and improving the incomes and livelihoods of chain actors. In Kisumu, long term investments are required to control natural disasters that cause loss of food crops in farms. For example, the proposed Koru-Sunoi dam project to control flooding in the Nyando River basin will reduce perennial flooding in Kano Plains and reduce loss of rice in farms and stores. Food loss at the farm level can also be reduced by controlling birds and other pests that destroy crops in the fields. This can be done through early warning systems and preparedness, and effective control measures. Simple and practical technologies and innovations exist, which need to be disseminated and scaled up to minimize losses. For instance, at the farm level, farmers can reduce their losses through proper practices such as timely harvesting, proper drying, maintenance of storage hygiene, grain treatment and employment of better processing and transportation techniques. Use of metal/plastic silos and hermetic bags can significantly reduce losses from pests. Both the national and county governments need to promote good on-farm and off-farm produce handling and management practices through extension service provision.

For the fishing industry, investments in fish preservation facilities at fish landing sites and processing facilities will reduce loss due to spoilage. Cage fish farming in Lake Victoria should be encouraged as it facilitates controlled harvesting, so that only quantities required in the market, and which processing and preservation facilities can accommodate are harvested from the lake.

Food processing industries should enhance recovery efforts of food that may be lost due to trimming, physical damage, aesthetic quality, and improper packaging but are otherwise fit for human consumption. They should be encouraged to invest in efficient production systems that minimize losses and encourage waste recovery for production of animal feeds and manure for improved food production.

Food lost in distribution through contamination, spoilage and damage can be minimized by investments in improved transport and storage infrastructure, and specialized food transportation trucks for large scale producers. Simple technologies also exist for small scale producers and distributors to reduce losses. For example locally fabricated coolers for fish, fruits and vegetables' are available in the market and their use should be encouraged. Small scale producers and traders should be encouraged to organize themselves into federations or co-operative societies so that they are able to deliver sufficient quantities and quality of fresh produce to supermarkets that have storage and refrigeration facilities.

Inadequate and inefficient market systems and infrastructure cause high food losses. Most wholesale and retail markets in Kisumu are overcrowded, unsanitary and lack cooling equipment. When there is oversupply, perishable products like cabbages, kales, carrots, mangoes and oranges get wasted in the markets and soon after there are shortages of the same commodities. Market information need to synchronize demand with supply. The city needs to collect data on food requirements and facilitate linkages and communication between food suppliers and retailers in the city to more accurately estimate demand. Availability of market information will enable food retailers to avoid overstocking but work with value chain actors to improve efficiency of the supply chains to ensure access to consumers. Food retailers should strengthen their stock management systems and take proactive measures to minimize expiry of food on the shelves. Such measures include selling inventories nearing expiry dates at a discount or donating some to social feeding programs.

As noted earlier, food waste at the consumption stage is minimal in Kisumu, just as in other cities in developing countries. However, some food is wasted mainly due to negligence, actions and choices of retailers and consumers. Minimizing food waste at this stage calls for attitude and culture change. For example, buffet providers should encourage people to serve only food they can finish. Restaurants should be encouraged to recover any leftover foods for feeding domestic animals. People should also be encouraged to diversify their staples to minimize looses of some foods that are not considered staple. For example, *ugali* is the main staple for majority of residents of Kisumu. In some seasons, rice may be in abundance but goes to waste due to preference for *ugali*.

Because the quality of some foods is lost due to inappropriate cooking or preservation techniques, there is need to strengthen mass education on appropriate cooking and food preservation techniques. In particular, Kisumu needs to support and expand the home economics and nutrition departments of the county government. Access to household infrastructure and services such as housing, water, sanitation, and energy is essential to minimize food wastage and improve hygiene at household level. The Kenya government has in recent years invested heavily in expansion of electricity and water provision, but these are still inadequate, particularly in informal settlements.

Food loss and waste occurs at all stages of the supply chain despite food insecurity still being a major challenge for majority of the residents of Kisumu city. There are linkages between urban infrastructure and services, socio-economic and socio-cultural dynamics, and food loss and waste along the supply chain. In addition to improving food production and value addition, policy should focus on minimizing food loss waste along the supply chain. This can be done by encouraging investments in on farm and off-farm food handling facilities, pests and disease control, provision of infrastructure and services, market information and better communication along the supply chain.

When more food is lost in the supply chain, less food is available for consumption. To feed the ever growing urban population, farmers therefore have to produce more, putting pressure on land and water resources. Additionally production of more food means more air and water pollution and loss of vegetation. Conclusively, minimizing food loss and waste will not only improve food security, but will also reduce pressure on land, reduce pollution and ensure environmental sustainability. Further research into the extent of food loss and waste is needed at national and local levels to inform future policy decisions and actions.

Acknowledgements

This publication was made possible by Kisumu Local Interaction Platform through the support of Swedish International Development Agency (SIDA). The Consuming Urban Poverty project was funded by the United Kingdom Department for International Development (DFID)/Economic and Social Research Council (ESRC), while the Nourishing Spaces project was funded by Canadian International Development Research Centre (IDRC).

Statement of Competing Interests

The authors have no competing interests.

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