Food and Agriculture Organization of the United Nations

IWMI
International Water Management Institute

Case studies on food waste quantification, characterization, and identification of prevention and reduction options in Colombo, Sri Lanka

CGIAR
RESEARCH PROGRAM ON
Water, Land and Ecosystems

Case studies on food waste quantification, characterization, and identification of prevention and reduction options in Colombo, Sri Lanka

Authors

Nilanthi Jayathilake, International Water Management Institute, Colombo, Sri Lanka

Mohamed Aheeyar, International Water Management Institute, Colombo, Sri Lanka

Nalaka Wickramasinghe, University of Kelaniya, Colombo, Sri Lanka

Camelia Bucatariu, Food and Agricultural Organization of the United Nations, Rome, Italy

Pay Drechsel, International Water Management Institute, Colombo, Sri Lanka

Food and Agriculture Organization of the United Nations
International Water Management Institute
Colombo, 2023

Required citation:

Jayathilake, N., Aheeyar, M., Wickramasinghe, N., Bucatariu, C. and Drechsel, P. 2023. C*ase studies on food waste quantification, characterization, and identification of prevention and reduction options in Colombo, Sri Lanka*. Colombo. FAO and IWMI. https://doi.org/10.4060/cb8396en

ISBN 978-92-5-135672-2 [FAO]

Contents

Figures

Tables

Photos

Annexes

Acknowledgements

The authors would like to thank all contributing organizations for their help and the participants of all case studies for their support in conducting the studies and providing valuable data. Thanks are also extended to Kalpana Lakshmi, Chathurya De Silva, Methila Hewage, Shehani Gamage and Hashan Wimalasiri for their huge support in the data collection process. This report is prepared under the FAO funded project on “Innovative approaches to reduce, recycle and reuse food waste in urban Sri Lanka” that was implemented under the oversight of the Ministry of Urban Development and Housing in collaboration with the International Water Management Institute (IWMI) from June 2019 to August 2021. Thanks also go to CGIAR research program on Water, Land and Ecosystems (WLE).

Abbreviations and acronyms

CEA	Central Environmental Authority
CSR	Cooperate Social Responsibility
DEC	dedicated economic center
ERP	Enterprise Resource Planning
FW	food waste
HACCP	Hazard Analysis Critical Control Points
GHGEs	Green House Gas Emissions
MoA	Ministry of Agriculture
NDEC	Narahenpita dedicated economic center
SDG	Sustainable Development Goal
SW	solid waste
SWM	solid waste management
UC	urban council
UDA	Urban Development Authority

Executive Summary

Food waste (FW) is a key challenge on the sustainable development agenda of countries worldwide. The lack of FW data and insights from its analysis about quantities, causes, and characteristics is a significant obstacle in implementing adequate reduction and prevention interventions for different sectors. The primary purpose of the case studies was to review FW prevention, reduction, and management initiatives. Lessons and best practices that enable and facilitate solutions were identified.

Nine case studies were conducted targeting five sectors: food services (one restaurant and one hotel), wholesale markets (one fruits and vegetables wholesale market), retailers (one retail market, one retail shop, and one supermarket), caterers (one hospital), and households (five middle- and five high-income households). The case studies consisted of a FW audit that measured the amounts generated from various processes and identified drivers/causes and current best practices. Quantification involved physical separation, weighing, and categorizing the different food components. The separation classified quantities into edible and inedible portions. The study also focused on assessing the environmental and socio impacts, based on assessed and categorized FW quantities.

Results revealed that some large-scale food business operators such as hotels and supermarkets are following voluntary commitments towards preventing and reducing FW. However, it was noted that the mechanisms to monitor the effectiveness of such interventions were lacking, hence the benefits of the investments made on those actions were not identified. The applied case study method allowed the identification of the most suitable FW prevention and reduction strategies that are sector specific, via measure-act-monitor approach. Moreover, results indicated that FW mostly consisted of vegetables in the wholesale and retail sector and cooked rice in the case of the food service sector with about 50–70 percent still edible at the time of discarding. Such disaggregated data were alarming to the participants. This type of knowledge can be used to set targets for FW prevention. For instance, the hotel case study successfully implemented several strategies that follow measure-act-monitor approach and was able to reduce FW from 540 g to 200 g per customer within four months.

Environmental impacts of FW estimated in terms of carbon footprint, water scarcity footprint, and soil quality index indicated different scenarios across the sectors depending on the FW volumes corresponding to food commodities (rice, vegetables, fruits, meat and fish) and the final disposal practices.

Lack of awareness, capacity, and expertise coupled with behavioral issues were essentially the most common causes for FW generation in all the case study sites. In addition to that, the hotel and supermarket case studies indicated that compliance requirement was a key barrier in implementing some of the FW prevention and reduction strategies such as food redistribution. The reasons for FW in the wholesale market were mostly associated with bulk transportation, poor handling of vegetables and fruits and lack of proper storage facilities. The retail sector also had similar reasons in addition to the customer behavior which demand the aesthetic appearance of the foods. Hospital and household case studies revealed that the lack of awareness and behavioral issues were the major causes for FW generation. Strategies specific to each sector were recommended based on findings such as increasing awareness, educational activities on food management, and identifying innovative business opportunities.

1. Introduction

Sustainable Development Goal (SDG) 12.3 aims to "by 2030, halve per capita global food waste (FW) at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses." Lack of FW data is a common challenge across the globe. Better data supports identifying appropriate strategies to reduce FW and to evaluate the cost-effectiveness of adopted strategies (Aschemann-Witzel *et al*., 2017; Muth *et al*., 2019)**.**

Data on FW are often confidential, unavailable, partial, or biased (Warshawsky, 2016). Warshawsky (2015, 2016) advises researchers to examine FW flows together with food business operators' role in the supply chain and their corporate motivations driving sustainability programmes. Lack of data and knowledge about FW quantities, categories, and edible and inedible portions, is a significant obstacle in implementing any reduction and prevention effort. In Sri Lanka, data on FW are scarce. Moreover, there is a lack of understanding of the characteristics of FW at different stages of the value chain.

Jayathilake *et al.* (2023) estimates that about 55 percent of the solid waste generated in the western province that is directed to three disposal sites; Kerawalapitiya, Karadiyana and Kaduwela is FW which is about 724 tonnes . However, there was no evidence available on the characteristics of the estimated FW. The primary objective of this study is to assess the FW generated by various food business operators and by selected households in Colombo (Sri Lanka) to facilitate the development and prioritization of reduction strategies via a case study approach. The generated cases serve as a tool to inform larger stakeholder groups and support their decision-making towards FW reduction. The case studies' primary purpose is to review and perform an analysis of FW quantities, categories, and edible versus inedible portions, for future prevention and reduction initiatives for food services, markets, retailers, caterers, and households while assessing FW environmental and socio-economic footprints.

2. Context

From June 2019 to August 2021, the project *Innovative approaches to reduce, recycle and reuse FW in urban Sri Lanka* was implemented under the oversight of the Ministry of Urban Development and Housing, in collaboration with the Food and Agriculture Organization (FAO) and the International Water Management Institute (IWMI). The project had six working areas (see **Figure 1**). This report is the deliverable for the 1.4 project component (i.e. field case studies).

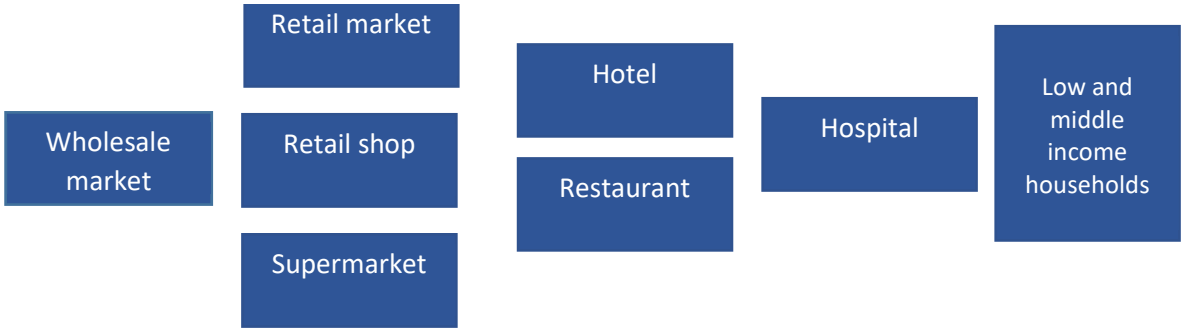
Figure 1: *Major components of the 2019 – 2021 project on Innovative approaches to reduce, recycle and reuse FW in urban Sri Lanka*

The major output of the project was to facilitate knowledge development for and drafting of the *Urban Roadmap on FW Prevention, Reduction, and Management in Sri Lanka*, that includes a comprehensive action plan (6 objectives and 15 actions) with monitoring and evaluation criteria.

3. Methodology

FW is a complex phenomenon where the amount, causes and consequences are contextually different (Foti *et al*., 2018). It is not easy to compare and contrast country-level data and the individual actors in the same country (Schanes *et al*., 2018). Therefore, the case study approach has been used in many FW-related studies (Eriksson *et a*l., 2012; Cicatiello *et al*., 2017; Ribeiro *et al.*, 2019). Multiple case studies can be expensive and time-consuming to implement (Gustafsson, 2017). Under this study, we analysed nine case studies targeting five sectors: food services (four restaurants, a dessert shop and one hotel), wholesale markets (one fruit and vegetable market), retail markets (one supermarket, one fruit and vegetable retailer, one Dedicated Economic Center), caterers/institutional canteens (one hospital) and households (five middle-income households and five low-income households) (see **Figure 2**). Entities were selected based on willingness to participate and an actual FW reduction need.

Figure 2: *Selected case studies*

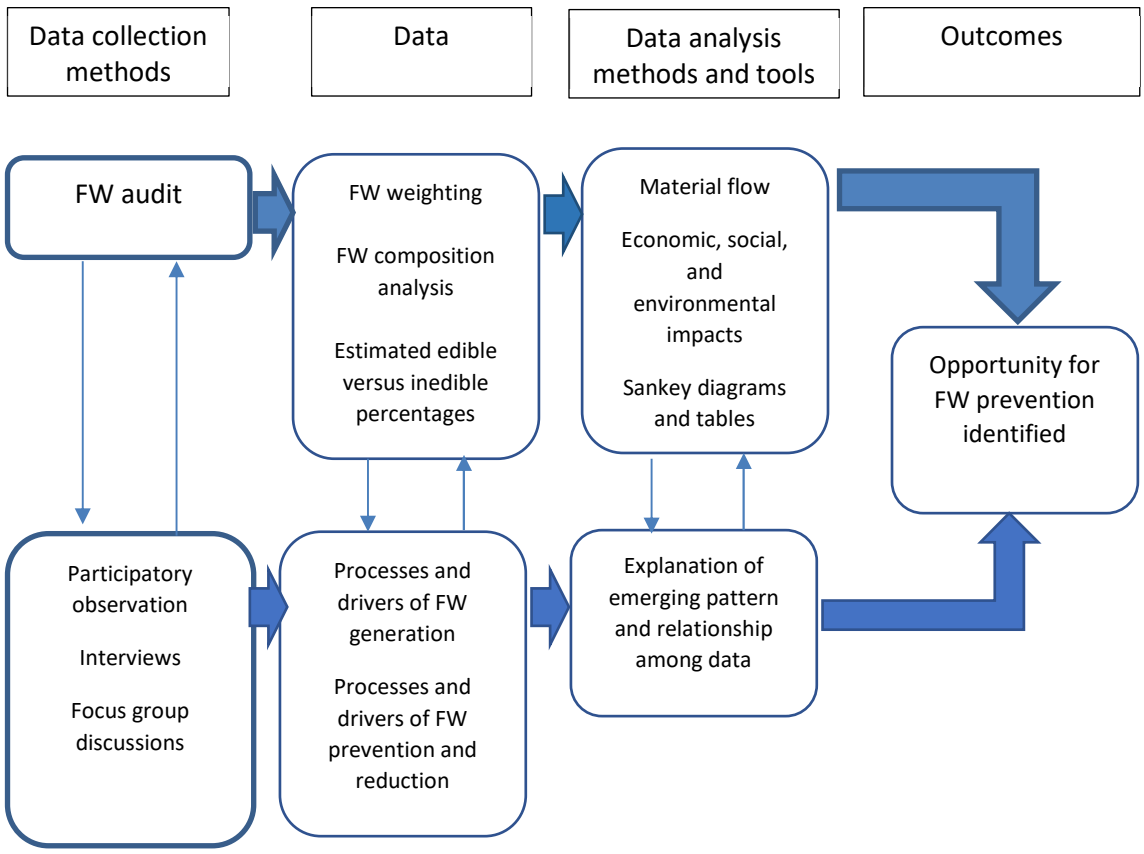


Source: Authors' elaboration.

3.1. Data collection and analysis

It was suggested (Papargyropoulou *et al*., 2019) that collecting qualitative and quantitative data to visualize the comprehensive picture of the FW at different food value chain stages can be effective towards reduction actions. Based on Papargyropoulou *et al.*, (2016) and Papargyropoulou *et al.* (2019), mixed methods were used to collect and analyze the selected case studies. **Figure 3** illustrates the used methodological framework.

Figure 3: *Conceptual framework for the project case studies (i.e. seven-day food waste audits)*



Source: Authors' elaboration, based on Papargyropoulou, E. Lozano, R. Steinberger, J.K. Wright, N. & bin Ujang, Z. 2016. Conceptual framework for the study of food waste generation and prevention in the hospitality sector. Waste Management, 49: 326-336. (also available at https://www.sciencedirect.com/science/article/abs/pii/S0956053X16300174?via%3Dihub)

The quantitative data collection methods comprised FW audits, photographic records, and collation of financial records and inventory of food purchases. FW audits were used to measure the amount generated from various processes, understand routines, and identify the location and causes. The main categorization of FW generation points are:

- *stock FW*, that can have edible or inedible portions from wholesale, retail, and food services;
- *kitchen FW*, also known as production FW (edible or inedible portions), is generated during preparation due to overproduction, peeling, cutting, expiration, spoilage, and overcooking, etc. The source of this flow was identified in wet garbage bins allocated for kitchen departments;
- *surplus FW* consists of excess food that has been prepared but has not been taken onto the customers'/family members' plate, is consumed partially, thus left on the buffet or a food storage area and later on discarded as FW (edible or inedible portions);
- *plate FW* (edible or inedible portions) is discarded food by customers/family members after the food has been sold or served.

The composition analysis was conducted to physically separate, weigh, and categorize FW to identify the different components. FW from each site was classified into predefined categories: first as edible and inedible and, subsequently, into secondary level by food category (see **Table 1** on p. 4). The

research team weighed and recorded the data in a preformatted template for statistical analysis and reporting. In parallel to that, the kitchens staff and, in the case of the household, the family member assigned for the FW audit were asked to maintain a kitchen diary (see **Annex 1**) to record and input waste quantities each day. The data were recorded for one week continuously throughout the day by actor and mealtime.[1]

Table 1: *Classification of FW for the selected case studies*

First level of categorization	**Second level of categorization**	
• Edible (originally purchased, prepared or served; could have been good for human consumption • Inedible (e.g. bones)	Category	Food items
	Rice	Cooked rice, fried rice, milk rice
	Vegetable	All vegetables
	Fruits	All fruits
	Meat	Chicken, pork, beef, sausages, meatballs, bacon, minced chicken
	Fish	All types of fish and sea food
	Starch	Bread, buns, noodles, pasta, cakes, and all other wheat-based products

The study also focused on assessing the environmental and socio-economic impacts of the FW generated. The financial loss of the edible portions from the total FW was calculated based on the unit prices of food. Environmental and social impact were calculated using the FReSH-FW Value Calculator beta V.1.0 version. Accordingly, environmental footprints were estimated based on three model components; carbon footprint, water footprint and land occupation/degradation impact that were measured using climate change impacts (kg CO_2 eq), water scarcity footprint (m^3-eq) and soil quality index (points) respectively (see **Table 2** on p. 5). The environmental impacts of FW are the sum of the impacts of the food's agricultural production, the intermediary accrued additional life cycle impacts between production and disposal (e.g. transports, storage, processing, and cooking, and referred to as life cycle impacts) and the impacts of the destination (e.g. landfill emissions referred to as destination impacts) (FAO, 2019).

[1] There are two different sampling methods: i. continuous sampling of a low fraction of waste, ii. more intensive selection carried out over one or more relatively short periods. As a method of estimating the amount and composition of waste over an entire year, statistical reliability strongly favors continuous sampling. However, practical considerations, including cost and duration of time, the latter method has to be considered. More intensive sampling was carried out at each selected case site for one week continuously in this survey.

Table 2: *Definitions of indicators used to measure the environmental impacts of FW with the FReSH-FW Value Calculator beta V.1.0 version*

Environmental impacts	**FReSH-FW Value Calculator beta V.1.0 version Indicator**	**Definition**
Carbon footprint	Climate change (kg CO_2 eq)	The climate change impact indicates the carbon footprint of FW due to greenhouse gas emissions (GHGs). This accounts for the radiative forcing of various GHGs using the Global Warming Potential for 100-year time frame.
Water footprint	Water scarcity footprint (m^3-eq)	The water scarcity footprint is a key water footprint indicator that encompasses the impact related to water consumption. It considers regional water scarcity as well as water quality.
Land occupancy	Soil quality index (points)	The soil quality index, otherwise known as "land use", in the product environmental footprint of the European Commission, indicates the deterioration of soil quality, where the higher the points the worse the soil quality. This impact is measured in points, which are a relative indicator aggregating impacts on land related to biotic production capacity, erosion, mechanical filtration of water, and groundwater replenishment.

Source: Authors' elaboration.

While the quantitative methods explained the type and measured the amount of FW generated, qualitative methods were adapted to explore the causes and patterns. Qualitative data were collected via in-depth interviews, observation combined with informal semi-structured interviews, and focus group discussions. Gaining an understanding of how much, what type, why, and how FW was generated ultimately helped to identify the most promising FW prevention measures.

After completing the FW audit, preliminary findings, including the proposed FW reduction strategies were shared with the participants. Subsequently, recommendations were made for participants on how to implement the possible FW reduction interventions. The second phase of FW quantification was also proposed to conduct to evaluate the effectiveness of the implemented FW reduction measures.

4. Limitations

In general, selecting the case studies as well as obtaining approvals from the participants was challenging under the circumstances of the COVID-19. Moreover, the first round of FW audits was carried out from August to October 2020, where the food value chain started to recover from the setback created by the first wave of the COVID-19 in Sri Lanka. It was observed that the majority of the cases had not operated at a regular scale, and this influenced the assessment, particularly on quantification.

Given that the FW audit and qualitative interviews were conducted with prior approval from the management of the business entities and the households, there were no restrictions experienced in

accessing and conducting the case analysis. However, due to competitive strategies, strict policies, and compliance requirements, some business entities were reluctant to provide a complete set of data particularly figures on input quantities, sources, sales quantities, and financial values. In such cases, the team adapted a system to acquire necessary information via key informant interviews and structured questions.

Finally, participants were sometimes reluctant to fill up the FW diaries, given the fast pace of some of the operations, and this warranted a continuous follow-up.

The study also intended to guide the participants to implement FW reduction strategies and subsequently assess the return on investment of the implemented strategies. However, this part of the assessment was possible to be performed only in one case study (i.e. the hotel). Continuation of other case studies towards implementing the strategies were not successful mainly due to the operation and time related issues driven by COVID-19. On the other hand, vendors in the wholesale and retail markets in Colombo had limited time available to support the case study given the nature of their business operations. Overall, the implementation of the identified prevention strategies is challenging since food business operators got used to their current processes. Finally, the participant supermarket has centralized decision-making and implementation policy that, coupled with COVID-19 challenges, was not conducive to support the case study to complete a second round of quantification in the scheduled time.

Proposed FW prevention and reduction strategies were well received by all participants.

5. Case studies

5.1. Case 1: Hotel

5.1.1. Characterization of the sector

The hotel and hospitality sector has been recognized as one of the primary FW generators (Papargyropoulou*, et al*, 2016). Many studies have been carried out to discuss the magnitude, causes, consequences and remedies to address the FW challenge in the hotel sector (Dolnicar *et al*., 2020; Leverenz *et al.,* 2021; Okumus *et al*., 2020). COVID-19 pandemic has pushed the hotels to consider FW prevention and reduction as an avenue for reducing their operational costs to safeguard the business (Aldaco *et al*., 2020).

Sri Lanka has been one of the leading tourist destinations in South Asia. According to previous studies, 46 percent of the solid waste generated by the hotel sector is FW (Sandaruwani and Gnanapala, 2016). The amount of food being discarded in hotels is usually either underestimated or ignored because of the assumption that if a hotel's restaurant has high-profit margins, the amount of FW is minimal; however, these assumptions are not based on FW audits that can capture the comprehensive FW economic costs for the hotels.

The hotel case study considered one of the renowned high-ranked hotels located at the heart of the capital city of Sri Lanka. The selected hotel has eleven banquet halls and eleven restaurants with an overall capacity for catering to over 4 000 guests at once with more than 400 employees.

The restaurants are developed and maintained under internationally accepted principles of food safety based on ISO 22 000 and Hazard Analysis Critical Control Points (HACCP).

5.1.2. Current FW management strategies and best practices

According to the latest available quantification FW data at the hotel, it has generated 28 200 kg of solid waste in January 2020 out of which 88 percent is FW. Owing to the best practice adopted by the hotel, FW is not directed to landfilling. Instead, the total FW is diverted to local piggeries daily. The hotel has already implemented multiple strategies to reduce the amount of FW generated:

- *Batch cooking* – The volume of the food prepared by the eleven banquets at various kitchens of the hotel is very high. Therefore, bulk cooking might be the preferred choice to reduce the workload of the kitchen staff, which leads to excess supply for certain items. Therefore, the hotel introduced a batch cooking practice where they cook food as they go from the buffet trays and menu cards. The hotel has defined the reorder quantity for each item and cook when the reorder quantity level is reached. This has reduced the food surplus generated at banquet buffets.
- *Reuse the buffet surplus for staff meals* – The food surplus at the buffet is not completely avoidable. This surplus is transferred to the kitchen staff where it is checked for quality by the senior chef and recommended (especially meat and fish items) as ingredients for the immediate next meal of the staff. By doing this, the hotel was able to reduce a considerable amount of FW, especially huge amounts of meat and fish waste.

> "I have been working in the hotel industry for more than 20 years and worked in many five-star hotels. As you know, you will never be able to achieve zero FW at the reputed hotels with the compliance requirements and standards to be followed. But our hotel is caring about FW. In most hotels buffet leftovers are not given or allowed to be given to employees, they are supposed to be dumped. I had one experience when I was working in a leading hotel, one day I have taken my lunch from the buffet leftover and the hotel charged me the buffet plate price. Employees are not allowed to get a meal from the leftovers, even if they are dumped. But at our hotel, we give the buffet leftovers to staff, and we reduce our FW." - High ranked officer

- *Raw food inspection* through a food specification guide and continuous interaction with suppliers – The hotel has registered suppliers for all the main food items. To maintain the freshness of perishables, the hotel has registered suppliers directly from Nuwara Eliya, where vegetables are grown. The supply department of the hotel has developed a specification guide to maintain the quality of the products, including grades, texture and appearance, and size. The supply division holds meetings with the suppliers every month to discuss quality, quantity, and prices. All suppliers are informed about the hotel standards. At the goods receiving section, authorized chefs of the requesting kitchen and supply department's personnel inspect the food items before accepting or rejecting them.
- *Store management* – The hotel keeps stocks of dry food items in stores and issues them on first in first out basis. Vegetables and fruits are purchased at the request of the respective kitchen department. Depending on the weekly functions and event schedules, the chefs request the quantities of vegetables and fruits from the stores. After quality inspection, they are directly sent to the relevant kitchen stores, which are well-maintained temperature-controlled cold storage areas. Owing to this stock maintenance strategy, the hotel has been able to reduce the amount of FW.
- *Reduce the number of waste bins* – This strategy was in implementation at the time of the FW audit. The hotel has reduced the wet and dry garbage bin points to reduce the ease of discarding waste. This strategy is equally applied to the wet garbage bins of the kitchens and restaurants. Consequently, 10-15 percent of the reduction of FW has been reported by the hotel.

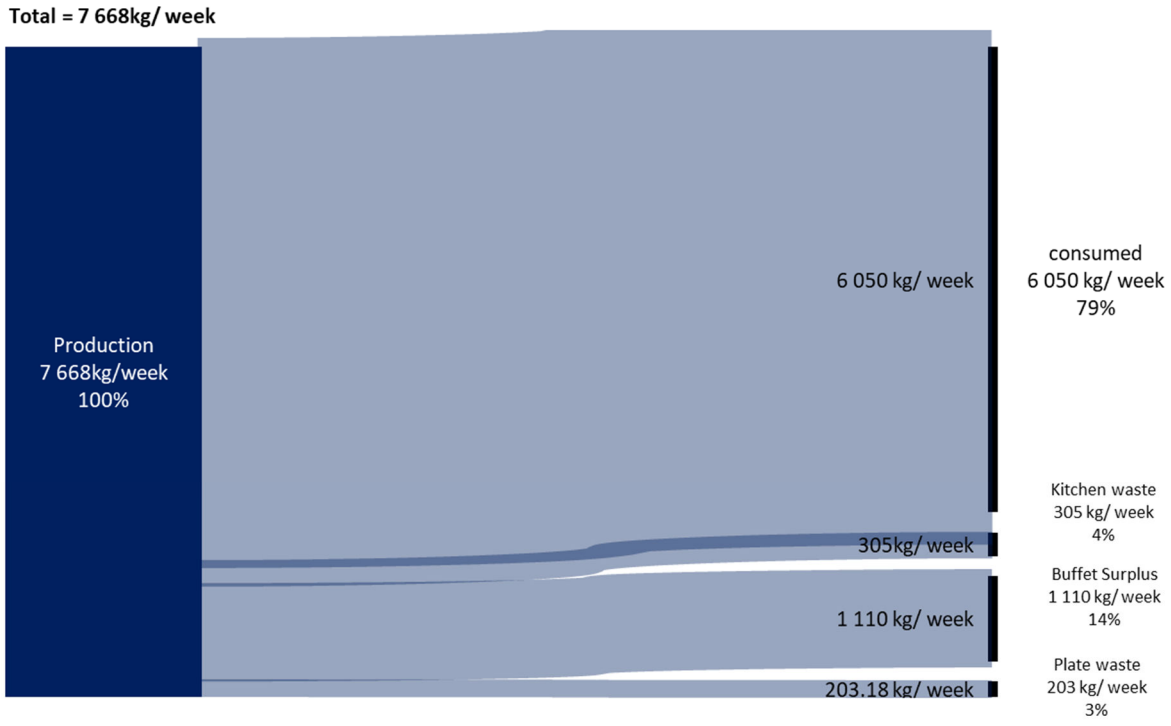
- *No bin days* – The hotel management has identified that the staff canteen is one of the main sources of wet garbage. To reduce the FW generated in the staff cafeteria, the management has introduced Monday and Friday as the no bin days. Employees are provided food without inedible parts to prevent plate FW.
- *Repurposing* – The repurposing of foods, such as preparing lime pickles, using vegetable or meat cuttings to prepare alternative reduced FW.
- *Diverting FW* for animal feed to local piggeries is a daily practice to manage the amounts of former foodstuffs generated by the hotel. The FW storage is equipped with a controlled temperature facility to prevent food spoilage until the collection.

While the hotel was implementing all these actions, there was no monitoring mechanism in place to assess their effectiveness. It was noted that these actions did not identify the key drivers of FW, the scale and nature (e.g. edible versus inedible). Consequently, there was a lack of evidence to identify the opportunities for improvements and to understand the barriers for scaling up.

5.1.3. FW quantification and qualitative assessment

The Sankey diagram (see **Figure 4**) illustrates the summary of the total FW generated at the hotel during a seven-day period. Based on the ingredients issuing records of the hotel, approximately 7 668 kg had been prepared by all kitchen departments during the week. The calculation was based on ingredients' quantities, pricing data collected from the costing department and approximated yield ratio. Owing to the FW audit findings, 21 percent of the total prepared food has been wasted. Previous studies estimate that, on average, FW in the hotel industry range from 16 percent to 28 percent (Papargyropoulou *et al.*, 2019).

Figure 4: Distribution of food production for consumption and waste at the case study hotel

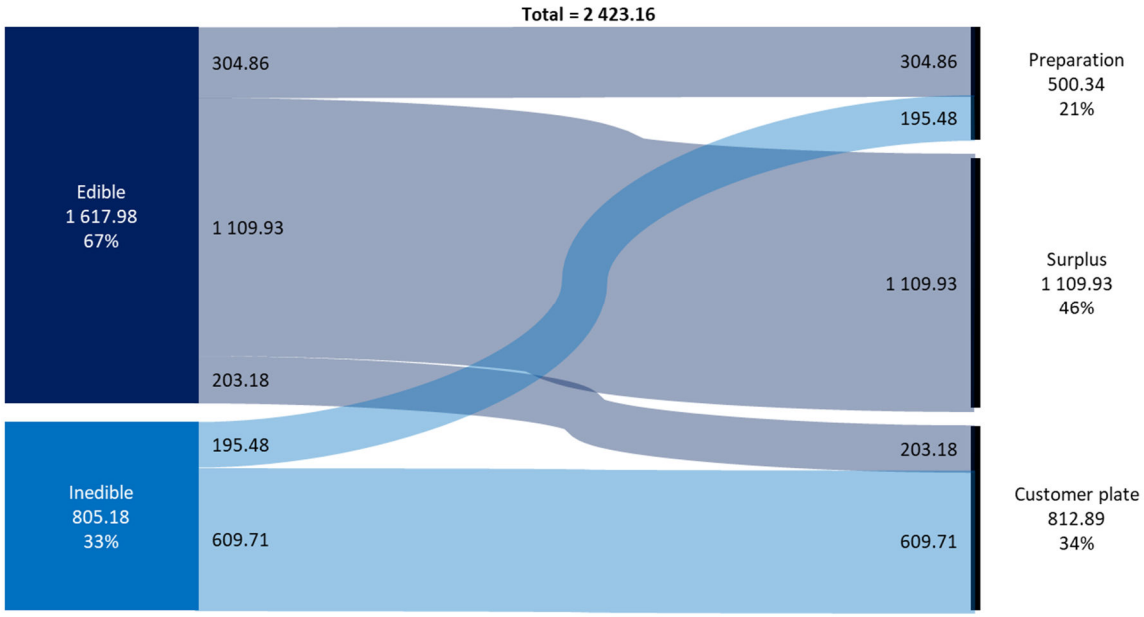


Source: Authors' elaboration, seven-day FW audit data, 2020.

FW can be classified by its origins into two categories: pre-consumer and post-consumer. Pre-consumer FW includes all food discarded at the receiving point, storing, and from the kitchen. Post-consumer FW is often referred to as 'plate waste' of both customers and staff. As **Figure 5** illustrates, during the FW audit, the case study hotel has generated a total of 2 423 kg FW out of which 21 percent from the kitchen, 46 percent buffet surplus, and 34 percent customers' plates.

The amount of edible food being wasted through the value chain of the hotel is significant. It was revealed that more than 2/3 of the FW at the hotel is edible. Further, 68 percent of the edible waste was generated at the buffet. This has questioned the demand estimation, menu preparation, and portion size calculations. Moreover, 61 percent of the kitchen waste and 25 percent of the waste generated from the customer's plates are counted as edible.

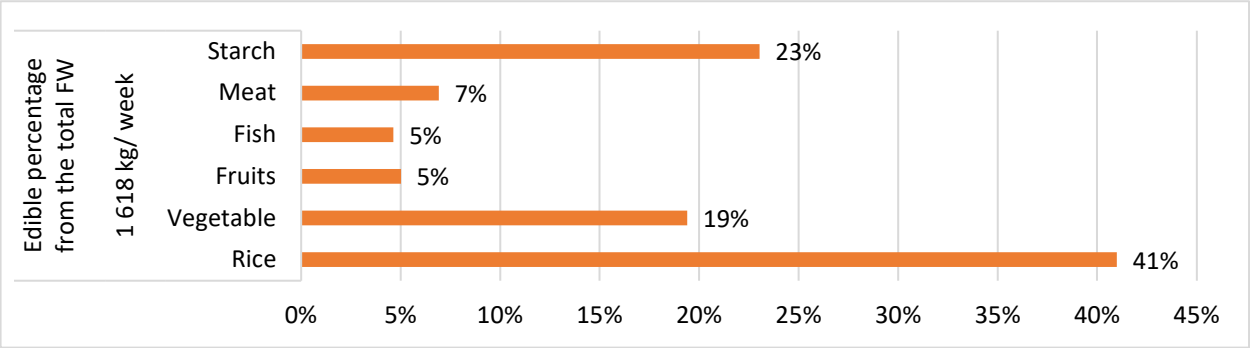
Figure 5: *FW quantification results at the case study hotel for the seven-day audit*



Source: Authors' elaboration based on 7-day FW audit data, 2020.

FW analysis indicates that the highest amount of edible portion of FW was cooked rice, followed by starch products, and vegetables (see **Figure 6** on p. 10). Although edible meat, fish, and fruits waste percentages were relatively low, the financial loss that occurred to the hotel is significant due to their higher prices. As per interviews with the chefs in the butchery, certain fish dishes require specific fish cuts. This results in a considerable volume of edible fish waste. Further, there were uncooked parts of chicken, sausages, and bacon slices observed in the garbage bin. This observation raised the question of better store management. Finally, large quantities of cakes and desserts were observed, especially in the mid-days of the week (Wednesday and Thursday).

Figure 6: *Composition of edible percentages from the total FW quantities, by category at the case study hotel*



Source: Authors' elaboration, based on seven-day FW audit data, 2020.

"We normally prepare a relatively large quantity of cakes and some of the desserts on Thursdays targeting the weekend customers. The normal shelf life of these items is maximum five days. The amount that remains unsold has to be discarded by Thursday to prepare the new set of the items" - a kitchen staff member at the hotel

Photo 1: *Cooked rice waste at the case study hotel*

Photo 2: *Meat and fish waste at the case study hotel*

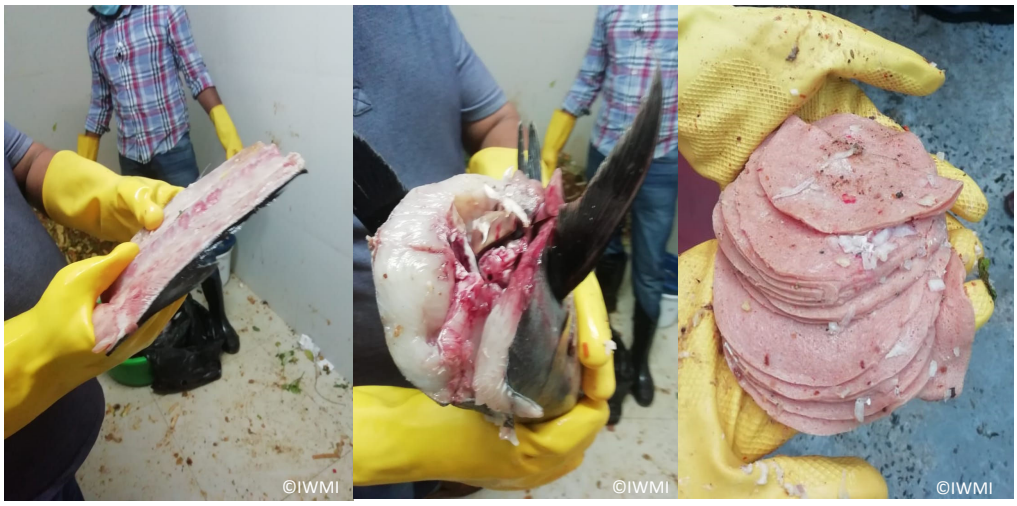


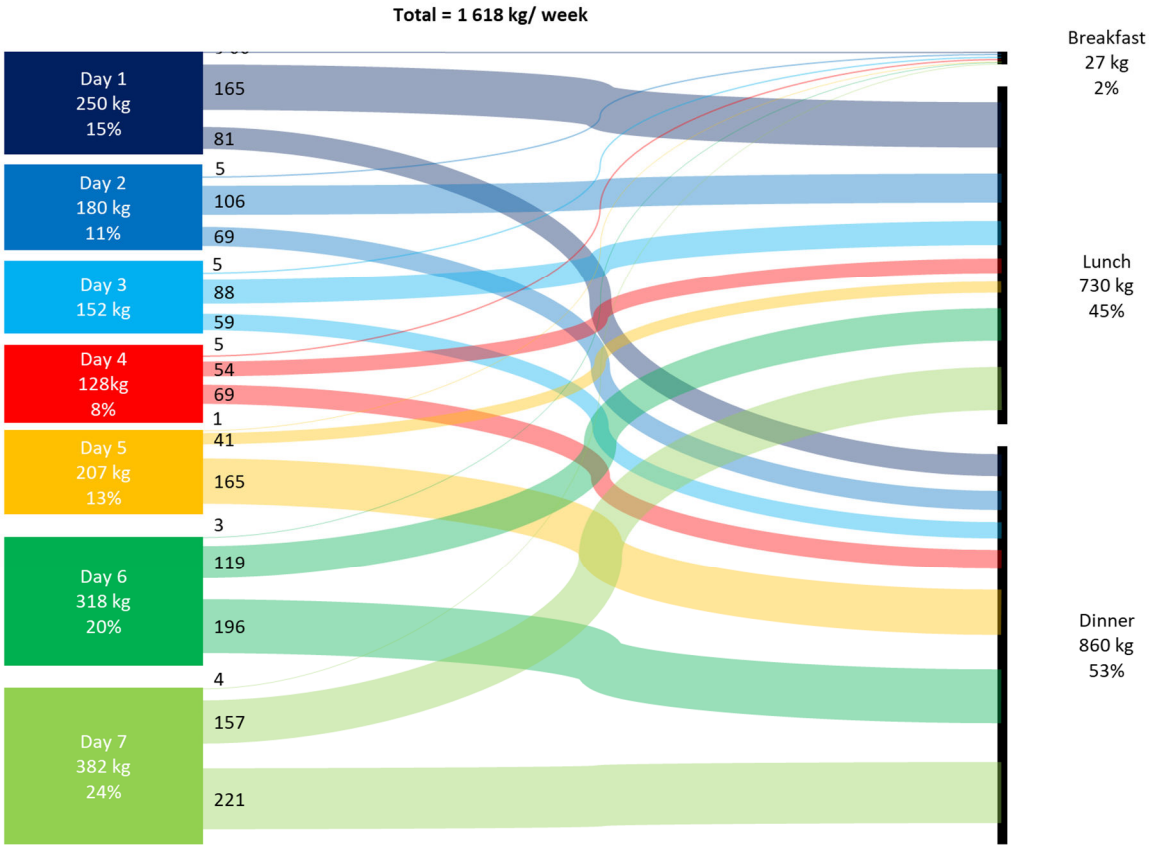
Photo 3: *Prepared cakes and desserts waste at the case study hotel*

"There is no specific pattern in guest arrivals and functions. Mondays and Tuesdays are off-peak days in most of the weeks. On Thursdays, we normally have more weddings since it is an auspicious day. During weekends, we have promotions, high teas, and buffets. If we have celebrations, we run in full capacity, and some days have five events at once. More events mean more FW" – the stewarding manager at the hotel.

The FW audit of the case study started on Monday and ended on Sunday. According to the analysis (see **Figure 7** on p. 12) of the daily edible percentages from the total FW, the largest proportion of FW occurred during the weekend (24 percent on Sunday and 20 percent on Saturday). It has been observed that weekends had a relatively large number of restaurant visitors and events' invitees. There was a positive correlation between the number of customers and the percentage of the edible portion from the total FW generated.

The results indicated that more than 50 percent of FW was generated during dinner meals and about 45 percent lunch meals. Menus with large quantities and varieties of rice for dinner and noodles/pasta for lunch generated a large quantity of surpluses. Since the hotel provides breakfast only for the staff, the waste generated at breakfast was lower.

Figure 7: Quantities of edible percentages from the total FW per day by meal at case study hotel



Source: Authors' elaboration, based on seven-day FW audit data, 2020.

Through observations and interviews with hotel staff, it was estimated that an average customer eats around 1.0 to 1.5 kg of buffet food and the average FW generated per customer is about 0.54 kg.

The staff cafeteria at the hotel provides three meals free of charge. At least 300-400 meals are prepared per day. During the week, the staff cafeteria has generated 113 kg of edible quantities from the total FW. At the time of the FW audit, the hotel was amid a cost-cutting process to reduce the COVID-19 pandemic loss. Hence, the staff buffet was not very rich in food combinations. However, the staff members were not complaining about the size of the buffet. Some employees complained about the taste and quality of the food. Further data from the observations and interviews is provided in **Figure 8**.

> "To be honest, the food provided here is not tasty; most of the chefs who cook for the staff are trainees and they do not know how to cook properly. It does not matter the type of food, but it should be tasty. That's why most of the staff throw away the served food…" – Staff member
>
> "Even though the kitchen department is supposed to make edible food items during the no bin days, they are not following the norm. Sometimes there are food items with inedible parts. Also, most of the staff members are not fully familiar with cutleries, so they discard the food items they can't eat without cutleries" – Staff member

5.1.4. Causes for FW

To obtain the specific reasons and approaches taken to reduce FW at the hotel, several key hotel staff members were interviewed. The employees highlighted that FW can be unavoidable at a higher end reputed hotel due to various reasons as discussed below.

Figure 8 *Observations and interview data from the case study hotel*

Lack of awareness The unavailability of FW data is one of the major reasons why management never intervened. The case study hotel generated large quantities of edible portions of wasted food. The hotel was unaware of that until the present FW audit. "We knew there is FW, but we never knew the quantity and nature of it. Especially edible percentages from the total FW at the kitchen. We never thought about it as serious." - Top management	**Lack of knowledge/guidance** Lack of guidance and monitoring made the kitchen staff ignore the edible portions of the wasted food generated in the kitchen. "Young chefs joining the hotel are directly from hotel schools. They were taught the standard way of cutting vegetables, fish, and meat. The kitchen head should be experienced and informed on FW. The garbage bin should be monitored by the chef and staff should be trained on how to avoid FW." - In charge of the kitchen
Compliance requirements Compliance requirements with food hygiene standards for hotels is still not sufficiently comprehended to enable FW prevention strategies. Requirements can be met while FW can be prevented or reduced. "As per the HACCAP standard, there are certain parameters to be maintained for the buffet. Sometimes we can keep certain food items for only three hours in the buffet. After that, we cannot give them to customers. Also, we cannot use them to make any other dishes."- Staff	**Poor marketing linkages for repurposed food** The hotel management introduced strategies for alternative dishes, like lime pickles. "We were asked to make use of lime shells to make lime pickle. We have made them. However, the daily waste quantity was very high and there was no mechanism developed to sell them to outsiders. Therefore, we had to stop producing them from time to time. Similarly, we have an oversupply of bread edges to make breadcrumbs. "- Staff in charge of a kitchen
Concerns on food hygiene associated with food redistribution Hotels are concerned that food donations might backfire. "As a reputed hotel, we have to build a reputation for quality food. That is why people come here. If we let a visitor at a function hall take the buffet surplus or if we donate surplus food to needy people, they might take them home without following the accepted hygiene guidelines. If someone gets food poisoning by consuming that food that will ruin the hotel name. This is the major concern in food donations. When there is food poison, no one would care we donated the food, they will accuse us of donating rotten food" - Stewarding manager	**Customer attitude** Customers pay also for the reputation and quality of the place along with the quality and quantity of food. Therefore, the hotel should satisfy the customer by providing expected quantities of food, despite customers' FW. "We observed high FW. So, we have reduced the portion sizes. Then, our customers started to complain about the portion sizes. Therefore, even if we know there will be FW, the hotel is unable to reduce the portion sizes. Portion size is a very sensitive issue. That is why we have introduced buffets at restaurants. However, this generates consumer plate FW". - Stewarding manager

5.1.5. Challenges and opportunities in FW prevention and reduction

The majority of the employees interviewed during the FW audit were not aware of the amount of FW and not sensitized of its consequences. Though the FW generated by the hotel was not directed to landfills, the social, economic, and environmental impacts in terms of loss of resources, nutrition, and opportunity to be eaten by needy people can be still significant. It was essential to increase the awareness among staff members on FW generated and to facilitate co-responsibility in reducing it. Even more, so that there is no financial cost to the hotel, given that the customer pays for the food regardless of it is being consumed or not.

With the COVID-19 pandemic, hotels and other tourism food services have an opportunity to integrate sustainability measures that would reduce FW and contribute to the circular economy at the same time.

5.1.6. Impacts analysis: social, economic, environmental

FW at consumption stages affects the sustainability of food systems in all its three dimensions: social, economic, and environmental (HLPE, 2014).

The hotel prepares food and beverages using high-quality fresh ingredients that provide high nutritional values. **Annex 3** indicates the calculated nutritional values of the measured quantities of wasted food items, by category. The calculations were done using the FReSH-FW Value Calculator beta V.1.0 version for the average daily wasted amounts.

Sri Lankans should improve the average nutrient values of their diets, compared to Asian and global status (Global Nutrition Report, 2019). However, FW is a food environment inefficiency that leads to less nutrients being available and accessible for direct human intake. For instance, according to **ANNEX 3**, the per person/day equivalent indicator shows the number of people that can get the minimum required nutrition level from the amount of FW measured. When considering the average amount of rice wasted at the hotel on a day, it could satisfy the daily energy requirements of 173 people. Similarly, all other food types could satisfy different nutritional requirements. Measures that work on FW minimization should be integrated into wider actions on safe and nutritious food availability and accessibility (geographical, social and economic).

FW creates an economic loss. **Figure 9** illustrates the monetary value associated with the different categories of FW generated at the hotel during the case study week. Given the hotel uses expensive types of seafood (seer, seabass, and tuna, etc.), the monetary value of the seafood accounted for more than 1/3 of the total cost of FW [LKR 158 387[2] (USD 857), 36 percent], followed by meat waste [LKR 86 420 (USD 468), 19.7 percent] and vegetable waste [LKR 72 535 (USD 392), 16.5 percent]. Starch waste comprises a large number of bakery products, cooked noodles, and pasta made of wheat flour. The raw ingredient value of the starch items (excluding other ingredients) was LKR 53 467 (USD 289) (12 percent). Even though the quantity of wasted in rice is the highest, the financial cost of raw rice waste has been only LKR 43 200 (USD 234) (9.8 percent). Overall, during the FW audit, edible percentages from the total FW have incurred approximately LKR 439 545 (USD 2 378) of financial cost to the hotel only on the key ingredients. A large portion of the edible part of total FW was prepared food from the buffet and the customer's plates meaning that many resources (e.g. other ingredients,

[2] Average exchange rate in August 2020 1USD=184.85 LKR.

condiments, oil, energy, man-hours, etc.) have been invested in preparing this food. Consequently, the cost would be much higher than the given LKR/USD amounts.

FW has a great impact on the environment both from the excessive use of scarce natural resources to produce the wasted food and the disposal of it into landfills. Environmental footprints of different patterns of food consumption vary significantly. Typically, food derived from animals requires more water and land while also producing more GHGs than plant-based food (Kashyap and Agarwal, 2019).

Figure 9: *Cost of edible percentages from the total FW at the case study hotel*

Source: Authors' elaboration, based on project FW audit data, 2020.

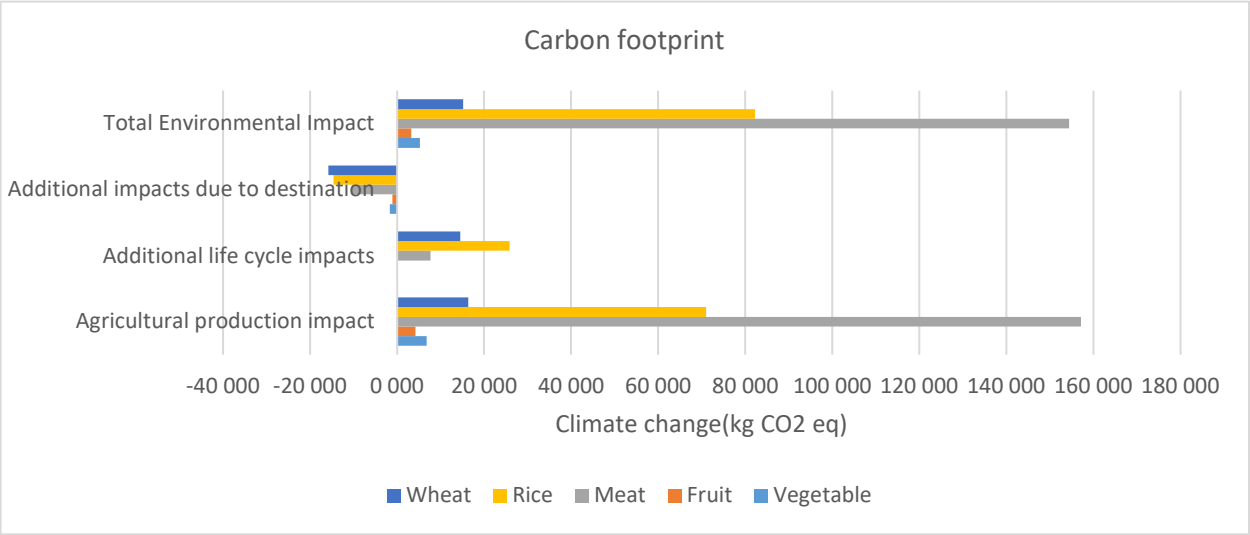
Table 3 gives the environmental impacts estimated for different categories of FW in terms of carbon footprint, water footprint, and soli quality index. Despite the lowest waste amount, meat has the highest carbon footprint. This is due to fact that meat has the highest impact during the production process (see **Figure 10** on p. 16). By diverting former foodstuffs for animal feed, the hotel has been able to offset some of the impact created by FW, through avoided CO_2 emissions of open dumping. However, the cumulative impact of FW is still significant in a life cycle context. In terms of water footprint and soil quality index, rice and wheat mark the highest values respectively (**Figure 11** on p. 16 and **Figure 12** on p. 17).

Table 3: *Environmental impacts of FW at the case study hotel*

	Vegetable	Fruit	Meat	Rice	Wheat (starch)
Quantity wasted(kg/year)	32 188	19 916	10 192	34 476	19 344
Climate change (kg CO_2 eq)	5 240	3 242	154 428	82 249	15 160
Water scarcity footprint (m^3-eq)	53 129	26 314	5 203	470 907	187 780
Soil quality index (points)	388 770	192 551	589 882	7 563 580	8 398 232

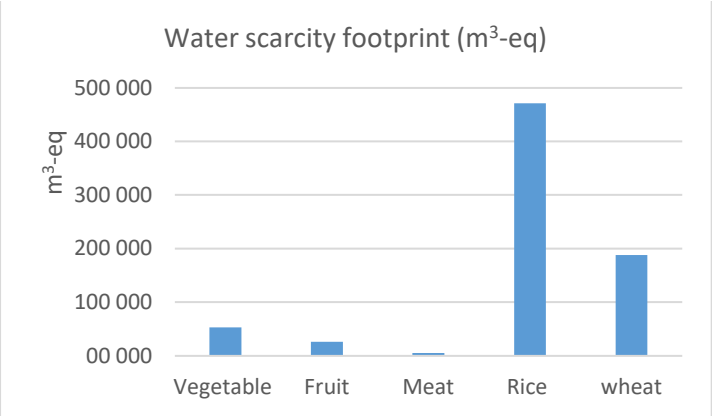
Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 10: *Carbon footprint of FW at the case study hotel*



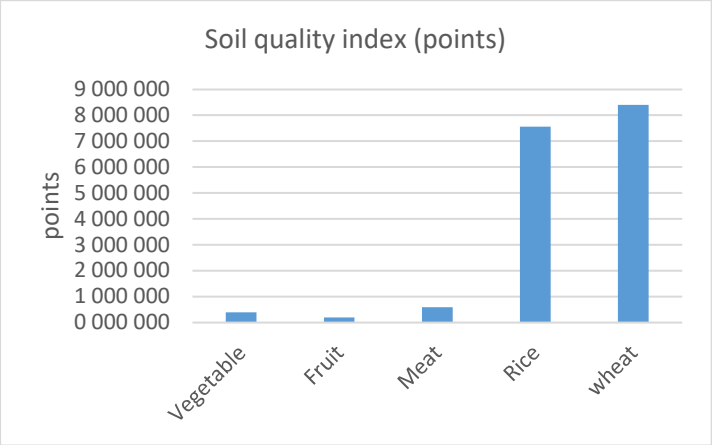
Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 11*: Water scarcity footprint of FW at the case study hotel*



Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 12: *Soil quality index associated with FW at the case study hotel*



Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

5.1.7. Strategies for FW prevention and reduction

At the end of the case study, the key findings of the FW analysis were presented and discussed with the staff. The discussion included data on FW magnitudes, causes, and reduction options. The facts and findings paved the way for the participants to agree on implementing interventions of FW prevention and reduction:

Recommendation 1: An accountable and responsible crew or task force should be appointed to manage the FW generated at each source. Visibility of the measures should be given also to the clients, to enable behaviour change.

Action 1: The hotel has appointed a team consisting of department heads to be led by the assistant hygiene manager. The chairman and top management will closely monitor the progress of the activities regularly.

Recommendation 2: Measuring FW at source is important to introduce specific reduction strategies. The process will assist in identifying the variation patterns in terms of amounts, characteristics, mealtimes, and days. This will give a benchmark against which to gauge for continuous improvement and will increase employee engagement.

Action 2: The stewarding department was instructed to weigh the FW bins daily and report to the assistant hygiene manager.

Recommendation 3: Display/inform daily FW quantities at source to create awareness and encourage a prevention mindset. Displaying the FW signs help customers and staff know what they should and should not put in the recycling bins while assuring staff segregates FW correctly.

Action 3: The assistant hygiene manager has been given the responsibility to report FW quantities by each kitchen and restaurant, including per customer data, to the heads of the departments at the meeting chaired by the chairman of the hotel, every morning.

Recommendation 4: Corrective measures such as purchasing cleaned, graded, or pre-processed food items, rather than buying raw food items, will reduce inedible parts of fish and fruits and vegetables.

Action 4: The supply department was encouraged to search for suppliers of pre-cut fish and vegetables and assess the financial viability of buying pre-processed food, rather than buying raw or ungraded food.

Recommendation 5: Train young chefs under well-experienced chefs. Two of the main reasons for FW are the lack of taste and surplus food preparation due to overestimated quantities. To overcome these challenging issues, a greater emphasis needs to be placed on mentoring and training younger chefs.

Action 5: Senior chefs should monitor and educate the young chefs to convert them to be innovative, efficient, and effective in preparing food.

Recommendation 6: Review the menu and optimize portion sizes. The hotel needs to re-standardize and monitor portion sizes. There were large quantities of dhal, potatoes, noodles, pasta, and vegetables in waste bins thrown away as buffet surplus. This has indicated the need for re-visiting standard menus and re-consider their combination.

Action 6: Review the menu after discussing with clients, chefs, and the accounting department to include the best possible options. The kitchen department has done some changes to the menu and customers are encouraged to choose the right combination of food items to avoid FW.

Recommendation 7: Repurposing food items. Encourage chefs to make alternative and innovative dishes from edible portions of what is at risk to become FW or from surplus food. These practices will help reduce throwing away food products (e.g. fish and meat) while offering economic returns.

Action 7: Preparing cutlets using edible portions of fish that were previously discarded, marmalade using orange peels, soups, and stocks from vegetable cuts, and breadcrumbs using edible portions of bread leftovers from preparation in the kitchens.

5.1.8. Analysis for the returns on investment for food waste prevention and reduction

It was identified that there should be a champion, an influential leader, who can delegate the vested authority to drive the institutional FW prevention strategy. After the completion of the FW audit, key findings were presented to the top management of the hotel that included the chairman, the general manager, all departmental heads, and the hygiene manager, who is responsible for waste management.

The management team was surprised by the amount of FW generated and its composition, particularly, with the high proportion of edible percentages discarded from the buffets.

> "I was amazed by the per capita FW generation at the hotel. We were unaware of the situation and this ratio indicates the seriousness of the issue. We can't waste 500 g per customer where they would eat only 900 g. The profit we should be earning is discarded as waste." – Chairman of the hotel

Having evidenced the scale, nature, and level of FW, the management was keen to implement strategies to reduce it. Given that large quantities of the total FW were identified as edible, strategies should also focus on prevention at the source. When it comes to the inedible part of the total FW, reusing by creating value addition was recommended. The research team provided a set of recommendations and actions to the hotel management based on the study findings. Upon

agreement, the hotel implemented two of those strategies: i) monitoring and reporting FW at source; and ii) create awareness among staff.

To monitor the amount of FW generated, the hotel invested in a weighing scale and required personal protective equipment (PPE) which cost about LKR 25 000 (USD 135). Daily amounts of FW were reported at the weekly meeting to the staff and progress was monitored. The research team provided two awareness raising sessions targeting management and staff. Other recommended strategies were gradually implemented such as repurposing food from events to the staff canteen as well as innovative dishes from what was previously discarded in the preparation operations. As a result of this, the hotel was able to successfully reduce FW from 540 g to 200 g per customer within four months.

5.2. Case 2: Restaurant

5.2.1. Characterization of the sector

FW at restaurants is generated from kitchens as well as from plates (Clowes *et al.*, 2019). Literature confirms that restaurants can significantly prevent and reduce their FW (WasteMINZ, 2018).

Several shopping malls have been set up in Colombo, Sri Lanka, in the recent past. This case study was conducted in a food court established in one of the largest shopping malls in the heart of Colombo city.

This food court comprises of two sections: one part containing the Food court, with restaurants Thalappakatti, Twister, China Express, Sumatran Spice, Jeewa's, The Mango Tree, Shiok, Cheese Heads, Tokyo Shokudo, Suksamran Thai and the other part is occupied by franchises such as Pizza Hut, WAFL, Manhattan Fish Market, and KFC. Out of the two sections in the food court, this case study exclusively investigated the FW from restaurants.

5.2.2. Current food waste management strategies and best practices

The case study food court has been a conceptual innovation in the food court industry in Sri Lanka, targeting foreign and high-end local customers. A key reason for low FW is portion control. This factor influences the customers to entirely consume their purchases, and the leftovers will mainly be the remaining inedible portions of the dishes served.

The food court has a relatively sound ingredient supply strategy that has reduced kitchen waste. They adapt pre-preparation of ingredients outside as best practice to minimize the rush at the outlet kitchen. Since space is costly at the mall, each outlet's kitchen space is relatively small. Therefore, unlike in other restaurants, kitchen staff cannot overstock food items and peel off inedible portions. Most vegetables, fruits, fish, and meat ingredients are received daily. Most items received onsite were pre-cleaned, already peeled off, and pre-prepared.

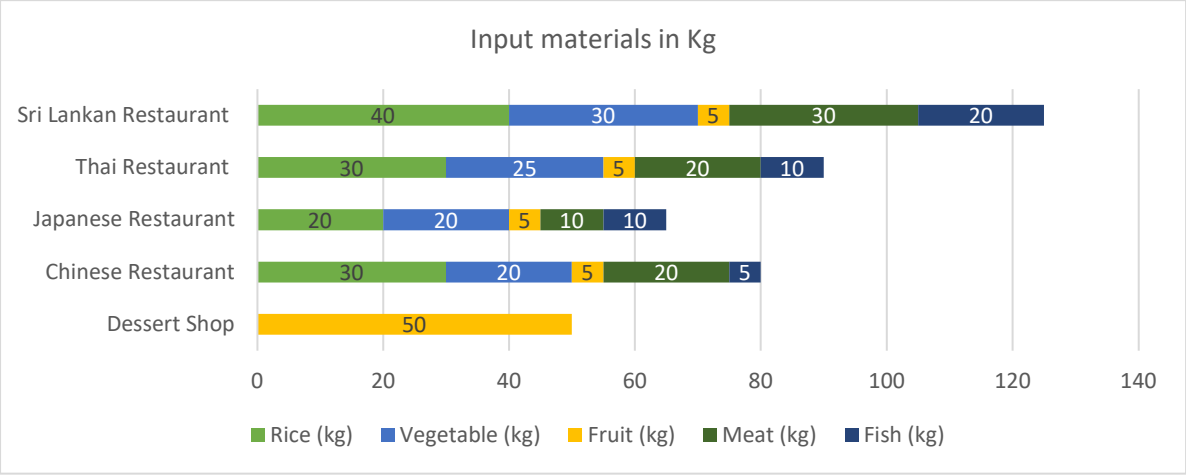
On the other hand, in some restaurants, various dishes are cooked at different venues and transported to the restaurant. Several traditional curries (e.g. ambulthiyal fish (spicy Sri Lankan fish curry), brinjal moju, malay pickle, and chicken curry) are cooked outsides the premise and delivered to the outlet. In such cases, the generation of FW in the food preparation phase onsite is reduced. Most of the outlets at the food court prepare final meals as per order. They do not keep buffets. Frying and mixing of pre-prepared ingredients are done based on the order. Therefore, prepared meal waste can be

reduced. However, currently, there is no internal control mechanism to assess and minimize the FW at the food court's selected outlets.

5.2.3. Food waste quantification and qualitative assessment

The study was conducted focusing on five outlets: Chinese, Japanese, Thai, Sri Lankan Restaurants, and a dessert shop. There were no formal records available to the research team to identify the exact amount of food purchased by the restaurants (see **Figure 13**). However, according to the employees of the selected outlets, there were no practices of keeping stock in stores. The number of customers visiting the Food court was significantly reduced due to the COVID-19 pandemic resulting in a nearly 30 to 50 percent drop in the regular sales at these restaurants, on a typical business day. Hence, no prediction on the expected number of customers was possible. Since there is a substantial reduction of customers, the amount of food input used in the kitchens has been reduced drastically in every outlet. . The usual practice of the restaurants is to purchase the required food daily. The five outlets have bought approximately 120 kg of rice (equivalent to 360 kg when it is cooked), 115 kg of vegetables, 70 kg of fruit, 80 kg of meat, and 45 kg of fish in total during the FW audit week (see **Table 4** on p. 21).

Figure 13: *Total food input during the FW audit week at the selected case study restaurants*



Note: values were calculated based on self-reported daily purchase data sheets
Source: Authors' elaboration, based on seven-day FW audit data, 2020.

One outlet receives all main dishes pre-cooked. Further, all outlets have used pre-prepared clean and cut food items given the limited availability of space. Therefore, edible portions are a high percentage of the total inputs, which reduces FW in preparation.

The research team quantified FW generated by each store during the seven-day FW audit week. The total amount of FW generated was estimated as 126 kg. The highest amount of waste was calculated for cooked rice, amounting to 47 percent of the total waste (59 kg) followed by vegetable and fruit waste in equal amounts (each 31 kg). Remarkably, fish and meat waste were minimal (zero fish waste and 3 kg of meat waste). Considering a yield ratio of three, the total amount of cooked rice corresponding to the input raw material can be estimated as 360 kg. Given the yield ratios of other

food items are nearly one, the total amount of prepared food amounts to 670 kg. Consequently, about 20 percent of the total prepared food have been wasted during the FW audit (see **Table 4**).

Table 4: *Total waste generated by food category in kg at the case study restaurants during the seven-day FW audit*

	Rice	Vegetable	Fruits	Fish	Meat	Starch	Total
Dessert shop			32				32
Chinese restaurant	14	6			1	1	22
Japanese restaurant	9	8				0	17
Thai restaurant	27	12					39
Sri Lankan restaurant	9	5			3		17
Total (kg)	59	31	32	0	3	1	**126**
Percent (%)	47	25	25	0	3	1	

Source: Authors' elaboration, based on seven-day FW audit data, 2020.

Past studies suggest that, in the prepared food industry, percentages of edible portions from the total FW are relatively high (Matzembacher *et al*., 2020; Tomaszewska, *et al.*, 2021). It was estimated in the FW audit that 70 percent of the total FW was edible (see **Table 5**). According to the case study findings, the total amount of rice waste was edible (47 percent of total waste, 59 kg) and the edible portion of vegetable waste was 27 kg (22 percent of the total waste). Further, 35 percent of the edible waste were generated from the customer plates, the rest being from the kitchen surplus (e.g. cooked rice, gravy, and vegetables). It should be noted that the considerable amount of FW was generated despite the measures taken by the restaurants' staff to reduce overall food quantities due to the COVID-19 reduction in customers. Given that most food items were pre-prepared, the amount of inedible waste generation was minimal. There were only 32 kg of fruit peels (25 percent of total FW percent) from the dessert shop, 4 kg of vegetable waste (3 percent of total FW) and 3 kg of meat residuals (3 percent of total FW) identified as inedible portion from the total FW.

Table 5: *Edible and inedible percentages from total FW during the seven-day audit at the case study restaurants*

	Rice		**Vegetable**		**Fruits**		**Fish**		**Meat**		**Starch**		**Total kg**
	edible	Inedible	edible	Inedible	edible	Inedible	edible	Inedible	edible	Inedible	edible	Inedible	
Dessert shop						**32**							32
Chinese restaurant	**14**		5	1						1	1		**22**
Japanese restaurant	**9**		6	1							0		**17**
Thai restaurant	**27**		11	1									**39**
Sri Lankan restaurant	**9**		5							3			**17**
Total FW (kg)	59	**0**	**27**	**4**	**0**	**32**	**0**	**0**	**0**	**3**	**1**	**0**	**126**
Edible or inedible waste percentage (%)	**47**	**0**	**22**	**3**	**0**	**25**	**0**	**0**	**0**	**3**	**1**	**0**	

Source: Authors' elaboration, based on seven-day FW audit data, 2020.

Currently, the former foodstuffs generated at the food court are diverted to piggeries for animal feed (i.e. 126 kg in seven-days).

Photo 4: *Edible surpluses of food from the total FW at the case study restaurants*

As per the analysis of waste items, boiled vegetables, raw vegetable salads, and rice were in large quantities in the waste bins. On the contrary, meat and fish quantities were less. This indicates that customers tend to consume all the meat and fish items without wasting but are wasting vegetables and rice. In some cases, observed portion sizes were not too large, but consumers tend to buy some food to try it out without knowing much about the food item. In some instances, the food items were oversized for their standard, but the taste was not to the customer's expectations.

Photo 5: *Inedible portions from total FW of vegetables at the case study restaurants*

Photo 6: *Inedible portions of fruit from the total FW at the case study restaurants*

5.2.4. Causes for food waste

The assessment revealed that more than 70 percent of the FW generated was plate waste. According to the previous studies, the quantity of FW is linked with the targeted customer segment and when serving a non-targeted customer, there is a chance of higher FW (Aschemann-Witzel, 2018).

The scale and nature of FW could also be attributed to the customers' behavior. The majority of the customers at the food court during the waste analysis period were the locals who visited the shopping mall. Although there are varieties of restaurants in this food court providing multi-country and multi-cultural traditional authentic dishes, the majority of the current customer segments are more inclined to have rice-based meals. For this reason, rice was found to be one of the most wasted foods throughout the analysis.

Although the FW is low in the Food Studio, some levels of wastage can be seen. Common causes of FW in these restaurants include overbuying, overproduction, and spoilage. Overbuying is often a result of inadequate forecasting of consumer demand. Specific authentic preparation techniques can also produce edible waste. The results obtained from the FW analysis in the food court may be quite different in a normal situation when the usual high-end customer segment is visiting the mall.

5.2.5. Impacts analysis: social, economic, environmental

The interviews with the Food Court staff members revealed that they were running with less than 25 percent capacity under the COVID-19 conditions. Therefore, at the fully functional level in a normal situation, the waste generated at selected outlets in the food court would be much higher. The research team conducted a market survey of the items found in waste bins and estimated the average market price of similar food items during the week. Further, FW quantities have been reverse calculated based on acceptable food yield ratios (Bognár, 2002). As per the financial loss calculations during the week (see **Table 6** on p. 24), the food court has incurred at least LKR 17 994 (USD 97) financial loss on FW. If the food court runs in full capacity, this would be four times higher than the study period.

Annex 4 indicates the calculated nutritional values of the measured quantities of wasted food items, by category. The calculations were done using the FReSH-FW Value Calculator beta V.1.0 version for the average daily wasted amounts.

Table 6: *Financial cost of raw food quantities from the total FW at the case study restaurants*

	Price per kg (LKR)	Waste quantity (kg)	Yield ratio	Raw materials quantity (kg)	Value (LKR)
Rice	230	59	3	20	4 536
Veg	150	31	1	39	5 826
fruits	150	32	1	43	6 386
Meat	360	3	1	3	1 156
Fish	480	0	1	0	0
starch	91	1	1	1	91
Total		**126**		**105**	**17 994**

Note: average unit prices were obtained from the central bank daily price reports
Source: Authors' elaboration, based on seven-day FW audit data.

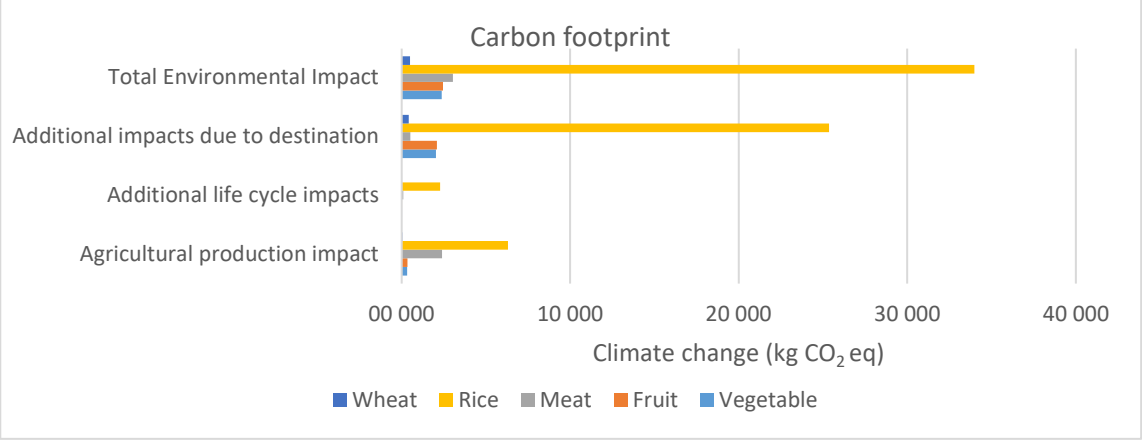
Table 7 gives the environmental impacts created by different categories of FW generated in terms of carbon footprint, water footprint, and land use. Rice waste marks the highest impact in terms of carbon footprint. Moreover, vegetable waste has the highest water footprint whereas meat has the highest soil quality index (See **Figure 14,** on p.25**, Figure 15, 16** on p. 26).

Table 7: *Environmental impact of the FW generated at the case study restaurants*

	Vegetable	**Fruit**	**Meat**	**Rice**	**wheat**
Quantity wasted(kg/year)	1 612	1 664	156	3 068	52
Climate change (kg CO_2 eq)	2 386	2 463	3 057	33 673	516
Water scarcity footprint (m^3-eq)	155 128	95 984	127 482	41 906	505
Soil quality index (points)	1 135 135	702 353	14 452 109	673 079	22 576

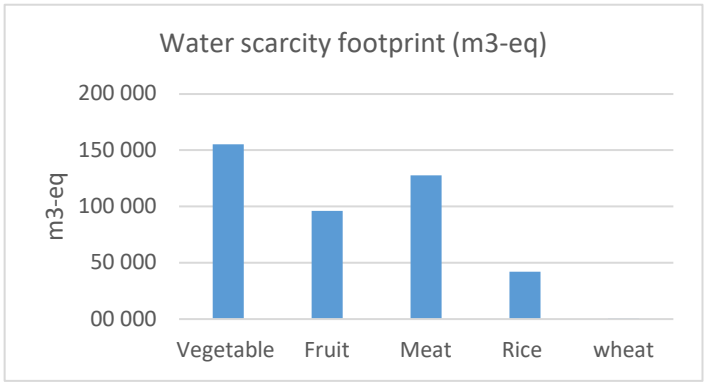
Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 14: *Carbon footprint of the total FW generated at the case study restaurants*



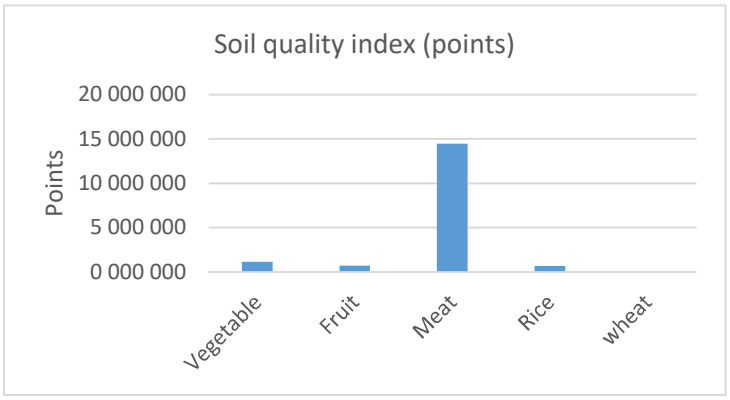
Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 15: *Water scarcity footprint (m3-eq) of the FW generated at the case study restaurants*



Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 16: *Soil quality index (points) of the FW generated at the case study restaurants*



Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

5.2.6. Strategies for food waste prevention and reduction

Even though the Food Court operated at a lower scale during the COVID-19 pandemic, there will be growth in the business with the ease of locked down conditions and foreign travel restrictions. Therefore, the food court should focus on strategies to reduce FW. Two strategies could be adapted by the food court to reduce FW:

1. Actions to reduce the customer plate FW
2. Actions to reduce the food surplus from the kitchens and buffets

Portion control would be an ideal option to reduce edible customer plate waste, for rice and vegetables. Additionally, awareness raising messages for the customers about the portion sizes available may minimize plate waste. Further, Food Court could also introduce the "take the excess" policy by providing biodegradable boxes where the customer can place the excess food for later consumption. A social media campaign such as a "Clean the plate challenge," where customers are provided an opportunity to upload their photographs with their clean plate, could also provide incentives for behaviour change. Finally, surplus meals can be offered at a discounted price.

Since there is a division of labor at the food court, the staff engaged in table cleaning are not linked with outlet staff. Therefore, outlet staff members are not aware of the customer plate waste. As a

strategy, the food court could introduce a measure to monitor and report FW within the outlets - to keep the staff updated on the magnitude and characteristics of FW. This could enable outlet staff members to know the customer plate composition and revisit their menus and cooking styles to reduce FW.

5.3. Case 3: Wholesale market for fruits and vegetables – the Manning market, Colombo

5.3.1. Characterization of the sector

Wholesale markets generate a significant amount of FW, in particular vegetables and fruits waste, due to various reasons. Fruits and vegetables are wasted at higher rates due to, for instance, bruises, temperature swings, lack of proper handling operations, and households' behaviour (Royte, 2016). This case study aims at providing empirical data from the Manning market in Colombo, Sri Lanka.

When it comes to vegetables and fruits, a large proportion of the quantity received by Colombo comes to Manning market. Before introducing the Dedicated Economic Centers (DECs) in and around Colombo, viz; Welisara, Ratmalana, Bokundara, Meegoda, and Narahenpita, the wholesale business of fruits and vegetables was fully provided by Manning market. However, due to DECs and the emergence of supermarkets, the Manning market's autonomy in the vegetable and fruit value chain has been shifting. The market is handling 200 – 250 lorry loads of vegetables, fruits, and meat per day. The market operates all weekdays.

At the time of case study, the Manning market was operating in a two-acre area consisting of 1 262 shops/stalls. Stall sizes are very compacted with limited space to move around and interact with people.[3] Outsiders often experienced difficulties in distinguishing different stalls though the vendors are aware of the boundaries of their allocated space. The limited space restricts proper storage and handling of the goods. Therefore, perishables are mostly packed into poly sacks bags and stacked together. This leads to waste.

The audit at the Manning market measured, FW at two vegetable shops, two fruits shops, and two meat shops and made direct observations and interviews to obtain qualitative data.

5.3.2. Current food waste management strategies and best practices

According to FAO, IWMI and RUAF (2016), Manning market produces about 20 tonnes of vegetable waste and 5 tonnes of carcasses per day. Currently, the entire vegetable waste produced at the market is directed to the landfills whereas the meat waste is collected by a private party for compost making. At present, there were no specific measures followed by the vendors to prevent or reduce FW.

[3] Manning market was shifted to a new spacious location (13.5 acres) on 20th November 2020 that provide vendors with larger, cleaner premises, and better access to storage, parking, and waste-management.

5.3.3. Food waste quantification and qualitative assessment

About, 200 – 250 Lorries come to the market daily with vegetables, fruits, and meat. There is no official quantification or record-keeping process. Therefore, there were no records on how much of vegetables, fruits, and meat are precisely transported to the market. Hence, in the present study, the total input of vegetables, fruits, and meat received by the selected stalls were taken from the stall owners, based on their daily input records maintained to settle the bills. The vegetables and fruits are delivered in poly-sacks that contain a bin card from the farmer or the collector mentioning the stall number and the quantity. The stall owners maintain their records to crosscheck with the card to verify the amounts. During the week, the vegetables, fruits, and meat received by the six stalls were 19 903 kg, 15 276 kg and 1 860 kg respectively (see **Table 8**).

Table 8: *Vegetables, fruits, and meat input in kg (per day/week) at the selected stalls in Manning market*

	Input (kg)				
Day	**Vegetable**	**Fruits**	**Meat**	**Total**	**Percentage (%)**
Day 1 Monday	105	5 628	388	6 121	16.5
Day 2 Tuesday	2 376	1 008	139	3 523	9.5
Day 3 Wednesday	3 469	3 640	124	7 233	19.5
Day 4 Thursday	3 361	12	408.73	3 781.73	10.2
Day 5 Friday	4 781	1 680	391.82	6 852.82	18.5
Day 6 Saturday	3 535	2 308	138.5	5 981.5	16.1
Day 7 Sunday	2 276	1 000	270.4	3 546.4	9.6
Total	**19 903**	**15 276**	**1 860.45**	**37 039.45**	100.0
Percentage (%)	53.7	41.2	5.0	100.0	

Source: Authors' survey, based on seven-day FW audit data, 2020.

All the stalls in the Manning market receive large quantities of vegetables, fruits, and meat daily. Waste analysis indicated that within the study period, FW generation at the selected stalls was only 2 percent of the total input. However, it was significant in terms of quantities. The total FW generated at the stalls, during the seven-day audit, was estimated as 740 kg from which 261 kg, 159 kg, and 321 kg were vegetables, fruits, and meat respectively. The highest quantity was the meat residuals, which were mostly inedible parts (see **Table 9**).

Table 9: *Waste generation by day and by food type at the selected stalls in Manning market*

	Vegetable (kg)	Fruits (kg)	Meat (kg)	Total (kg)	Percentage (%)
Day 1 Monday	**46**	**6**	**86**	**138**	**19**
Day 2 Tuesday	**26**	18	29	73	10
Day 3 Wednesday	**63**	27	34	124	17
Day 4 Thursday	**39**	42	47	128	17
Day 5 Friday	**33**	36	38	107	15
Day 6 Saturday	**31**	13	35	78	11
Day 7 Sunday	**23**	17	52	91	12
Total waste	**261**	159	321	740	100
Percentage (%) (of total FW)	**35**	22	43	100	
Percentage (%) (of input)	**0**	0	0	0	

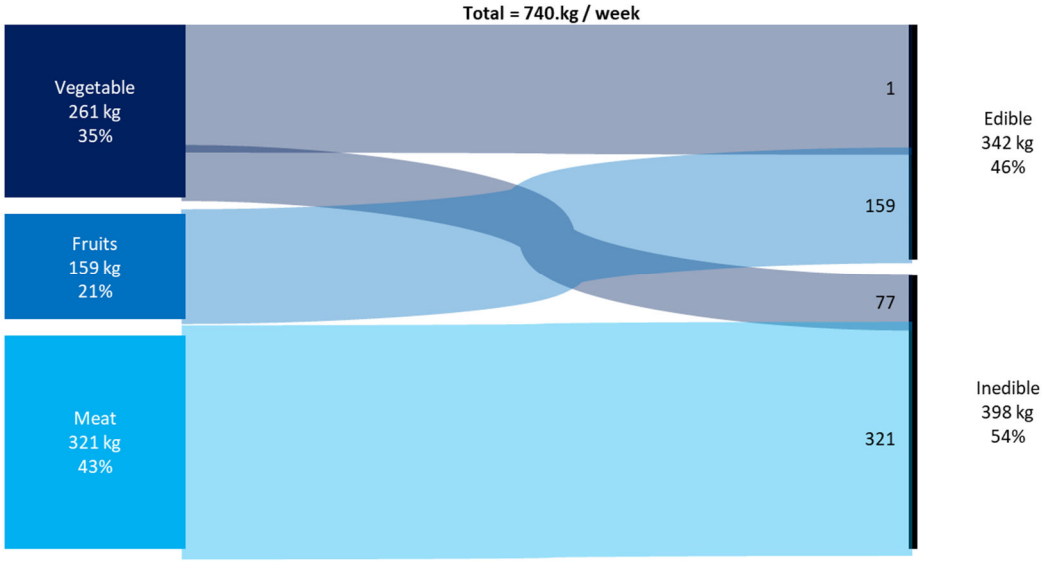
Source: Authors' elaboration, based on seven-day FW audit data, 2020.

Extrapolating sample findings into all the stalls at Manning market would indicate the seriousness of the FW generated. Eventually, the absolute waste quantities are significant compared to the total number of stalls. The waste management officer stated that four waste collection Lorries with a

minimum of 3 – 5 tonnes capacity are permanently parked at the premises and all four of them become fully loaded by 2 to 3 pm. However, vendors were not conscious of the waste quantities generated at the market.

The waste analysis indicated that 46 percent of the 740 kg of FW generated at the Manning market consists of edible vegetables and fruits. All the meat wastes are inedible parts of beef and mutton (see **Figure 17**).

Figure 17: *Total FW generated at the selected stalls in Manning market during the seven-day FW audit*



Source: Authors' elaboration, based on seven-day FW audit data, 2020.

Photo 7: *Edible portions of FW at selected stalls at Manning market*

5.3.4. Causes for food waste

The items sold in the vegetable stalls change depending on the stocks the vendors buy in a day. However, the stalls are not equipped to store and preserve vegetable stocks under different temperatures and humidity. For example, it is difficult to store and maintain the freshness of leafy vegetables (perishables) under the prevailing conditions of Manning market.

Fruits and vegetables are usually loaded into trucks either in bulk or in bags, depending on the most convenient method available to the trader. This way of handling leads to compressed stacking which is an often-noted issue for stock waste. In some instances, complete sacks of vegetables (such as cabbage, carrots, and leeks) are rejected by vendors when the top layer of vegetables in the sack appears damaged, regardless of whether the inside layers are in good condition. This practice adds up to a lot of waste that could be avoided if there was a better mechanism for packaging, handling, and transporting fruits and vegetables.

> "We have to throw away leafy parts of the vegetable such as radish and beetroots quite often. Also, vegetables sometimes get exposed to rain while they are transported, that limit the keeping quality of products to two days. Sometimes we have to throw away the entire sack because of the spoilages due to rain." – Vendor at a vegetable stall at Manning market.

Another immediate cause of vegetable spoilage is the lack of adequate weighing systems. Outdated weighing systems such as spiral balances tend to damage fruits and vegetables when bags are hung for measurement. Finally, the lack of process management in the supply chain is also another cause for FW at the wholesale level. For example, when vendors prefer only parts of the vegetables, the rest, even if edible and saleable in other circumstances, will get thrown away.

Most fruit stalls focus on selling specific fruits compared to the arbitrary nature of business in vegetable stalls. The fruit stalls tend to have conventionally demarcated areas for the selling of different fruits. One of the significant issues that cause waste in the fruit stall is the lack of proper storage facilities. Due to inadequate storage, many fruits are exposed to the pests such as rodents and harmful weather conditions. Similarly, the lack of standards in transportation also results in the waste of fruits.

It was observed that all the fruits that arrive at Manning market are usually unripen. The sellers adopt various methods to ripen the fruits artificially, within a short time. For instance, for fruits such as Papaya, the ripening is done within two days. This creates a high amount of fruit waste if the demand is lower than anticipated. Such methods also may cause hazardous effects to the consumers due to improper use of chemicals.

Meat shops only dispose of the inedible portions. There is no specific reason for that other than the nature of the meat and food-related practices in the Sri Lankan context. The meat waste is collected by a private operator to be recycled into compost. In the absence of the private party, municipal waste collectors collect it separately.

The selected shops for the study were mainly involved in the wholesale business. In most cases, vegetable and fruit sellers resell the unopened poly-sacks straightaway to the business customers. Therefore, sometimes the waste generated due to Manning market operations is diverted elsewhere, which can be much higher than the FW collected within the Manning market premises. Individual retailers receiving the items may also be receiving a large proportion of FW.

> "The majority of the businesses are wholesale businesses, where no one opens the sacks to see the quality of the items. Therefore, actual FW is received by retail business owners like us. We are the ones who open the sacks and separate the perished and broken items". – Regular business customer of Manning market.

5.3.5. Challenges in food waste prevention and reduction

Lack of proper transportation is a major cause of FW at Manning market. One solution is to use standardized craters. However, farmers, transporters, and even vendors are reluctant to adopt this practice due to various reasons. Farmers and wholesale vendors are not interested as it reduces their sales quantity. Transporters prefer sacks over craters since the transport vehicles can store more sacks than baskets, which will reduce their saleable quantities. Moreover, the use of baskets, even if given, is discouraged because they are not easily replaceable when lost or out of use, compared to sacks.

Manning market is a compact market that has a tight operation schedule and multiple stakeholders. Most of the stalls are not designed for their purpose. Additionally, the employees who handle the food items lack training. Therefore, FW prevention is a challenging task at the Manning market.

> "Our duty starts from 10 am and business runs till evening. During that time, we are fighting with competitors and sell our items to customers. If there are no regular customers, we have to work hard to sell to new customers. You can see how busy this place is. So how can we care about the waste and do something to prevent it? It is challenging from our end. But we do not throw away food easily, we make efforts to sell all the goods within a day, that's what we can do to prevent the waste." – A vegetable seller at Pettah Manning market

The COVID-19 pandemic has significantly affected everyday business operations by, for instance, reducing the demand for lower graded foods.

5.3.6. Impacts analysis: social, economic, environmental

The food quantities that are leftover at Manning market represent a value-added cost from the farmer to the wholesale market itself. Interviewed vendors stated that they pay the supplier (farmer or agent) when items arrive, irrespective of quality. Price is being decided at Manning market through an agreed price for vegetables and fruits, at arrival. When there is waste, the vendor has to absorb the cost of it. The cost of FW was estimated based on the average fruit and vegetable prices of the FW audit week. Accordingly, selected vendors of vegetables, fruits, and meat, collectively incurred, during the seven-day FW audit, a financial loss of LKR 166 168 (USD 899) (see **Table 10** on p. 31). The majority of wasted vegetables and fruits could have been avoided given the optimized transportation and storage conditions mentioned above. However, the meat waste generated was unavoidable due to the inedible parts that are discarded.

Table 10: Economic loss due to FW generated at the selected stalls in Manning market

	Average price (LKR)	Financial loss due to edible portion of waste (LKR)	Financial loss due to inedible portion of waste (LKR)	Total (LKR)
Vegetable	133	24 459	10 263	34 722
Fruits	101	16 059	0	16 059
Meat	360	0	115 387	115 387
Total		**40 518**	**125 651**	**166 168**

Source: Authors' elaboration, based on seven-day FW audit data, 2020.

ANNEX 5 indicates the calculated nutritional values of the measured quantities of wasted food items, by category. The calculations were done using the FReSH-FW Value Calculator beta V.1.0 version for the average daily wasted amounts.

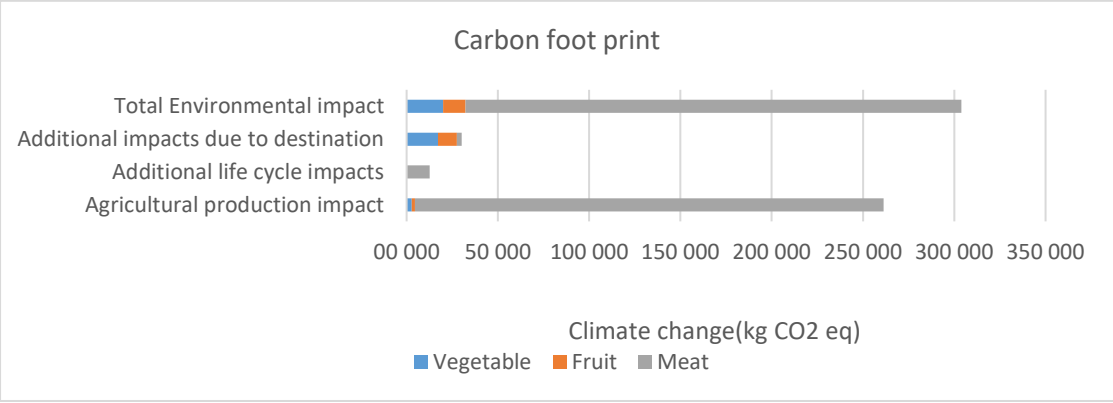
Meat has the highest impact in terms of all three environmental impact indicators though it is largely from unavoidable inedible portions (see **Table 11**). The second highest impact is indicated by the vegetable waste. An important aspect to note is that the carbon footprint associated with the final disposal was higher for vegetables and fruits whereas it was relatively low for meat, given that meat waste is sent to composting (see **Figures 18, 19, 20**).

Table 11: Environmental impact from the FW generated at the selected stalls in Manning market

Environmental impact	Vegetable	Fruit	Meat
Quantity wasted(kg/year)	13 520	8 268	16 640
Climate change (kg CO_2 eq)	20 011	12 238	271 688
Water scarcity footprint (m^3-eq)	65 159	39 847	80 195
Soil quality index (points)	476 793	291 578	586 823

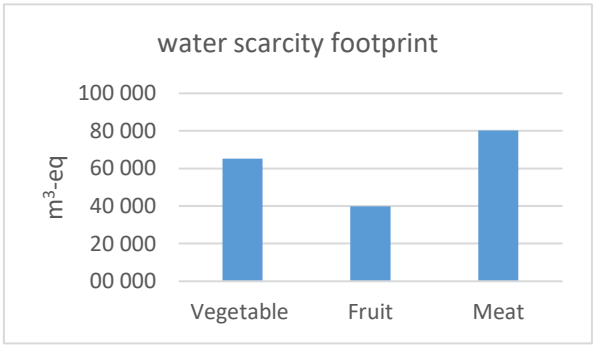
Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 18: Carbon footprint due to FW generated at the selected stalls in Manning market



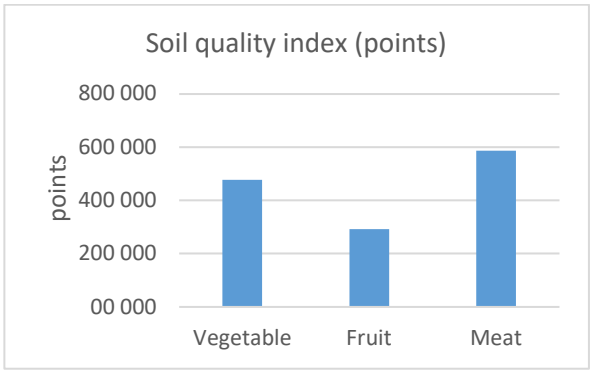
Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 19: Water scarcity due to FW generated at the selected stalls in Manning market



Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 20: Soil quality index due to FW generated at the selected stalls in Manning market



Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version

5.3.7. Strategies for food waste prevention and reduction

The following strategies were recommended from the quantitative and qualitative data collected and analysed during the seven-day FW audit:

1. Introduce specifications to farmers on grading vegetables at the source. Vendors often tend to blame the value chain's upper nodes (e.g. farmers) for FW. Having specifications will guide farmers to be more cautious on maintaining the quality of their product as well as follow good practices to reduce FW.
2. Introduce measures to minimize FW occurring during transportation. For example, covering the products during the transport to prevent exposure to harsh environmental conditions.
3. Improve existing storage facilities by optimizing the Manning marketspace utilization to increase the shelf life of vegetables and fruits and prevent damages from animals.
4. Food redistribution for direct human consumption. It was observed that there is a huge demand for unsold vegetables and fruits from the urban poor living near Manning market. Appropriate mechanisms such as the establishment of a food bank should be considered with public-private partnerships, to distribute the unsold quantities to food insecure and needy people. The manager, along with vendors, with guidance from the authorities can start such initiatives as a pilot project, which can subsequently be scaled up and replicated elsewhere.

5. The potential for unsold vegetables and fruits to be used as animal feed can also be explored with the local pig farms.

5.4. Case 4: Dedicated Economic Centre-Narahenpita

5.4.1. Characterization of the sector

The food retail sector in Colombo comprises Dedicated Economic Centers, weekly or daily street markets (open markets), modern channel supermarkets, and traditional vegetables and fruits stalls. Retail stalls in Sri Lanka sell vegetables, fruits, spices, and other cooking ingredients.

This seven-day FW audit aimed at providing empirical findings of FW generated in a typical retail market in Sri Lanka, at the Narahenpita Dedicated Economic Center (NDEC). The NDEC situated in Colombo 05 is a supply center under the purview of the Ministry of Agriculture (MoA). The DECs were established aiming to enable access to quality food and consumer goods at fair prices for customers in the vicinity of the capital city. The functioning of the center commenced in 2008, that provides food and other consumer products including locally produced vegetables, fruits, and animal products, while also hosting mobile, textile, cosmetics, and shoe stalls.

Photo 8 *An image of Narahenpita Dedicated Economic Centre (NDEC), Colombo*

Sales operations at NDEC start at 10 am and end at 11.00 pm. Within this timeframe, small retailers, hoteliers, food parcel suppliers, institutional consumers, and private consumers visit. Currently, there are 197 shops and most of shops sell vegetables and fruits.

5.4.2. Current food waste management strategies and best practices

Waste generated within the premises is about 2.5 tonnes per day. The waste collection is outsourced to the private sector. Most of FW, as it was assessed through interviews, is vegetable waste. Poor segregation by the vendors was highlighted, by the waste collector, as the major issue. In addition, there is no proper waste management plan within the premises and all waste is currently transported to Kerawalapitiya waste dumping site. However, there were few good practices followed by certain vendors to reduce FW:

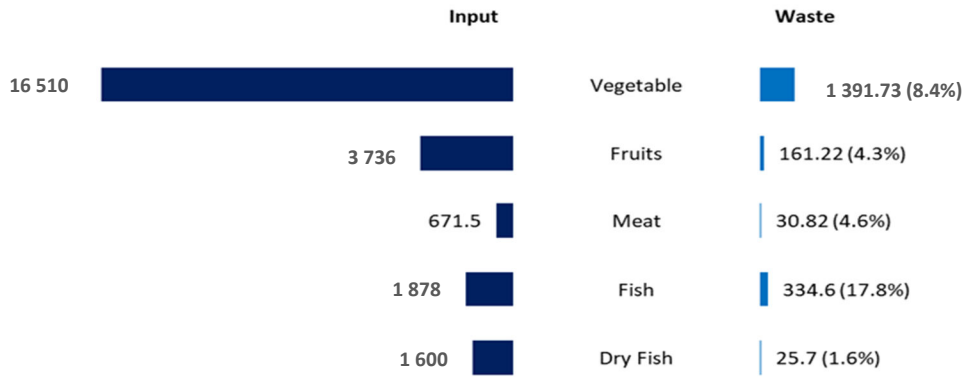
- There is a demand for ugly and second grade vegetables and fruits from specific segments such as canteen owners and small-scale caterers. For example, vendors keep the discolored and dehydrated fruits in the stall and sell those at a nominal price to specific buyers.

- Fish stalls generate large quantities of inedible residuals. However, they have developed a relationship with a company that makes fish oil from the entire fish residuals that is collected daily.
- There are vendors at NDEC selling traditional yams and roots. Since urban customers are not familiar with these products, the demand is low. Vendors have started to produce flour from these yams and roots so that people can mix it with wheat flour to provide a different taste. The flour has a relatively high demand, which has prevented yams from being discarded as waste.

5.4.3. Food waste quantification and qualitative assessment

NDEC is a one-stop service center. Traders across the country transport vegetables to NDEC in two batches, morning, and evening. Owing to the scope of the study among stalls at NDEC, two vegetable stalls, two fruit stalls, one fish stall, one meat stall, and one dry fish stall were selected for FW quantification. During the seven-day FW audit, all stalls have taken 24 396 kg of raw food in the form of vegetables, fruits, fish, meat, and dry fish. The analysis revealed that 1 944 kg FW was generated, which is eight percent of the total food items (see **Figure 21**). Given there is no extra cleaning for the dry fish at the stalls, the waste from dry fish appears to be negligible.

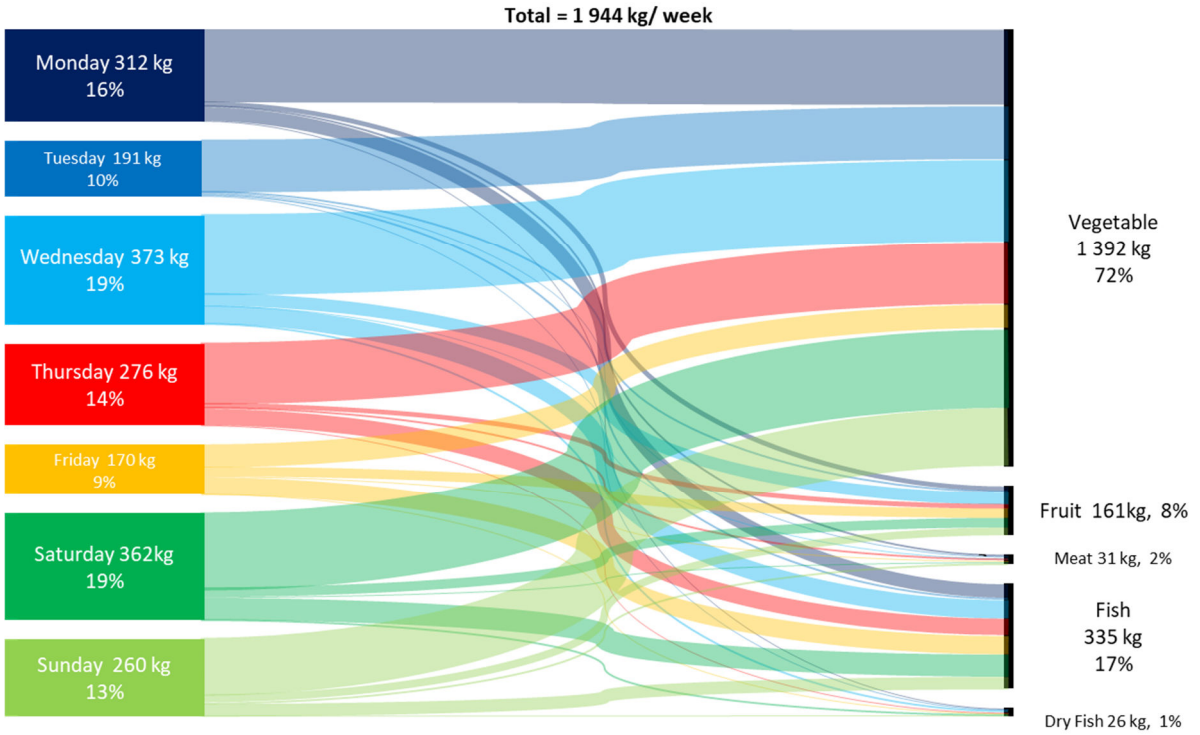
Figure 21: *Input to FW percentage of the selected stalls in NDEC during the seven-day FW audit*



Source: Authors' elaboration, based on seven-day FW audit data, 2020.

Photo 9: *Vegetable waste at NDEC*

Figure 22: Daily FW generation at the selected stalls by food type during the seven-day FW audit at NDEC



Source: Authors' elaboration, based on seven-day FW audit data, 2020.

Daily analysis of FW generated indicates that 72 percent of FW consists of vegetables followed by fish (17 percent) (see **Figure 22**). Dry fish (one percent) and meat (two percent) waste recorded the lowest percentages. The highest amounts were recorded on Wednesday (373 kg) and Saturday (362 kg) – mainly due to the higher quantities of remaining vegetables discarded to make the space available for the next lot.

Seven NDEC shops discarded 2 tonnes of FW per week averaging 277 kg per day. According to the waste analysis, 90 percent of the vegetable waste were edible, which is a remarkably high rate with 1.2 tonnes of waste per week from just two stalls at NDEC (see **Table 12**). Edible fruit wasted was about 45 percent. Most of the waste in fruit stalls is related to products such as apples and guava, which were damaged during transport. The selected meat shop mainly sells poultry, and the waste was mostly inedible. The fish stall did not generate any edible waste. The owners and employees of the selected vegetable and fruit stalls consider waste as an unavoidable aspect of the business.

Table 12: Composition of edible and inedible percentages of the total FW from all participating stalls at NDEC

	Total (Kg)	Edible portion of FW (kg)	Percentage (%)	Inedible portion of FW (kg)	Percentage (%)
Vegetable	1 392	1 259	90	133	10
Fruits	161	72	45	89	55
Meat	31	3	8	28	92
Fish	335	0	0	335	100
Dry Fish	26	0	0	26	100
Total	**1 944**	**1 333**		**611**	

Source: Authors' elaboration, based on seven-day FW audit data, 2020.

5.4.4. Causes of food waste

The vendors highlighted several common factors influencing the high level of waste in the market.

Environmental conditions
Most of the Lorries carrying vegetables and fruit are not adequately covered and also overloaded. This causes higher waste in fruits and vegetables during the transport, especially during rainy days. On the other hand, as the market roof warms up during sunny days, vegetables and fruits, especially leafy vegetables, tend to lose freshness very quickly. Therefore, vendors have to throw away dehydrated parts unless there is demand for second graded items.

No proper storage facilities
The shops are not equipped to maintain temperature and moisture control for their items. Vendors at NDEC have a space of 14 – 18.5 m^2 per single stall, which is inadequate to maintain large stock. For instance, since vegetable vendors sell all types of vegetables at the same stall, and all types of fruits at the fruits stall, the entire space is allocated to display items to allow customers to choose. Vendors generally keep additional stock in front of the stall and refill the display area as needed. Since both display items and stock items remain in hot and humid conditions, they tend to dehydrate and sometimes perish before being displayed.

Buying patterns of customers
The current self-service arrangement of goods in the market leads to damages to the items due to the customer practices adopted in checking the quality of the products (e.g. thumb pressing). However, vendors are reluctant to discourage the buyers' action due to prevailing competition between the traders. On the other hand, when vegetables and fruits do not look fresh the customers tend to reject those items. Typically, customers purchase items based on aesthetic appearance.

Continuous supply of food items
The supply of fruits and vegetables to urban markets is not uniform due to the seasonality of produce. The irregular supply based creates surpluses and scarcities in the urban context.

Attitude and awareness of the employees
The vendors are selling vegetables and fruits as a family business. Experience allows them to make decisions for pricing and selling for an adequate profit. However, training provided through public – private partnerships could be beneficial for optimized handling, storing, and FW prevention and reduction – measures that could also increase profits.

> "We buy a watermelon for LKR 12 per kg, we sell them LKR 60 per kg. So, if we can sell one-third of the load at that price it's profitable. This is true for all the sellers here. We can't do much to avoid the waste, but we recover the loss even from another item." – A vendor from the NDEC

Photo 10: *Large quantities of vegetables wasted at NDEC*

5.4.5. Challenges in food waste prevention and reduction

Longer food miles reduce the shelf life of perishable food. For most of the wholesale and retail markets in Colombo, the vegetable and fruit lorries arrive from distant areas such as Nuwara Eliya, Dambulla, Embilipitiya, Welimada, and Balangoda, or Colombo Manning market as the secondary destination. Since the food items are in compactly packed conditions in the Lorries for up to 8-10 hours, the outer layers of many vegetables and fruits get dehydrated. This creates a huge waste of food and is a common challenge encountered by both wholesale and retail markets.

Despite the awareness of the FW issue, it was observed that there was a lack of knowledge or interest to take remedial actions. When the research team shared their findings with the vendors, they accepted the validity of the findings but also stated that FW is part of their business.

"We can't keep the old stock with us for a long time. We normally receive a new stock at least four days a week. We need to sell them quickly otherwise they will get dehydrated. Customers always look for freshness. So, if we are unable to sell the old vegetables at night, as second grade, we have to throw them away to put the new stock on display. This is the way we do business. Unlike supermarkets, we do not have cool rooms to keep vegetables. On the other hand, people come to NDEC to buy fresh vegetables each day." – Vegetable vendor at NDEC

"Even if we throw away food, we do not donate food or give discounts to retail customers here. If we do that, they would take that for granted and wait till such donations or price discounts." – Vegetable vendor at NDEC

"COVID-19 had significantly bad impact on our business, virtually all business customers who used to buy second-grade items have stopped buying. That's the main reason for such large quantities of waste. Also, that influences the vegetable and fruit prices. Now we need to cover the loss from the private customers, so we need to charge a high price for first-grade vegetables" – Vendor of a vegetable store at NDEC, 16 August 2020

Vendors are aware of solutions to prevent FW, such as donating or offering discounts to retail customers. Nevertheless, they are reluctant to implement them due to fear of becoming this a practice that will reduce their profit margins.

NDEC is located in the southeastern region of Colombo, where a large number of micro-small and medium-sized entities in the foodservice sector purchase food items. During normal circumstances, a significant portion of the dehydrated and damaged vegetables and fruits are purchased by these business entities. However, owing to the COVID-19 pandemic, most of the business buyers either do not buy or have drastically reduced quantities. Reduction of demand for lower grade vegetables has resulted in large quantities of edible FW at the market.

5.4.6. Impacts analysis: social, financial, environmental

According to the business practice at NDEC, the vendors have to pay the suppliers for the raw quantity they are receiving. Even though there is a food loss due to improper packaging and transportation, as a practice, they have to pay the average wholesale market price to the suppliers. The financial loss calculated (see **Table 13**) reflects the approximation of monetary loss incurred by both edible and inedible portions of the total FW, which is ultimately transferred to the end customer. According to the approximation - at linear average prices of each food item - vendors are facing a total LKR 394 050 (USD 2 131) financial loss from the total FW. From that, LKR 175 947 (USD 951) were from edible FW that could have been sold. Furthermore, LKR 167 772 (USD 908) were generated from edible vegetable waste. The highest financial loss from inedible waste, LKR 160 608 (USD 869) is from residual fish waste, which is considered unavoidable for the current context (i.e. lack of technologies to extract nutrients and other processing options such as feed, to the extent quality allows this, rather than only composting).

Table 13: *Economic loss due to food waste at the selected stalls in NDEC during the seven-day FW audit*

Waste type	Food category	Wholesale price* (LKR)	Waste quantity (kg)	Value (LKR)
Edible	Vegetable	133	1 259	167 772
	Fruits	101	72	7 275
	Meat	360	3	900
	Fish	480	0	0
	Dry Fish	800	0	0
	Total			175 947
Inedible	Vegetable	133	133	17 732
	Fruits	101	89	9 008
	Meat	360	28	10 195
	Fish	480	335	160 608
	Dry Fish	800	26	20 560
	Total			218 103
	Grand total			394 050

***** published average wholesale market prices for August 2020 by the Central Bank of Sri Lanka.
Source: Authors' elaboration, based on seven-day FW audit data, 2020.

ANNEX 6 indicates the calculated nutritional values of the measured quantities of wasted food items, by category. The calculations were done using the FReSH-FW Value Calculator beta V.1.0 version for the average daily wasted amounts.

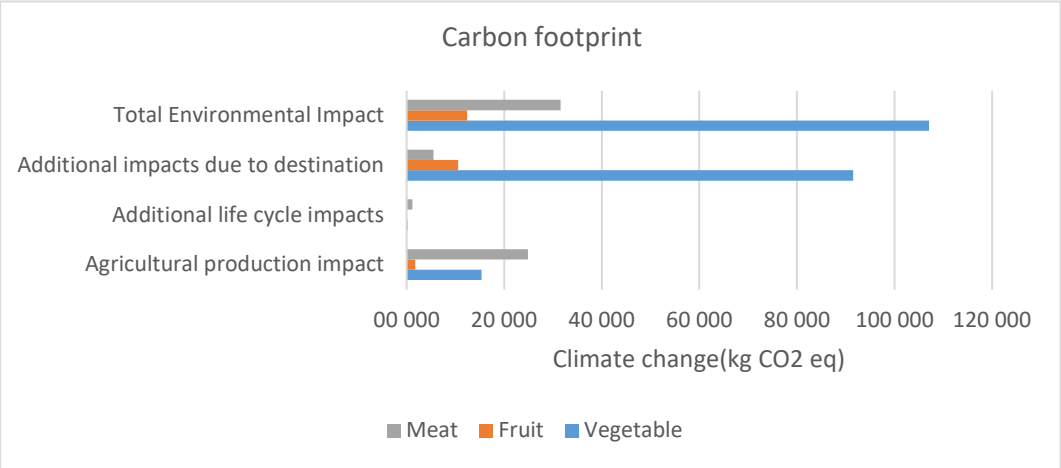
Vegetable waste indicates the highest impact on the environment in terms of all three indicators; carbon footprint, water footprint, and soil quality index (see **Table 14**, **Figure 23**, **24** on p.39, **Figure 25** on p. 40). This is caused by the significantly higher volumes of vegetable waste generated at NDEC, compared to the other types of waste.

Table 14: Environmental impact assessment of FW generated at the selected stalls in NDEC

Environmental Impact	Vegetable	Fruit	Meat
Quantity wasted (Kg)	72 332	8 372	1 612
Climate change (kg CO_2 eq)	107 061	12 392	31 585
Water scarcity footprint (m^3-eq)	348 599	40 348	7 769
Soil quality index (points)	2 550 845	295 245	56 848

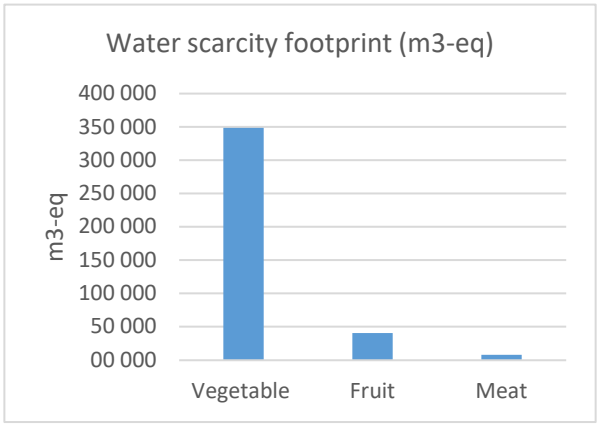
Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 23: Carbon footprint of FW generated at the selected stalls in NDEC



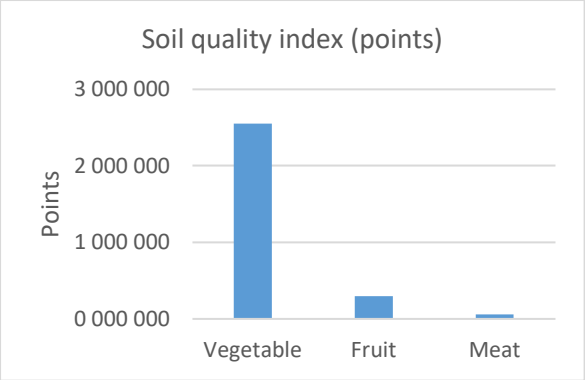
Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 24: Water scarcity footprint of FW generated at the selected stalls in NDEC



Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 25: *Soil quality index of FW generated at the selected stalls in NDEC*



Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

5.4.7. Strategies for food waste prevention and reduction

Observations suggest that a large quantity of FW could have been used as animal feed. Most of the vegetables and fruits that are thrown away could potentially be given to the National Zoo as animal feed or to the local livestock farmers. The remainder could be used for composting or biogas generation. However, the edible FW generated at NDEC would be able to feed a large number of people who are in need. Therefore, it is recommended to implement the following waste prevention and reduction strategies to reduce the amount of FW generated at the NDEC– in which both vendors and customers have to play a key role.

Adhere to proper storage practices

There are affordable technologies available, such as mist sprays or air-cooling the stalls for vegetables and fruits, with automated timing facilities. If vendors would use such technologies to prevent dehydration, FW could be reduced.

Food donation to institutions

NDEC can explore the potential of establishing a mechanism to redistribute food. Even though food donation presents, currently, various concerns, vendors can investigate the possibility of donating unsold food in bulk quantities to institutions (orphanages, children, and elders' homes, etc.) and food redistributing charities while maintaining the required hygiene conditions.

Provide food bundles

Food bundles have become popular in Sri Lanka during the COVID-19 pandemic when customers have become more price-conscious. Vendors could capitalize on this change and bundle slow-moving items with high moving items and charge a competitive price for the bundle. This can increase the sales of slow-moving items, which are regularly discarded as waste.

Infrastructure improvements

Infrastructure improvements such as transporting, packing, and storing are associated with increased efficiency in food value chains, including less FW. The use of additional or common storage and handling technologies could allow wholesale markets to keep the quality of foods for extended periods. Provision of adequate storage and handling facilities at wholesale markets for fruit and vegetables could prevent excessive heat buildup within stored bulk goods. Cold storage facilities should be provided for highly perishable products such as leafy vegetables.

Offer discounted prices on oddly shaped or colored food items (ugly foods)

Oddly shaped or colored food items produce ends up being fed to animals when there is no human market for it. Foods that are not unattractive to sell get thrown away, whether it is because an apple is bruised or because a carrot is too strangely shaped to be sold. Therefore, offering customers oddly shaped or colored produce at a significant discount would reduce FW.

Educating customers on choosing food items/ creating awareness

Most of the customers who visit NDEC take vegetables and fruits for at least one week. Customers' awareness on choosing food items needs to be raised to accept the nature of fresh produce. There should be an awareness campaign highlighting the amount of money that could be saved by the households from purchasing oddly shaped or colored safe and nutritious food items.

5.5. Case 5: Small-scale vegetable stall

5.5.1. Characterization of the sector

The retail market is the most vulnerable sector from FW in the food value chain. Retailers represent the final node of the value chain's supplier side, starting from farmers, agents/middlemen, and wholesalers. Since their immediate next node is the end customers, they have to maintain the appearance, quality, and reasonable price of their goods. Therefore, in practice, the retailer is most often the node that will unpack the goods for customer display. Hence, a certain proportion of waste has to be absorbed by the retailers.

According to Schneider & Eriksson (2020), the retail stage generally produces a proportionately smaller mass of waste, whereas other stages in the food supply chain exceed this value. Nikkel *et al.* (2019) report that retail FW contributed 12 percent to the entire FW along the Canadian food supply chain , and according to Stenmarck *et al*. (2011), retail is believed to produce about five percent of the total FW in the European Union. Even though the percentage is relatively low, the retail sector's amount of waste has been significant in terms of volume. As per the general observations and discussions with retailers in Sri Lanka, there are multiple FW sources at pre-store and in-store levels.

This case study focused on a small retail shop that sells vegetables and fruits to understand the FW scenario at an individually operated, small-scale level.

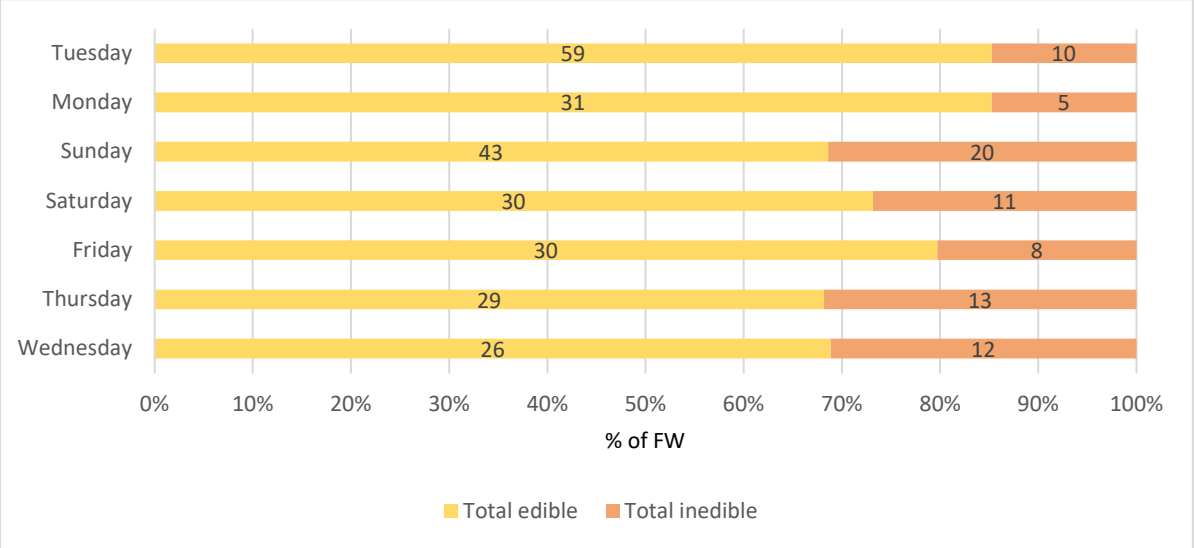
5.5.2. Food waste quantification and qualitative assessment

The current practice in terms of waste management in the shop was to hand over the waste to the municipal council collection trucks. During the week of the waste audit, the retail stall generated 327 kg of FW comprised of vegetable (307 kg) and fruit waste (20 kg). This amount is relatively high compared to the scale of the business.

According to the stall members, the stall receives approximately 3 tonnes of vegetables during the week, consequently, 10 percent ended up as waste. The highest FW was reported on Tuesday (69 kg) and Sunday recorded the second highest (63 kg). As the week progressed, the amount of waste generated had shown slightly increasing trends, where large quantities of stocks arrived on Mondays and Saturdays.

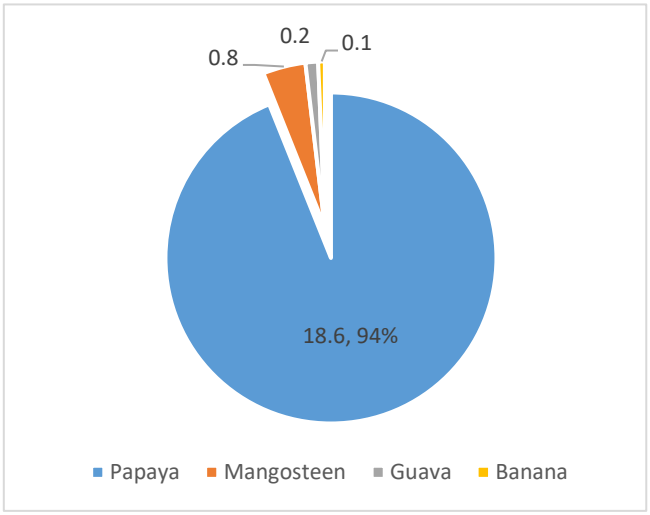
Among the total waste, there is a high percentage of edible daily FW at the retail stall. At least 66 percent of the waste on each day was edible and that rate increased up to 85 percent on certain days without having any conclusive reasons (see **Figure 26**). As per the observation, when the new stock arrives, the employees tend to discard unsold lower grade vegetables and fruits to make space for new arrivals.

Figure 26: *Edible and inedible quantities of waste in kg from the seven-day FW audit at the small vegetables and fruits retail shop*



Source: Authors' elaboration, based on seven-day FW audit data, 2020.

Figure 27: Fruit waste by type at the small vegetables and fruits retail shop (kg/week)



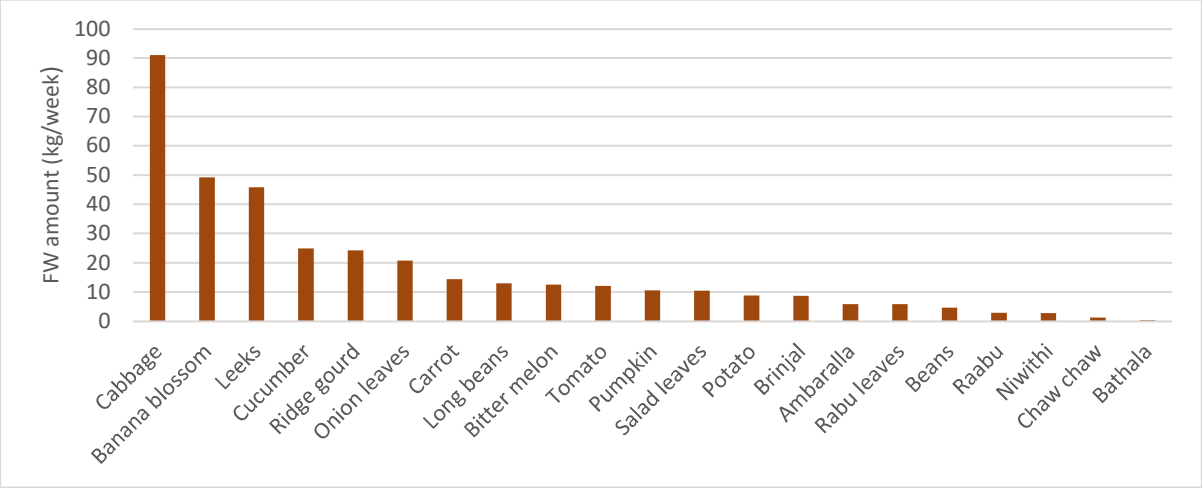
Source: Authors' elaboration, based on seven-day FW audit data.

Since the stall focused on the vegetable market, there were only seasonal fruits available for purchase. Therefore, for the entire week, there was only 20 kg of fruit waste at the stall, and 94 percent of it was papaya (see **Figure 27**). According to the stall owner's opinion, middle-class people mostly eat bananas, papaya, and watermelon as fruits. They are not eating many seasonal fruits since they are relatively expensive. Furthermore, the customers prefer not to purchase fruits with discolored or squeezed outer skins and always seek a perfect look in the items they buy.

Photo 11: High volume of edible percentages from total FW generated at cleaning

Based on the detailed analysis of the stall's edible waste profile, it was observed that vegetables that can be peeled off, dehydrated, discolored, and have damaged layers represent high volumes of waste. Cabbage, banana blossom, and leeks were the three main vegetables falling into that category (See **Figure 28** on p. 44). The second highest wastage was represented by vegetables with sensitive skin like cucumber, tomato, ridge gourd, and onion leaves. Vegetables like brinjals, carrots, and beans were normally thrown away due to dehydration and insect damages.

***Figure 28**: Amount and type of still edible vegetables wasted during the seven-day audit at the small vegetables and fruits retail shop*



Source: Authors' elaboration, based on seven-day FW audit data, 2020.

5.5.3. Causes for food waste

The stall owner has been involved in the vegetable business for a long time and he believes FW is unavoidable in this business. The main reason he pointed out was the long food miles. None of the vegetables or fruits consumed in Colombo are grown within the 50 km radius and transport and handling damages are the main causes for the waste.

> "Everyone knows there will be a certain percentage of damaged vegetables and fruits when they receive a bulk. No one is complaining about that since everyone accepts that as part of the business. Middle- and high-income customers do not buy damaged or otherwise aesthetically unpleasant produces – common for vegetables like carrots and tomatoes and fruits like bananas. On most days, produce will remain on the shelf until there is a demand from the second-grade market." – the owner of the fruits and vegetables retail shop

Unlike the supermarket, the roadside retail outlets do not have air conditioners or cold room facilities. Hence, the stall leaves the vegetable and fruit stocks in sacks and open displays in hot and humid conditions. Freshness is maintained by peeling off the dehydrated portions.

5.5.4. Impacts analysis: social, financial, environmental

During the week of the FW audit, the stall had generated 307 kg of vegetable waste and 20 kg of fruit waste. As per the average unit price of LKR 133 and LKR 101 for vegetables and fruits respectively, the stall has lost LKR 40 831 (USD 221) on vegetables and LKR 2 020 (USD 11) on fruits on a week. Overall, LKR 42 851 (USD 232) of financial loss was incurred due to the waste generated at the stall. **Annex 7** indicates the calculated nutritional values of the measured quantities of wasted food items, by category. The calculations were done using the FReSH-FW Value Calculator beta V.1.0 version for the average daily wasted amounts.

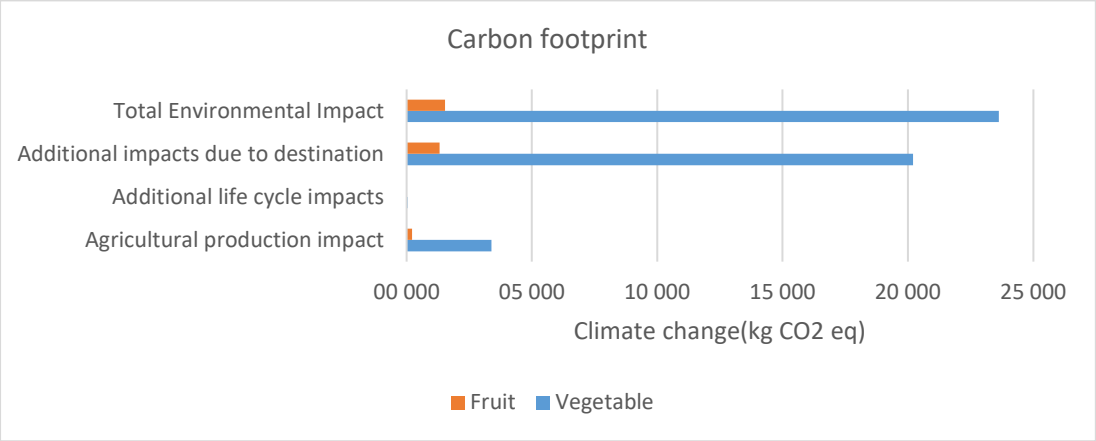
According to the environmental impact assessment, vegetables mark the highest impact in terms of all three environmental impact indicators; carbon footprint, water footprint and soil quality index (see **Table 15, Figures 29, 30, 31**) which can be attributed to the highest volume compared to the fruit waste.

Table 15: *Environmental impact assessment of FW generated at the small retail shop*

Environmental Impact	Vegetable	Fruit
Quantity wasted per year (kg)	15 964	1 040
Climate change (kg CO2 eq)	23 629	1 539
Water scarcity footprint (m3-eq)	76 937	5 012
Soil quality index (points)	562 983	36 676

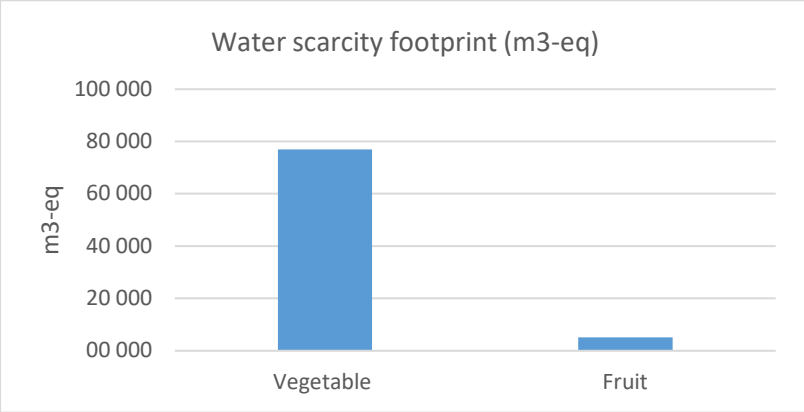
Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 29: *Carbon footprint of FW generated during the seven-day FW audit at the small retail shop*



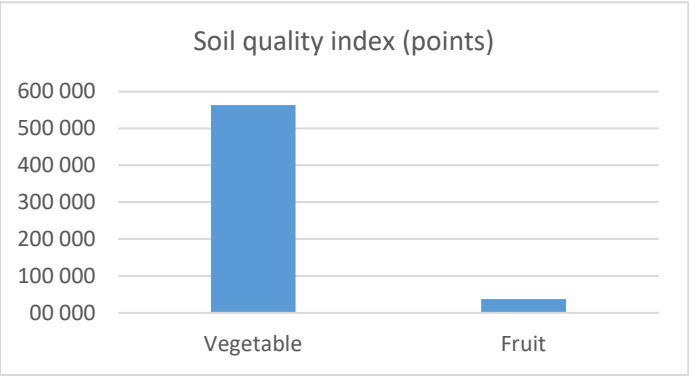
Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 30: *Water scarcity footprint of FW generated during the seven-day FW audit at the small retail shop*



Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 31: *Soil quality index of FW generated during the seven-day FW audit at the small retail shop*



Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

5.5.5. Strategies for food waste prevention and reduction

Given the quantitative and the qualitative FW data collected during the seven-day audit, the following actions for FW prevention and reduction were identified:

- Spraying water on vegetables frequently through a moisture spraying water line or air cooling the stall would allow vegetables to keep hydrated for a longer period
- The current practice at the stall is to keep fruits and vegetables in sacks until they come to the display. The lack of ventilation in the current practice creates heat stress. The use of plastic crates with ventilation windows would reduce this cause of FW.
- Set a price-dynamic based on freshness. For instance, first day fresh at a higher price than second and third days, to increase the income of the stall while reducing FW.
- Introduce fruits and vegetable bundles by mixing slow-moving with highly demanded products. The sales patterns and available stocks allow the vendor to decide the baskets' composition.

5.6. Case 6: Supermarket

5.6.1. Characterization of the sector

Supermarkets play a dominant role in the retail sector of the country. The Supermarket sector has been rising rapidly as a result of changing lifestyles associated with urbanization. Essentially the supermarket outlets sell many food items, including vegetables, fruits, fish, meat, bakery products and hot kitchen products. Hence, there can be multiple FW sources at pre-store and in-store levels of the supermarket. This case analysis aims to present an assessment of FW generated in a selected supermarket outlet in Colombo, Sri Lanka that belongs to a popular supermarket chain in the country.

5.6.2. Current food waste management strategies and best practices in the selected retail outlet

It was noticed that the supermarket has already adopted FW reduction strategies as voluntary commitments. The central management of the supermarket has set up a sustainability team, which is

linked and facilitated by the corporate social responsibility (CSR) program. The FW management practices observed at the supermarket outlet were:

FW is controlled through the supply chain: the central management closely monitors the supermarket outlet. The central store of the chain provides all the food items. Vegetables and fruits are cleaned and delivered to the outlet in well-designed and standard plastic crates from farmers to warehouse and then to outlets.

Stock is monitored and maintained to avoid excess by transferring to other outlets and reducing the volume of the next order.

Price reduction for items before they get expired: There are strict hygiene policies to be followed by the outlet, where once food items are taken out from the cold stores to display areas, they are not allowed back. Owing to the air-conditioned environment and cold shelves, the vegetable and fruits displayed at the outlet have extended shelf life. Outlet managers were permitted, for up to 50 percent of the stock, to offer quick deals for short expiry raw and cooked food items. However, it is not allowed to do any outside promotion of such discounts. The outlet managers are not allowed to sell offcuts of damaged or second-grade vegetables and fruits though this is in practice in other supermarkets.

Repurposing: This outlet has a fresh juice bar within the premises and fruits with short shelf life are used for juice. This action reduces the amount of fruit waste.

*Former foodstuffs as animal feed***:** A truck visits the branch two days a week to collect cooked rice and bakery items from hot kitchens for piggery farms.

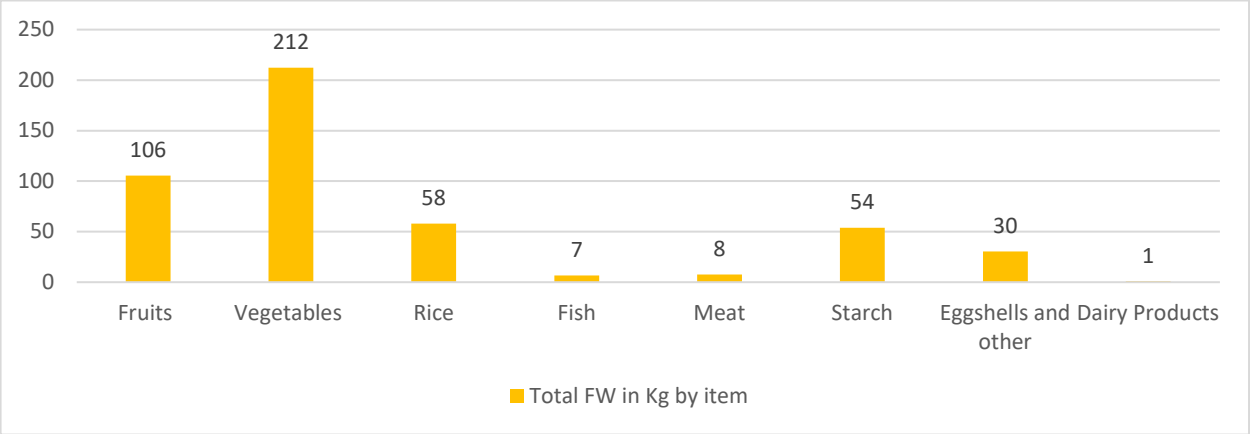
Enterprise Resource Planning (ERP) based Internal record system of FW allows tracking the waste and identifying hot spots.

5.6.3. Food waste quantification and qualitative assessment

Approximate input values of the food items were obtained from the manager of the outlet. Accordingly, 2 tonnes of vegetables, 1 tonne of fruits, 150 to 160 kg of fish and 160 to 180 kg of meat were brought to the supermarket during the audit. Fruits, meat, and fish are usually brought only three days a week. During the case study week, a total of 445 kg of FW was generated, with an average of 64 kg per day.

Among the week's FW, vegetable waste (212 kg) is highest, followed by fruit (106 kg) and cooked rice (58 kg). Starch based products (bakery, pizzas) reached 54 kg of waste (see **Figure 32** on p. 48).

Figure 32: Total FW generated by type during the seven-day audit at the case study supermarket outlet



Source: Authors' elaboration, based on seven-day FW audit data, 2020.

As per approximate input quantities stated by the outlet manager, more than ten percent of vegetables and fruits were wasted during the week. Fish and meat waste percentages were relatively low similar to other case studies.

Table 16: Input to waste ratio during the seven-day audit at the retail outlet

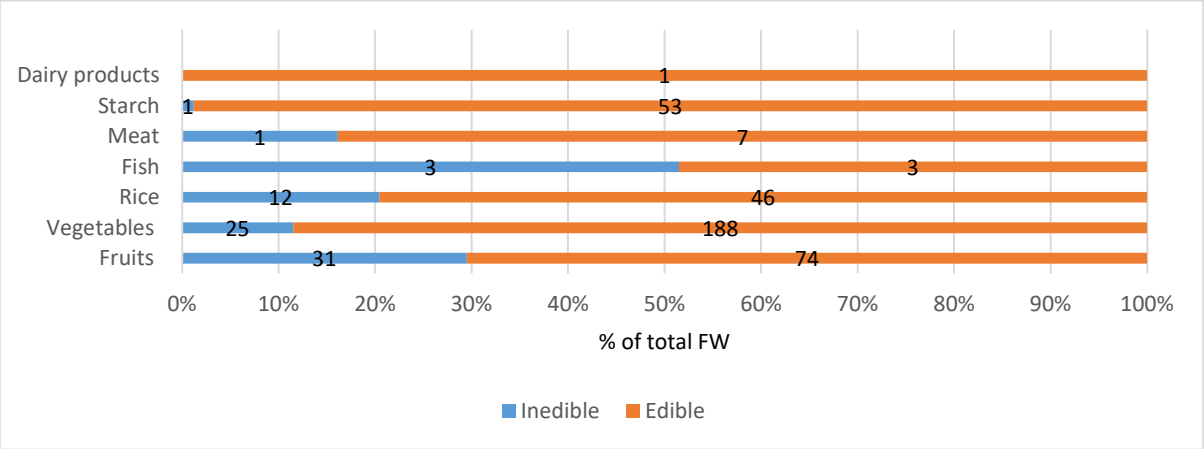
Item	Weekly input (Approx.) (kg)	Weekly waste (kg)	Percentage (%)
Vegetables	2 000	212	11
fruits	1 000	106	11
meat	180	8	4
Fish	150	7	4
Total (kg)	3 330	332	10

Source: Authors' elaboration, based on seven-day FW audit data, 2020.

Photo 12: Vegetable, fruit, and cooked rice waste at the case study supermarket outlet

Analysis indicated that 84 percent (372 kg) of the total FW was in edible condition and consisted of more than 50 percent vegetables, 20 percent fruits, 14 percent starch products, and 12 percent cooked rice (see **Figure 33**).

Figure 33: *Edible and inedible quantities of FW, by item, at the case study supermarket outlet*



Source: Authors' elaboration, based on seven-day FW audit data, 2020.

Since the supermarket chain's central store distributes clean vegetables and fruits in crates, a large quantity of this type of waste consisted of discarded items from the display. Observations suggest that the size of the display requires larger quantities to be displayed to make it attractive to customers. Edible fish and meat portions of the total FW also consisted of expired quantities. However, there were also cases where whole roasted chickens were discarded by the hot kitchen. Finally, it was observed that the total quantity of cooked rice waste generated in the hot kitchen was still in edible condition.

5.6.4. Causes for food waste

The absence of demand prediction is one of the major reasons for the high volume of FW in vegetables, fruits, cooked rice, and bakery items, especially pizza and sliced bread. The supermarket outlet is not allowed for dynamic pricing to increase the sales of slow-moving perishable items. Currently, the outlet is giving quick deals up to 50 percent based on expiry dates.

Photo 13 *FW from the bakery and the hot kitchen at the retail outlet*

Even though the supermarket encourages shelf control, actual shelf sizes are not matched with daily demand. Since the supermarket's shelves are standard in size across the chain, the outlet's specific demand was not considered. Irrespective of the size of the daily demand, vegetables, fruits, fish, and meat are displayed. At the end of the day, large quantities are left unsold and become FW. What is left on the shelves in the evening hours is mostly low quality even if this is, usually, the peak time for many customers, coming from work to buy goods.

5.6.5. Challenges in food waste prevention and reduction

Compliance requirement by the supermarket chain sometimes limits the opportunities for FW reduction. Outlet managers are not allowed to initiate campaigns to attract customers. For example, the outlet manager could not do any promotional activity to encourage people to come and buy hot kitchen items.

5.6.6. Impacts analysis: social, financial, and environmental

As per average prices for August 2020, the supermarket outlet experienced a financial loss of LKR 45 491 (USD 246) during a week due to FW (see **Table 17**). More than half of it is generated by edible vegetable waste and fish, but meat records the lowest loss contribution. **Annex 8** indicates the calculated nutritional values of the measured quantities of wasted food items, by category. The calculations were done using the FReSH-FW Value Calculator beta V.1.0 version for the average daily wasted amounts.

Table 17: *Approximate financial loss due to edible portions from the total FW at the case study supermarket outlet*

Item	Average price (LKR)	Edible waste (kg)	Loss (LKR)
Rice	91	46.11	4 196.01
Vegetables	133.29	187.86	25 039.86
fruits	101	74.38	7 512.38
meat	360	6.5	2 340.00
Fish	480	3.25	1 560.00
Dry fish	800	0	0.00
starch	91	53.22	4 843.02
Eggs	20	0.43	8.60
		371.75	**45 499.87**

Source: Authors' elaboration, based on seven-day FW audit data, 2020.

According to the manager, on average, the outlet has LKR 3 – 4 million (USD 15 000 – 20 000) worth of sales per day, and the financial loss of edible portions due to FW becomes insignificant. Hence, FW prevention has not been received full attention by the supermarket management. However, attention has been provided to the protection of the environment, discouraging customers from using polyethylene bags.

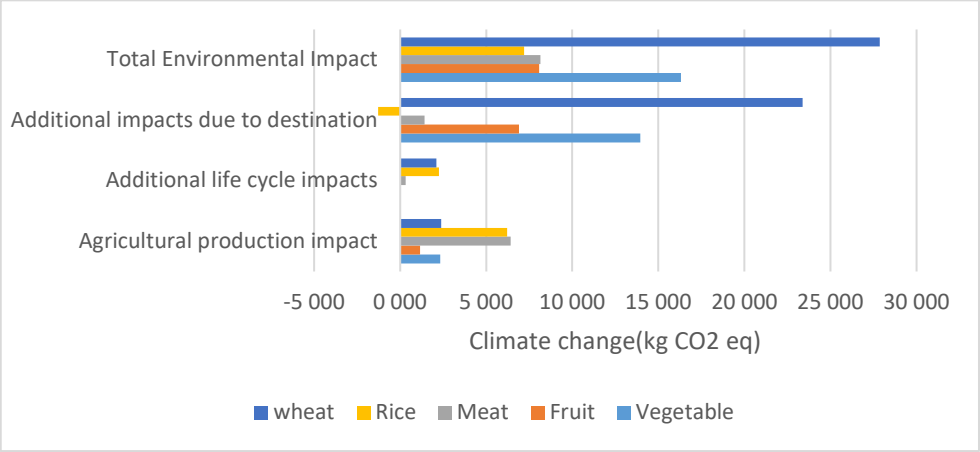
Environmental impact assessment conducted for the FW generated at the supermarket indicates that, starch (wheat) products report the highest impact in terms of carbon footprint followed by vegetables (see **Table 18**). Rice indicates the highest impact in terms of water footprint followed by wheat products. As far as soil quality index is concerned wheat marks the highest value (see **Figure 34, 35, 36**). Therefore, it can be concluded that the wheat products create the highest impact in terms of environmental indicators and reducing the amount of wheat products waste can significantly help reduce the environmental impacts compared to the other food categories.

Table 18: *Environmental impact assessment of FW generated at the case study supermarket outlet*

Environmental impact	Vegetable	Fruit	Meat	Rice	Wheat
Quantity wasted(kg)	11 024	5 460	416	3 016	2 808
Climate change (kg CO_2 eq)	16 317	8 082	8 151	7 195	27 869
Water scarcity footprint (m^3-eq)	7 769	8 020	1 951	41 196	27 258
Soil quality index (points)	56 848	58 682	221 206	661 671	1 219 098

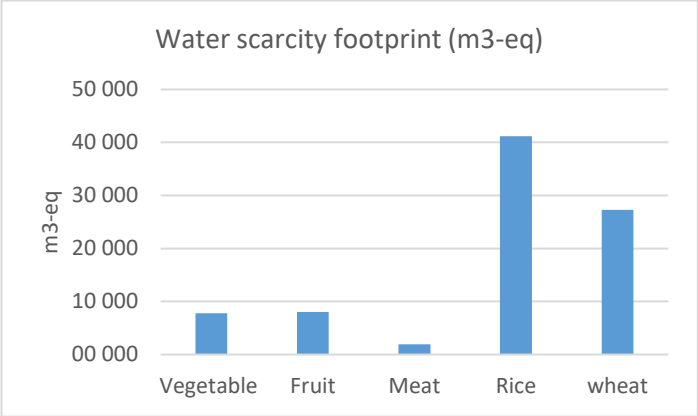
Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 34: *Carbon footprint of FW generated at the retail outlet*



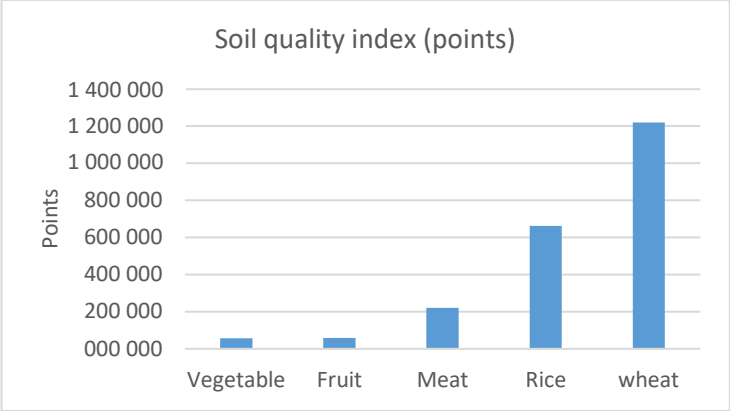
Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 35: Water scarcity footprint due to FW generated at the retail outlet



Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 36: Soil quality index due to FW generated at the retail outlet



Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

5.6.7. Strategies for food waste prevention and reduction

The associated financial loss due to FW generated in the supermarket is mostly absorbed through the selling price. However, it is essential to take measures that minimize the edible percentages of FW by adopting some practical strategies. As per the quantitative and qualitative analysis of waste at the supermarket outlet, three broad possible solutions were identified:

Prevention of vegetable and fruit waste

- Vegetable waste could be prevented by adapting dynamic shelf management practices based on the demand forecast of the given outlet. Accordingly, the outlet manager can fill-up the display shelves with vegetables and fruit in an attractive manner but in smaller quantities. If there is a sudden increase in demand, the staff could re-fill the amounts, as required. That would reduce the vegetable and fruit quantities taken out from the cold store and thus expose to dehydration and other causes of FW, such as customers handling.
- The supermarket can prepare meal packs/bundles of produce, which is highly sensitive to touching and squeezing such as tomatoes, capsicum, okra, beans and other leafy vegetables and fruits. That would reduce the FW generation by customer handling.

- The introduction of dynamic pricing would also be an effective strategy to increase sales. The pricing strategy can be changed as the quantity available for discount changes.
- Both supermarket management and customers set high cosmetic standards for food products. To curb this cause of FW, supermarkets can sell products at discounted prices.

Prevention of cooked FW at the hot kitchen

- Hot kitchen FW incurs additional production costs for the supermarket when compared with the raw food that is wasted. As a long-term strategy, a change in the outlet's shop floor plan could be considered for customer attraction– to take the hot kitchen to the front side of the outlet.
- The pricing strategy of hot kitchen items should prioritize affordability through quantity-based rather than portion-based pricing.
- Pizza is the most wasted starch product at the supermarket outlet. It should only be baked when the order is confirmed.
- The supermarket manager is allowed to offer up to 50 percent discounts for the savory items at the bakery. A similar pricing dynamic and markdown strategies should be introduced for the hot kitchen items.

Prevention of fish and meat waste

- The fish and meat waste are not as high as FW for vegetables and fruits. However, there is a higher proportion of edible percentages from the total meat waste for the hot kitchen that could be prevented by adapting demand prediction and online pre-orders.
- The supermarket chain already has online marketing facilities and that can be used to get pre-orders for prepared fish and roasted chicken. Dishes can be delivered to the customers by pick up in stores or delivery platforms.
- Pet food production using fruits, vegetables, meat and fish from the entire retail chain could be appealing to customers.

5.7. Case 7: Colombo south teaching hospital (CSTH)

5.7.1. Characterization of the sector

Hospitals have a large environmental impact through waste generation and energy and water usage (Mior, 2009). Hospitals' FW is a major concern as the health care sector is one of the largest sectors for food catering (Gomes *et al*., 2020). Recent literature calls attention to conducting FW audits in the health care sector (Hadipour *et al.*, 2014, Gomes *et al*., 2020).

Empirical analyses conducted in Sri Lankan context to understand the magnitude of FW and associated issues in the health care sector are limited. A study conducted at the National Hospital of Sri Lanka (NHSL) revealed that 55 percent of breakfasts, 62 percent of lunches and 57 percent of dinners were wasted. It was highlighted that, by allowing patients to choose food, FW can be reduced significantly (Rathnayake & Dalpatadu, 2020). A study conducted in Warakapola base hospital estimated that the total waste of hospital food was 24.26 percent (Mallawarachchi *et al*., 2019).

This case study (seven-day FW audit) focuses on providing empirical FW data for the Colombo south teaching hospital (CSTH). CSTH is the second largest public hospital in the country. It has a bed strength of 1 100 for inward patients and 2 600 staff that is involved in patient care. It provides treatment to about 150 000 (on average 2 885 per week) inward patients and 750 000 (on average 13 840 per week) outpatients, in addition to similar numbers of routine clinic patients per year. The hospital runs an Outpatients Department (OPD) 24/7 and admits inpatients to the wards of all major disciplines and several medical specialties.

5.7.2. Current food waste management strategies and best practices

According to the data gathered from the waste collection workers in the area, the hospital generates about 500 – 600 kg of FW per day. The hospital has allowed local piggeries to collect the generated FW. Therefore, the percentage of FW sent to landfill is remarkably low. The hospital keeps separate bins for FW, recyclable waste, and clinical waste in every ward and other public utility areas in the hospital. Bin waste is transferred to the central waste storage area at least three times a day.

According to the food management system in healthcare institutions in Sri Lanka, the hospital follows strict guidelines provided by government circulars and the hospital management handbook. Diet management in medical institutes is prescribed by Circular 01-21/2015 issued by the Ministry of Health (Ministry of Health, 2015). The circular provides detailed menus, quantities, specifications, and record-keeping requirements to be followed by the hospital. Accordingly, a patient's daily diet includes the entire requirement of food for 24 hours starting from noon each day to noon of the following day. It is a mandatory requirement of the hospital to consider food requirements based on the number of patients admitted by noon on a particular day to plan for the next meal cycle. At every admission, patients are inquired about the meal requirement expected from the hospital (breakfast, lunch, dinner, etc.) and, accordingly, estimations are made on the suitable diet. The hospital maintains a kitchen and procures its raw foodstuffs: vegetables, fruits, fish, meat and eggs, dry food, bakery products, and packed food from selected suppliers following the Ministry of Health procurement committee guidelines.

A clerk is assigned to receive the raw materials from the supplier. The diet clerk must visit each ward daily and scan each bed head ticket (BHT) manually to calculate the diet order. In practice, the diet clerk checks with the patient whether he/she needs the meal. The final calculation of the meal requirement is calculated on daily basis and the raw ingredient provisions are ordered each day considering the number of diets required for the patients. Meal distribution takes place in bulk from the kitchen to the wards, in the presence of a diet stewardess. Weekly menus of each meal type are decided by a food management committee, as per the instructions given in the circular.

Table 19: *Example of food orderings specifications in the 01-21/2015 Circular (Ministry of Health) of the CSTH*

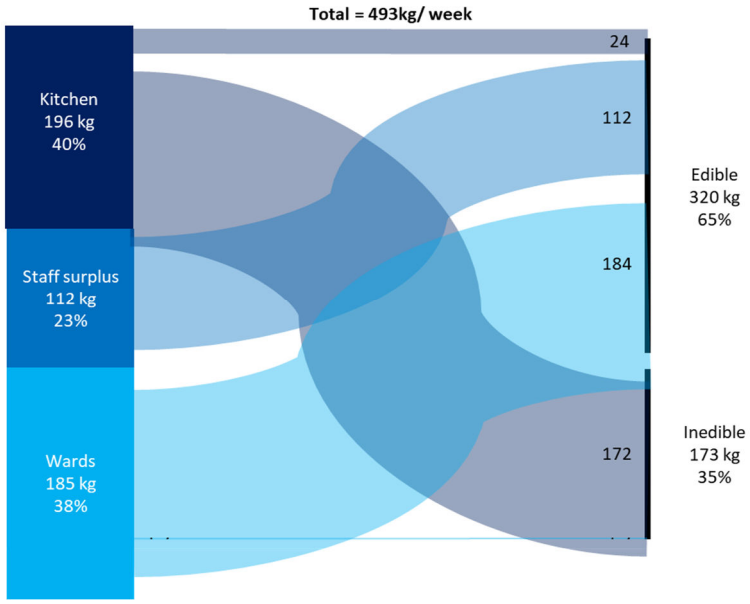
5.1.2. These foods should be ordered according to the following weekly programme of diets		
Serial No.	Types of diet	No. of days that diet should be given per week
i.	Vegetables	One day (specially on Sunday)
ii.	Eggs, fish, meat, or canned fish, fried fish	Four days
iii.	From the foods which are egg, fish, meat or canned fish, dried fish (food should be decided according to the lowest price of the market)	Two days

A weekly plan is made available to all the wards, ward clerical branch, food-ordering officer, suppliers, payment branch and diet stewardess. The kitchen department follows specific guidelines and weekly menu plans. The food management committee decides the monthly raw ingredient requirements and informs registered suppliers to provide the required ingredients as per schedule. The same 01-21/2015 Circular indicates a similar process to decide the menus for health care attendants and labourers at the hospital.

5.7.3. Food waste quantification and qualitative assessment

The FW seven-day audit examined the prescribed food management at the hospital. The desk review of secondary data relevant to quantify provision of diets to the patients was carried out, by accessing the diet control circular, the hospital management manual, the records of diet from the clerk and the records of the kitchen. Unlike many other industries, maintaining a kitchen diary is mandatory in state hospitals in Sri Lanka. Therefore, data about food preparation was readily available.

Figure 37: *FW composition by source and type at the selected wards of the CSTH*



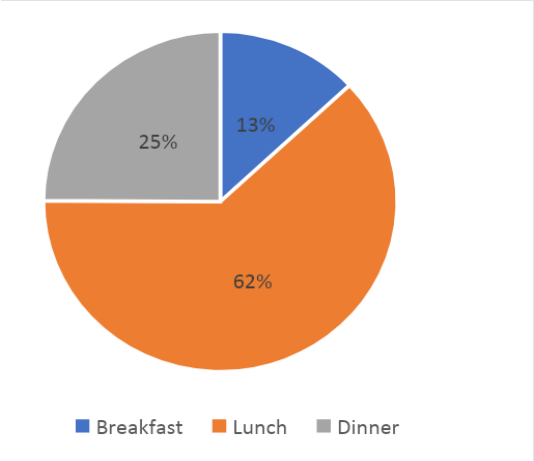
Source: Authors' elaboration, based on seven-day FW audit data, 2020.

During the period of seven days, waste bins located at the kitchen, staff meals, and wards no. 5 and no. 9 were analyzed. According to the calculation, a total of 493 kg of FW was generated out of which about 65 percent were considered edible. The rest of the waste was inedible – mostly residuals of vegetables generated in the kitchen. The highest percentage (40 percent) of FW was recorded from

the hospital kitchen. Patient plate waste collected at wards no. 5 and no. 9 recorded the second-highest FW quantity, which was about 38 percent of total FW. FW generated by the staff meals were counted as 23 percent of the total FW (see **Figure 37** on p. 55).

According to observations and analysis, more than 98 percent of the total FW generated by the wards was still edible when it was thrown away as fully or partially unconsumed. The staff meals surplus for the day is also discarded. Thus, the total edible portion out of the total FW is significantly high. However, the waste composition analysis has shown that a larger proportion of total FW from the wards is not from hospital meals but from the outside food brought by relatives and friends visiting warded patients. According to hospital staff, more than 70 percent of patients receive outside food. FW analysis quantified that out of the total FW generated at lunch 62 percent was still edible when it was thrown away (see **Figure 38**). This indicates that a mechanism to minimize outside food received by patients is required.

Figure 38: *Percentage of edible portions from the total FW by mealtime at the selected wards of the CSTH*

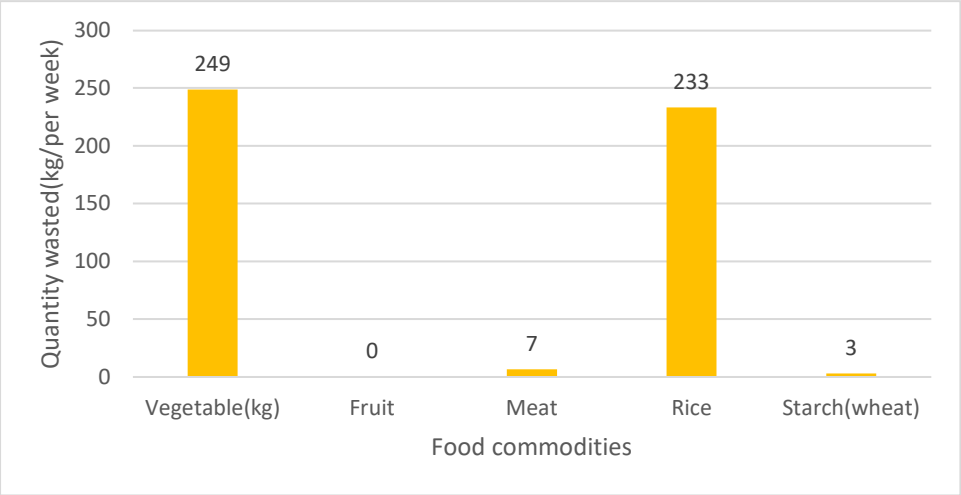


Source: Authors' elaboration, based on seven-day FW audit data, 2020.

During the interview with the director of the hospital, it was stated, "the cost incurred by the hospital to provide free meals to a patient in a day is approximately LKR 200-250 (USD 1 to 1.25). We cannot control the visitors and it is unethical to ask them not to bring food. As per regulations issued by the Ministry of Health, we should encourage outside food that would help reduce the cost of the health system of the country."

Results indicated that the highest portion of FW consists of vegetables (51 percent) followed by rice (48 percent) (see **Figure 39** on p. 57). The quantities of waste of fish, meat, cereals, and starch items were negligible. In Sri Lanka, the staple food is rice. However, a nurse stated, "most of patients are unable to eat a heavy diet due to their illnesses, and this includes rice. Visitors, especially at lunchtime, bring rice, which is not easily digested by patients". This was also confirmed by the interviewed patients.

Figure 39: FW by type generated at the selected wards of the CSTH



Source: Authors' elaboration, based on seven-day FW audit data, 2020.

5.7.4. Causes for food waste

According to the Ministry of Health Circular 01-21/2015, the hospital provides food only for the patients and the health care attendants and labourers of the hospital. It was reported that, during the FW audit, 2/3 of the in-patients had not requested hospital meals. According to a ward attendant, even the patients who requested meals from the hospital are receiving food from visitors. The portion sizes brought from outsiders were often much bigger than a patient food requirement. Consequently, outside food represents the larger portion of FW at the hospital.

Neither patients nor hospital employees have the freedom to choose food according to their preferences. As per key informants, this is the most significant factor for the large amount of FW at the hospital. However, patients do not complain because they are aware that the diet is also part of their treatment.

5.7.5. Challenges in food waste prevention and reduction

The main observation of the FW audit was the lack of freedom for kitchen staff to be innovative in the preparation of menus and food selection. The current practice is that the kitchen staff should adhere to the specific guidelines stated in the circular rather than focus on providing a variety of food to the patients. Even though the strict guidelines might be good as an internal control mechanism to reduce meal costs, that stance was identified as a barrier to address the desirability of meals. Moreover, as per the aforementioned circular, meals should be prepared by the employees of the Ministry of Health, but without specifying the minimum cooking skills requirements.

5.7.6. Impacts analysis: social, financial and, environmental

As specified in the same circular, the standard diet should contain 250 g of rice, 60 g of fish or meat, 180 g of vegetables, 120 g of green vegetables, and in cases, 125 g of bread. By converting the weighted edible portion from the total FW into possible meals, it is indicated that rice waste, in the week of the FW audit, is equal to the requirement of preparing 929 meals (see **Table 20** on p. 58).

Further, the amount of vegetables wasted equals 463 meals, meat 20 meals, cereal 17 meals and starch 22 meals. **ANNEX 9** indicates the calculated nutritional values of the measured quantities of wasted food items, by category. The calculations were done using the FReSH-FW Value Calculator beta V.1.0 version for the average daily wasted amounts.

Table 20: *Conversion of wasted quantities at the selected wards into potential meals at the CSTH*

	Rice	**Vegetables**	**Fish**	**Meat**	**Cereals**	**Starch**
Standard menu in kg	0.25	0.18	0.06	0.06	0.12	0.125
Edible waste in kg	232	83	0	1	2	3
Loss of meals	929	463	0	20	17	22

Source: Authors' elaboration, based on seven-day FW audit data, 2020.

The case study estimated that, currently, the cost of a meal is about LKR 104.15 (USD 0.56) (Table 21). Based on the estimated number of meal losses presented in **Table 20**, during the week of the FW audit, the financial loss on ingredients was accounted for LKR **17 483** (USD 88).

Table 21: *Estimation of economic costs due to total FW generated at the selected wards of the CSTH*

	Average price (LKR/kg)	**Yield Ratio**	**Standard menu per meal (kg)**	**Cost per meal (LKR)**	**Loss of meals (#)**	**Cost of waste (LKR)**
Rice	93	3	0.25	7.75	929	7 199.75
Vegetables	90	0.8	0.18	20.25	463	9 375.75
Fish	500	1	0.06	30.00	0	0.00
Meat	300	1	0.06	18.00	20	360.00
Cereals	120	1	0.12	14.40	17	244.80
Starch	110	1	0.125	13.75	22	302.50
Total				104.15		**17 482.80**

Source: Authors' elaboration, based on seven-day FW audit data, 2020.

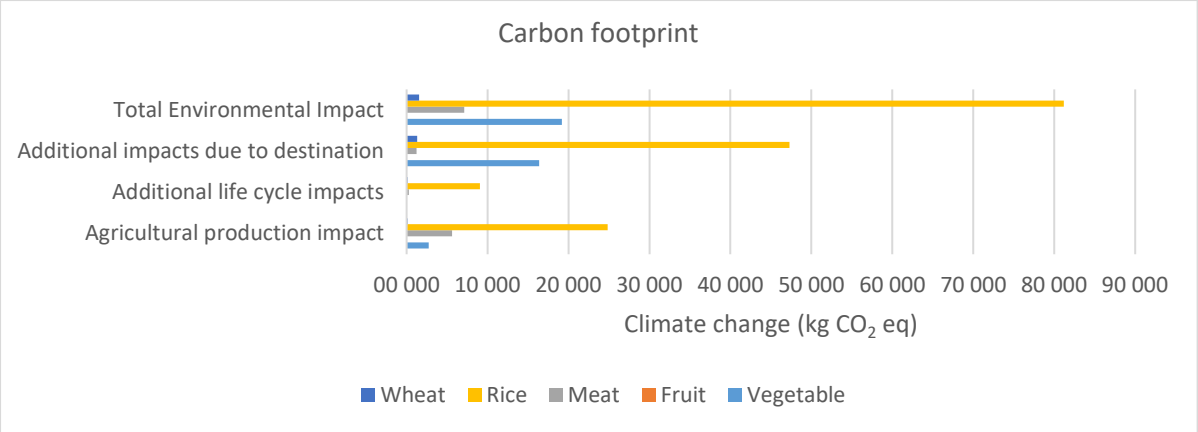
According to estimations, the environmental impacts associated with rice are significantly high compared to the other food commodities in terms of all three environmental indicators: carbon footprint, water scarcity footprint and the soil quality index. Vegetable marks the second highest impact in terms of carbon footprint and water scarcity index. Meat although with a small quantity indicated second highest soil quality index (see **Table 22, Figure 40, 41, 42** on p. 59–60).

Table 22: Environmental impacts of FW generated at the selected wards of the CSTH

Environmental impact	Vegetable	Fruit	Meat	Rice	Wheat
Quantity wasted (kg/ year)	12 948	-	364	12 064	156
Climate change (kg CO_2 eq)	19 165	-	7 132	81 186	1 548
Water scarcity footprint (m^3-eq)	62 402	-	4 553	164 782	1 514
Soil quality index (points)	456 621	-	516 147	2 646 683	67 728

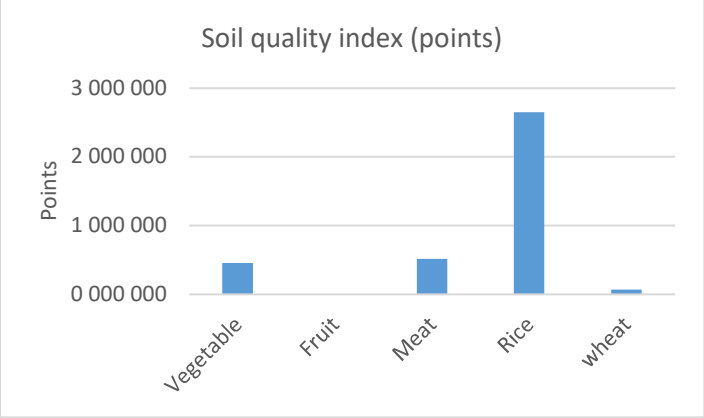
Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 40: Carbon footprint of total FW generated at the selected wards of the CSTH



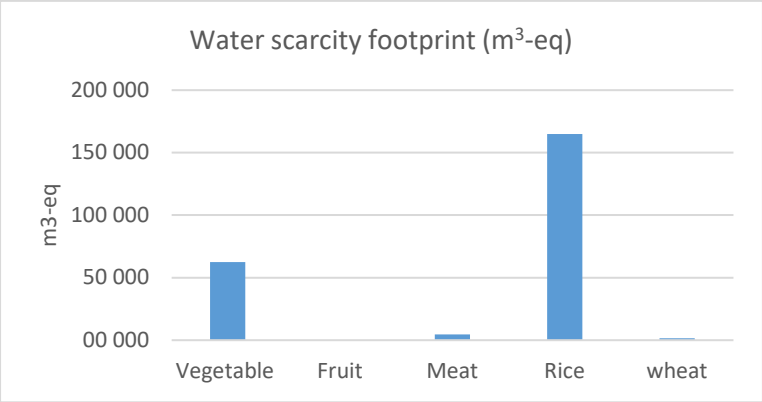
Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 41: Soil quality index due to total FW generated at the selected wards of the CSTH



Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 42: *Water scarcity estimates from the total FW generated at the selected wards of the CSTH*



Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

5.7.7. Strategies for food waste prevention and reduction

According to the results obtained from the FW audit and interviews, waste generation at the CSTH can be classified into four components:

1. Meal preparation
2. Meal administration
3. Patient and staff members
4. Visitors

The strategies for FW reduction have been specifically identified for these four areas.

Meal preparation

- Recruit qualified chefs and cooking staff or provide comprehensive training to improve the cooking skills of existing staff members to enhance the quality and taste of prepared dishes.
- Increase the number of food choices in the prescribed food items for the staff and patients to reduce monotony.

Meal distribution

- Prescribe meals considering patients' preferences from the available guided choices to reduce the amount of meals thrown away.
- Communication on FW quantity and quality can be transmitted between the different departments so that solutions are implemented for the identified reasons.
- Distribute meals to the patients hygienically and attractive manner with the clean dress (distributing staff), good quality plates/dishes and cutleries

Patients and staff

- Sensitization to the topic of FW is important since employees and patients need to understand the significance of reducing FW. Translating FW quantities into lost money, wasted rice, or vegetable portions would effectively support concrete actions identification and implementation. The hospital can increase patients' awareness about FW at the hospital through, for instance, trilingual (Sinhala, Tamil, English) posters and short video clips/audio messages.

Visitors

- Visitors should be informed about the dietary plan of the patients and provided with guidance on bringing food items and portion sizes that can be useful for the diet of the patients while also preventing FW.
- Visitors should be made aware of the FW generated at the hospital premises and the impact their own behavior is having on the total FW generated. The hospital can increase visitors' awareness about FW at the hospital through, for instance, trilingual (Sinhala, Tamil, English) posters and audio messages.

5.8. Case 8: Households in Colombo

5.8.1. Characterization of the sector

Households' FW in Sri Lanka has been a matter of discussion for a considerable amount of time. According to Jayatissa *et al*. (2014), variables influencing diets include culture, job category, income, and internal migration situation. The universal commitment made through SDG 12.3 has given priority to preventing and reducing FW. This requires focused attention and a deep understanding of FW levels and composition at the household level. The direction of recent literature have shifted towards the prevention and reduction of edible portions from total FW, rather than recycling (Liu and Nguyen, 2020; Soma *et al.,* 2020).

The present case study focused on two clusters of households: five households to represent low-income group and five households to represent middle-income group. Data is presented to facilitate comparisons and contrasts for the identification of effective reduction options.

"Due to COVID-19 we do not have a regular income, so we cook only one meal per day. If there is anything left, we are used to eating leftovers with a loaf of bread. If there is any leftover rice, we give it to a dog. We do not worry about waste separation and waiting for the municipal waste collection service. The solid waste we give to the municipal Lorries has zero FW "– A low-income household in the Mirihana area in Colombo district.

"We are not wasting food, if there are any gravy remains from the lunch, we buy bread and eat that as dinner, only thing is, we might have excess rice. Normally, we give them to our pets or dogs on the road. Hardly, we throw away anything edible. When we prepare raw food, we also try our best to make use of all the edible parts" – A low-income household in the Nugegoda area in Colombo district.

5.8.2. Current food waste management strategies and best practices

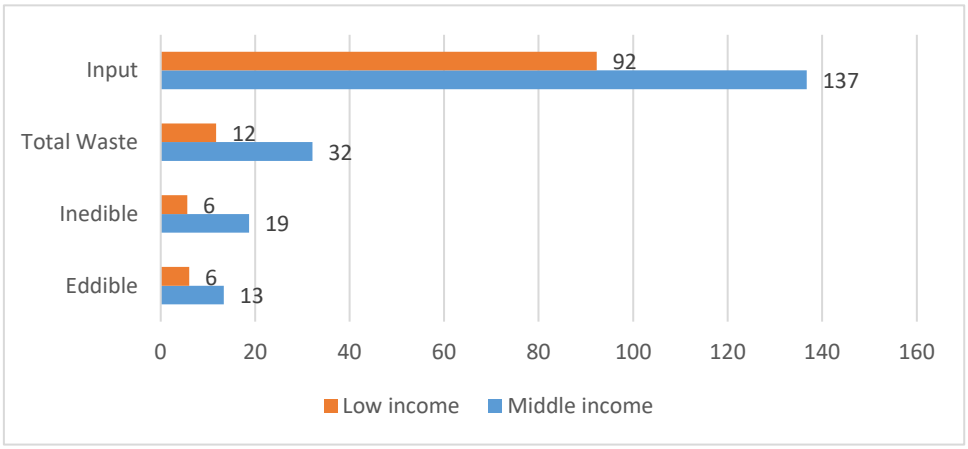
Traditionally, households used to cook three meals separately for breakfast, lunch and dinner. However, with the engagement of both males and females in economic activities, the food culture and cooking patterns have changed considerably, especially in the urban context. Food options and price ranges diversified rapidly in the last decade. Given these facts, both low and middle-income households mostly prepare one main meal and, if necessary, cook additional smaller portions to fill up shortages.

The FW seven-day audit observed a large proportion of raw vegetables and fruits residuals in the households. There is a high rate of inedible parts from the total FW during the preparation stage, in cases where households buy uncut raw vegetables, fruits, and fish. Higher edible percentages from total FW were observed due to plate FW and leftovers for the middle-income households. The low-income householders are vigilant about leftovers and whenever there is surplus food it is consumed within the day. For all participating households, there were some extra portions of rice. However, households would give the excess cooked rice to pets or stray dogs. Except for one household, none of the houses had any pets to feed the unconsumed food.

5.8.3. Food waste quantification and qualitative assessment

The FW analysis revealed that for both household samples, the middle-income households group consumed a relatively higher quantity of food during the case study week (137 kg) with an average of 4 kg per household per day, whereas the low-income group consumed only 92 kg of food with an average of 3 kg per household per day (see **Figure 43**). Subsequently, middle-income households generated 32kg/ week of FW while the low-income household group generated 12 kg/week. This can be averaged as 0.92 kg/ day in a middle-income household and 0.34 kg/ day in a low-income household. In Asia and the Pacific regional context, an analysis of survey responses found that the self-reported FW generation rate per household in Hanoi (Vietnam) averaged 1.192 kg/day in urban areas and 1.694 kg/day in rural areas (Liu and Nguyen, 2020). The findings of the present case study analysis show that the families in Colombo generate a comparatively less amount of FW, particularly among the low-income groups. Considering an average family size of four members, per capita FW generation in a middle-income household was 0.23 kg/day, whereas in a low-income household it was 0.08 kg/ day.[4]

Figure 43: *Quantities of inputs and inedible and edible portions of FW in the sample households (kg/week)*



Source: Authors' elaboration, based on seven-day FW audit data, 2020.

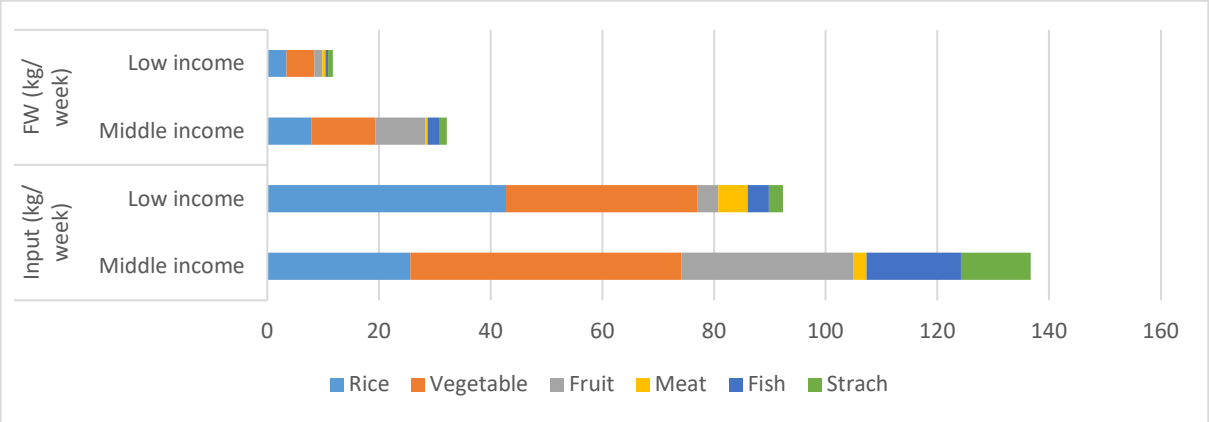
The analysis results have indicated that both inedible and edible portions from the total FW are higher among the middle-income households with 19 kg inedible and 13 kg edible waste respectively. Altogether, 19 percent of both groups' total input was wasted as either inedible (11 percent) or edible (8 percent) waste. However, among middle-income households, the total waste percentage was 24 percent (inedible 14 percent and edible 10 percent), which suggests that almost ¼ of the total food

[4] Average number of family members were four in both cases of low income and middle-income category. ANNEX 10 provides the profile of the household sample.

input has been wasted. Among the low-income households, the total FW was 13 percent of its input (6 percent inedible and 7 percent edible). This indicates that the sampled middle-income households tend to waste more food than lower-income households.

Ninety percent of households cook once or twice a day. In most cases, the second cooking session is more a fill-up for the dinner, with one or two curries. Further, in almost all cases, family members are not taking breakfast and lunch at home. Instead, they pack and take it to work or school. Therefore, the actual waste quantification recorded mostly dinner FW. However, on average, middle-income households waste twice as much as low-income families. In terms of amounts of FW, vegetable represents the highest proportions (see **Figure 44**).

Figure 44: *Food consumption among middle- and low-income households by type of the commodity*



Source: Authors' elaboration, based on seven-day FW audit data, 2020.

However, edible portions of total FW mainly consist of rice (see **Table 23**). A relatively higher quantity of edible vegetables and fruit waste is generated in middle-income households. Both groups hardly waste any edible portions of fish or meat. Nevertheless, both waste starch as slices of bread. Overall, middle-income households are wasting more edible portions of food than lower-income families.

Table 23: *Quantities (kg) of edible portions out of total FW for the middle- and low-income households*

	Amount of edible portion of FW, in kg per week					
Sample	Rice	Vegetable	Fruits	Fish	Meat	Starch
Middle-income	7.89	2.13	2.10	0	0.03	1.26
Low-income	3.39	1.85	0	0	0	0.85

Source: Authors' elaboration, based on seven-day FW audit data, 2020.

5.8.4. Causes for food waste

Given that households are accessing food for direct consumption, analysis of causes focused on the identification of cause for and solutions to edible portions from the total FW. Low-income and middle-income households have different reasons for generating edible portions of FW:

Eating habits. Low-income households' members are not very selective. Therefore, menus are prepared in view of the availability of time and money. However, for middle-income households, preferences play a major role. Nevertheless, when cooking, households do not always consider all

preferences. Hence, middle-income households tend to have higher percentages of edible FW. In certain households, family members dislike eating the same vegetables/curries for all three meals. In such cases, households have to throw away the leftovers. However, households also refrigerate some leftovers for future use, but there are instances that the refrigerated food also ends as FW after a few days.

Behaviors leading to FW

Buying practices: Middle-income households have more preparatory edible waste than low-income households due to their bulk-purchasing pattern do. As per the households' kitchen diary entries, low-income households buy food items from nearby retail shops daily. Middle-income families purchase food weekly and, in some cases, once in two weeks. The difference in buying patterns is mainly due to the cash flow. Low-income households' earnings are generated daily while middle-income houses receive monthly payments and maintain fixed work schedules that limit them frequent shopping. Due to the day-to-day buying patterns, low-income households can often consume fresh vegetables and fruits. This results in low edible FW percentages. However, weekly or fortnightly buying patterns of middle-income households result in less fresh vegetables, which can potentially create a higher amount of edible FW.

Photo 14: *Weekly purchased vegetables for one middle-income household*

Lack of awareness: households were not aware of the exact quantities and financial loss due to FW. Therefore, until the present study, FW had not been of significant concern. Members of the middle-income households tend to decide eat-outs ad-hoc without considering food availability at home. They prefer to have outside food, especially during dinnertime, even when the households have already cooked dinner.

Food grades: Second graded foods (vegetables and fruits, dehydrated and broken vegetable parts, and food items nearing expiry dates) are sold at discounted prices by vendors. Households in the low-income group were price-conscious and inclined to buy second-quality vegetables and fruits.

However, middle-income households often looked for attractive vegetables and fruits from markets or the DEC.

"We are earning a small income, hence going to supermarkets is not affordable. We buy things from a nearby vegetable shop. We are always concerned about the price but are not concerned about appearance. We tend to buy broken and damaged fresh vegetables and fruits at a low price. Whatever the food, we cut them before cooking, so appearance is immaterial for us." – A member of low-income household

"We are used to go to NDEC for purchasing fresh, high-quality vegetables and fruits. I am used to handpick every item, such as carrots, beans and tomatoes. I do not buy unattractive food and lower-grade vegetables. We pay money, so we select good ones. Further, there might be rat bites, bat bites, or other damages. There were cases where people died eating damaged fruits. So why take a risk? - A member of middle-income household

5.8.5. Challenges in food waste prevention and reduction

Preparing too much food, forgetting about the expiry date of foods at the back of the fridge, and unwillingness to consume leftovers are a few causes identified for household FW generation. Households essentially can address these causes with various corrective actions. However, the attitude of each household in implementing FW reduction actions and continuing these good practices is key to have success in reducing FW at a given household. Attitudinal and behavioral changes can start with the young family members such as school children with correct motivations.

Some causes for FW are beyond the household level although consumers are ultimately responsible for the FW generated. For example, large portion sizes of food products sold at different retail outlets can lead to FW at the household level. However, households as customers can make efforts to demand the right portion sizes through which retailers can be motivated to introduce customized portion sizes.

5.8.6. Impacts analysis: social, financial and environmental

The sample households have purchased all the food items consumed during the week of the FW audit. The average retail price of each food item was calculated from the Central Bank press release on food prices during that week. On average, middle-income households had spent LKR 4 402 (USD 22), while the low-income households had spent LKR 2 558 (USD 13). The finding indicates that the average middle-income household in the sample loses 20 percent of their food expenditure as FW (LKR 889, USD 4), while low-income families lose about 13 percent (LKR 325, USD 2) (see **Table 24** on p. 66). **ANNEX 11** indicates the calculated nutritional values of the measured quantities of wasted food items, by category. The calculations were done using the FReSH-FW Value Calculator beta V.1.0 version for the average daily wasted amounts.

Table 24: Financial loss due to FW by income level of the participating households

		Middle-income households (LKR)			Low-Income households (LKR)		
	Rate	Input	Inedible waste	Edible waste	Input	Inedible waste	Edible waste
Rice	91	2 334	6	718	3 890	3	308
Vegetable	133.29	6 465	1 237	284	4 565	421	247
Fruit	101	3 107	691	212	379	146	0
Meat	360	871	133	11	1 908	203	0
Fish	480	8 107	1 038	0	1 824	219	0
Starch	90	1 123	0	113	223	0	77
Total		**22 008**	**3 106**	**1 338**	**12 789**	**994**	**632**
Average per household		**4 402**	**621**	**268**	**2 558**	**199**	**126**
Economic loss (%)			14	6		8	5

Source: Authors' elaboration, based on seven-day FW audit data, 2020.

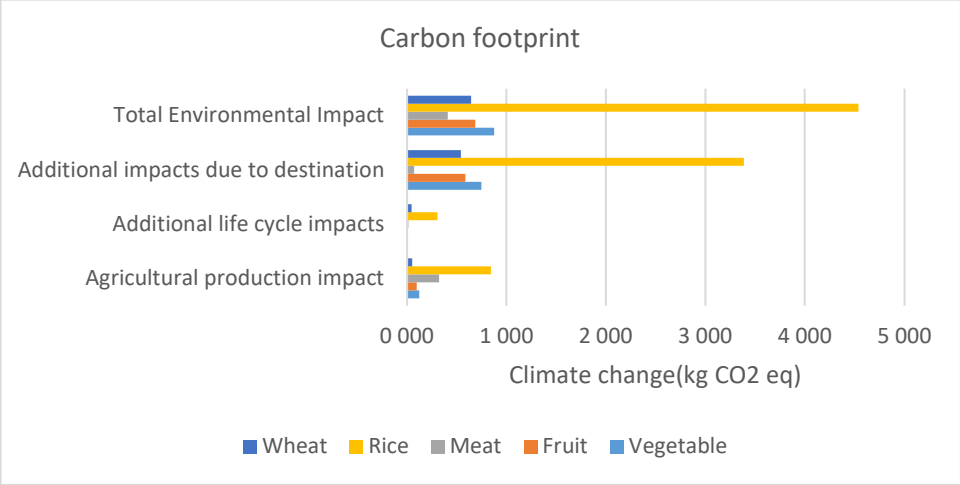
Rice generates the highest impact in terms of all environmental indicators followed by vegetables (see **Table 25**, **Figures 45, 46, 47**). Given that the final disposal of FW is landfilling, the carbon footprint associated with the disposal stage is higher compared to the other stage of the value chain.

Table 25: Environmental impacts of FW generated by the participating middle-income households

Environmental impact	Vegetable	Fruit	Meat	Rice	Wheat
Quantity wasted(kg)	593	464	21	410	65
Climate change (kg CO_2 eq)	876	685	396	4 233	596
Water scarcity footprint (m^3-eq)	2 858	2 236	263	5 600	631
Soil quality index (points)	20 913	16 363	29 778	89 949	28 220

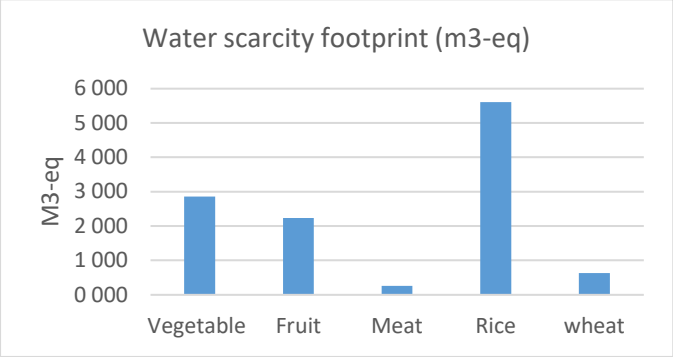
Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 45: Carbon footprint of total FW by the middle-income households



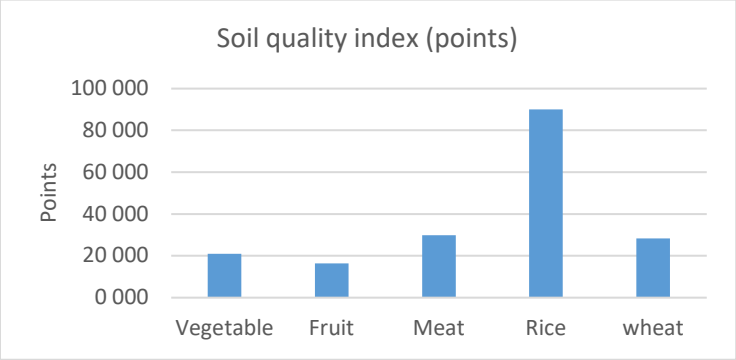
Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 46: Water scarcity estimations due to total FW by the middle-income households



Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 47: Soil quality index estimated for the total FW generated by the middle-income households



Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

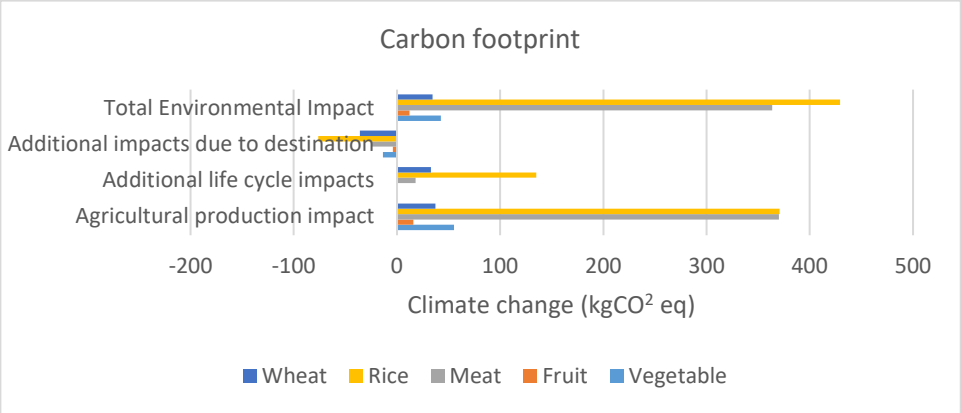
The environmental impact assessment for the low-income households shows similar results to the middle-income household group (see **Table 26, Figures 48, 49, 50**) with rice marking the highest impact.

Table 26: Environmental impact assessment of the total FW generated by the low-income participating households

Environmental impact	Vegetable	Fruit	Meat	Rice	Wheat
Quantity wasted(kg)	261	75	24	180	44
Climate change (kg CO^2 eq)	386	111	452	1 858	404
Water scarcity footprint (m^3-eq)	1 258	361	300	2 459	427
Soil quality index (points)	9 204	2 645	34 032	39 490	19 103

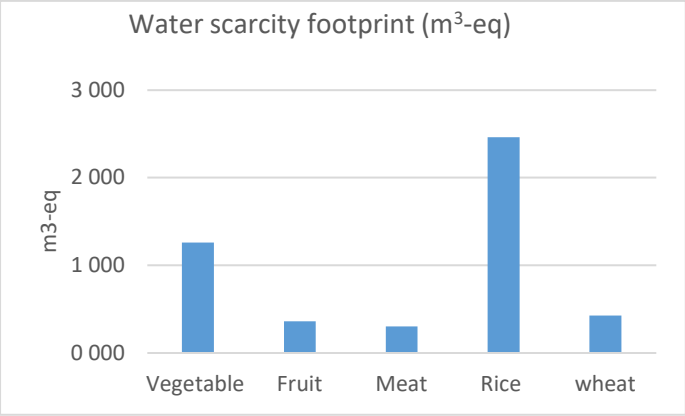
Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 48: Carbon footprint of total FW generated by the low-income participating households



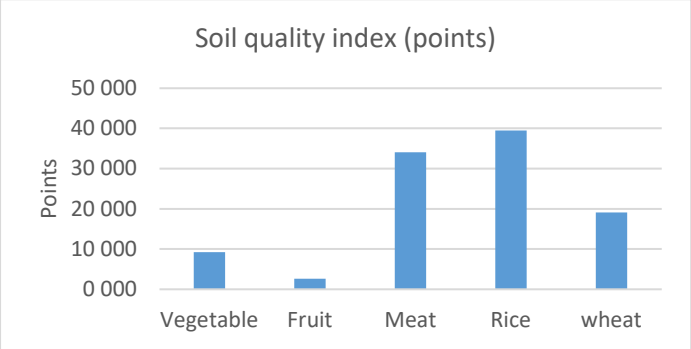
Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 49: Water scarcity footprint of the total FW generated by the low-income participating households



Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Figure 50: Soil quality index of the total FW generated by the low-income participating households



Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

5.8.7. Households can change behavior

In general, food management in low-income households was relatively better than in middle-income families. Middle-income families tend to buy perishable food items such as vegetables and fruit in

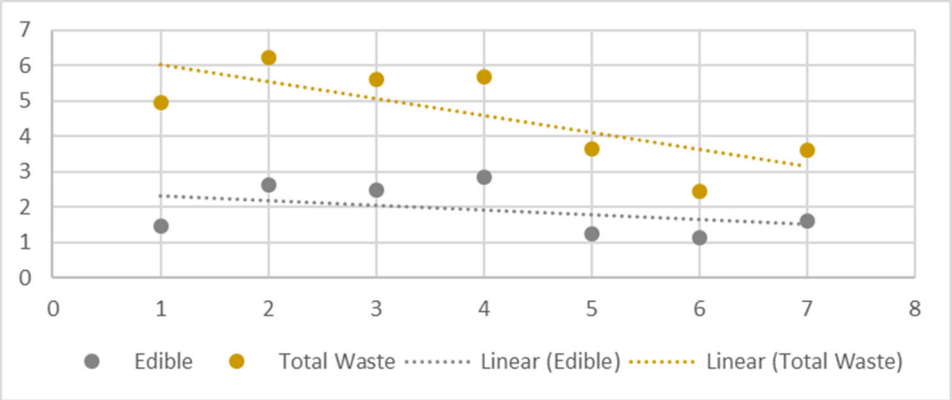
bulk. By increasing the frequency of purchasing vegetables and fruits, while reducing the purchasing quantities per session, FW for this category may be minimized.

As an example, it has been observed that many households regularly cook dhal curry. However, relatively a high proportion always becomes leftover. Changes in the menu and recipes could prevent FW. Thus, maintaining a good awareness level of family members' food preferences could help reduce overcooking.

Further, awareness raising needs to be strengthened, through state and non-state activities alike, on safe and ugly vegetables and fruits. Purchasing these optically different foods reduces FW that would cost less for the family budget.

Weighing edible portions of total FW for at least two weeks by the households to identify the wasting pattern can often be helpful. During the case study, it was observed that households quickly learned the FW quantities and gradually minimized their FW in the following days of the week.

Figure 51: *Reducing trend of edible percentages of total FW at middle-income households during the FW audit*



Source: Authors' elaboration, based on seven-day FW audit data, 2020.

6. Conclusions

Food waste (FW) prevention and reduction is a key to the progress of the whole sustainable development agenda. FW analysis (i.e., quantities, causes, and characteristics) is needed to identify interventions for FW prevention and reduction in different sectors.

The nine case studies conducted targeted food services (one restaurant and one hotel), wholesale markets (one fruits and vegetable stall), retailers (one supermarket), caterers (one hospital), and households (four middle- and four high-income households). The method applied was a FW audit that measured the amounts generated from various processes and identified drivers/causes and current best practices through physical separation, weighing, and categorizing quantities into edible and inedible portions.

Methods and mechanisms to monitor the effectiveness of FW interventions are needed to demonstrate the effectiveness of required investments. The measure-act-monitor approach that takes 6 weeks, applied for the case studies, is an effective tool to trigger FW prevention and reduction interventions. The applied method identified sector-specific solutions and quantified FW, giving thus an overview of, for instance, the direct financial loss due to wasted edible quantities.

FW mostly consisted of vegetables in the wholesale and retail sector and cooked rice in the case of the food service sector with about 50 – 70 percent still edible at the time of discarding. Moreover, the hotel case study implemented several strategies that follow the measure-act-monitor approach and was able to reduce FW from 540 g to 200 g per customer within four months.

State and non-state actors should focus on raising awareness, strengthening food quality and safety capacity for food business operators, and food literacy for consumers. FW prevention and reduction solutions should be widely disseminated.

References

Aldaco, R., Hoehn, D., Laso, J., Margallo, M., Ruiz-Salmón, J., Cristobal, J., Kahhat, R., Villanueva-Rey, P., Bala, A., Batlle-Bayer, L., Fullana-I-Palmer, P., Irabien, A. & Vazquez-Rowe, I. 2020. Food waste management during the COVID-19 outbreak: a holistic climate, economic and nutritional approach. *The Science of the total environment,* 742: 140524. (also available at https://doi.org/10.1016/j.scitotenv.2020.140524)

Aschemann-Witzel, J. 2018. Helping you to waste less? Consumer acceptance of food marketing offers targeted to food-Related lifestyle segments of consumers. J*ournal of Food Products Marketing*, 24(5): 522–538. (also available at https://doi.org/10.1080/10454446.2018.1472693)

Bognár, A. 2002. *Tables on weight yield of food and retention factors of food constituents for the calculation of nutrient composition of cooked foods (dishes).* BFE (Bundesforschungsanstalt für Ernährung) , Karlsruhe, Germany. (also available at http://www.fao.org/uploads/media/bognar_bfe-r-02-03.pdf)

Buzby, J. C. & Hyman, J. 2012. Total and per capita value of food loss in the United States. *Food Policy*, 37(5): 561–570. (also available at https://doi.org/10.1016/j.foodpol.2012.06.002)

Cicatiello, C., Franco, S., Pancino, B., Blasi, E. & Falasconi, L. 2017. The dark side of retail food waste: Evidences from in-store data. *Resources, Conservation and Recycling*, 125: 273–281. (also available at https://doi.org/10.1016/j.resconrec.2017.06.010)

Clowes A., Hanson C. & Swannell R. 2019. *The business case for reducing food loss and waste : restaurants.* A report on behalf of champions 12. 3. (also available at https://champions123.-business-case-.pdf)

Dolnicar S., Juvan E., & Grün B. 2020. Reducing the plate waste of families at hotel buffets – A quasi-experimental field study. *Tourism Management,* 80: 104103. (also available at https://doi.org/10.1016/j.tourman.2020.104103)

Eriksson, M., Strid, I. & Hansson, P. A. 2012. Food losses in six Swedish retail stores: Wastage of fruit and vegetables in relation to quantities delivered. *Resources, Conservation and Recycling*, 68: 14–20. (also available at https://doi.org/10.1016/j.resconrec.2012.08.001)

FAO, IWMI & RUAF Foundation. 2016. *City region food system situational analysis-Colombo, Sri Lanka*, working document, Colombo, FAO and IWMI. 251 pp. (also available at https://www.fao.org/3/bl821e/bl821e.pdf).

FAO. 2019. *State of Food and Agriculture 2019. Moving forward on food loss and waste reduction*. Rome. 182 pp (also available at https://www.fao.org/3/ca6030en/ca6030en.pdf)

Foti, V. T., Sturiale, L. & Timpanaro, G. 2018. An overview of food waste phenomenon: By problem to resource. *Quality - Access to Success*, 19(S1): 232–240. (also available at Link.FW overview)

Gomes, A., Saraiva, C., Esteves, A. & Gonçalves, C. 2020. Evaluation of hospital food waste-A case study in Portugal. *Sustainability (Switzerland)*, 12(15): 1–9. (also available at https://doi.org/10.3390/su12156157)

Gustafsson, J. 2017. Single case studies vs. multiple case studies: A comparative study. Academy of Business, Engineering and Science Halmstad University, Sweden, 1–15. (also available at https://www.diva-portal.org/smash/get/diva2:1064378/FULLTEXT01.pdf)

Hadipour, M., Saffarian, S., Shafiee, M. & Tahmasebi, S. 2014. Measurement and management of hospital waste in southern Iran: a case study. *Journal of Material Cycles and Waste*

Management, 16(4): 747–752. (also available at https://doi.org/10.1007/s10163-013-0214-x)

Jayathilake, N., Aheeyar, M., Drechsel, P. & Bucatariu, C. 2023. *Quantitative analysis of food waste from wholesale to households in Colombo, Sri Lanka*. Colombo, FAO and IWMI. doi: https://doi.org/10.4060/cb7810en

J**ayatissa, R.L.N., Wickramasinghe, W.D. & Piyasena, C.** 2014. *Food consumption patterns in Sri Lanka.* Colombo: Hector Kobbekaduwa Agrarian Research and Training Institute. (also available at https://www.worldcat.org/title/food-consumption-patterns-in-sri-lanka/oclc/907133294)

Kashyap, D., & Agarwal, T. 2020. Food loss in India: water footprint, land footprint and GHG emissions. *Environment Development and Sustainability*, 22(4): 2905-2918. (also available at Link India footprint)

Leverenz D., Hafner G., Moussawel S., Kranert M., Goossens Y. & Schmidt T. 2021. Reducing food waste in hotel kitchens based on self-reported data. *Industrial Marketing Management*, 93: 617-627.

Liu, C. & Nguyen, T. T. 2020. Evaluation of household FW generation in Hanoi and policy implications towards SDGs target 12.3. *Sustainability (Switzerland)*, 12(16). (also available at https://doi.org/10.3390/su12166565)

Mallawarachchi, S. M., Mallawarachchi, C. H. & Dalpatadu, K. C. S. 2019. A Project to improve the process and practices of provision of diet to inward patients in a government hospital , Sri Lanka. *International Journal of Research Foundation of Hospital and Healthcare Administration*, 7(2): 85–89.(also available at https://www.jrfhha.com/doi/JRFHHA/pdf/10.5005/jp-journals-10035-1111)

Matzembacher, D. E., Brancoli, P., Maia, L. M., Eriksson, M. 2020. Consumer's food waste in different restaurants configuration: A comparison between different levels of incentive and interaction. *Waste Management*, 114 : 263-273. (also available at https://doi.org/10.1016/j.wasman.2020.07.014)

Ministry of Health. 2015. Circular on supply of diet to patients and minor employees in medical institutions, Circular No. 01-21/2015. (also available at http://www.health.gov.lk/CMS/cmsmoh1/upload/english/01-21-2015-eng.pdf)

Mior, C. 2009. *Strategies to reduce waste in patient food services.* Aramark Healthcare. (also available at http://greenhealthcare. waste reduction research paper.pdf)

Muth M. K., Birney C., Cuéllar A., Finn S. M., Freemane M., Galloway J. N., Gee I., Gephart J., Jones K., Low L., Meyer E., Read Q., Smith T., Weitz K. & Zoubek S. 2019. A systems approach to assessing environmental and economic effects of food loss and waste interventions in the United States. *Science of the Total Environment,* 685: 1240-1254. (also available at https://www.sciencedirect.com/science/article/pii/S0048969719328037)

Nikkel, L., Maguire, M., Gooch, M., Bucknell, D., LaPlain, D., Dent, B., Whitehead, P. & Felfel, A. 2019. *The avoidable crisis of food waste: roadmap.* Second Harvest and Value Chain Management International. Ontario, Canada. (also available at https://secondharvest.ca/Crisis-of-Food-Waste-The-Roadmap.pdf)

Okumus, B., & Taheri, B., Giritlioğlu, İ. & Gannon, M. 2020. Tackling food waste in all-inclusive resort hotels. *International Journal of Hospitality Management*. 88: 102543. doi: 10.1016/j.ijhm.2020.102543.

Papargyropoulou, E. Lozano, R. Steinberger, J.K. Wright, N. & bin Ujang, Z. 2016. Conceptual framework for the study of food waste generation and prevention in the hospitality sector. *Waste Management*, 49: 326-336. (also available at https://www.sciencedirect.com/science/article/abs/pii/S0956053X16300174?via%3Dihub)

Papargyropoulou, E., Steinberger, J. K., Wright, N., Lozano, R., Padfield, R. & Ujang, Z. 2019. Patterns and causes of food waste in the hospitality and food service sector: FW prevention insights from Malaysia. *Sustainability (Switzerland)*, 11(21). (also available at https://doi.org/10.3390/su11216016)

Rathnayake, D. & Dalpatadu, S. 2020. A systematic approach to reduce hospital food waste based on patient experience. *British Journal of Healthcare Management*, 26(10): 1–7. (also available at https://doi.org/10.12968/bjhc.2019.0100)

Rathnayake, R. M. S. S. & De Silva, D. 2016. Diet cost of patients in Teaching Hospital Kalubowila. *Anuradhapura Medical Journal*, 10(1): 1-5. (also available at https://doi.org/10.4038/amj.v10i1.7596)

Ribeiro, A. P., Rok, J., Harmsen, R., Carreón, J.R. & Worrell, E. 2019. Food waste in an alternative food network – A case-study. *Resources, Conservation and Recycling*, 149: 210–219. (also available at https://doi.org/10.1016/j.resconrec.2019.05.029)

Royte, E. 2016. How 'ugly' fruits and vegetables can help solve world hunger. *National Geographic, 1 March 2016.* (also avaiable at https://www.nationalgeographic.com/magazine/2016/03/global-food-waste-statistics/)

Sandaruwani, J. A. R. C. & Gnanapala, W. K. A. C. 2016. Food wastage and its impacts on sustainable business operations: A study on Sri Lankan tourist hotels. *Procedia Food Science*, 6: 133–135. (also available at https://doi.org/10.1016/j.profoo.2016.02.031)

Schanes, K., Dobernig, K. & Gözet, B. 2018. Food waste matters – A systematic review of household FW practices and their policy implications. *Journal of Cleaner Production*, 182: 978–991. (also available at https://doi.org/10.1016/j.jclepro.2018.02.030)

Schneider, F. & Eriksson, M. 2020. Food waste (and loss) at the retail level. In R*outledge Handbook of Food Waste*. Routledge.

Soma, T., Li, B. & Maclaren, V. 2020. Food waste reduction: A test of three consumer awareness interventions. *Sustainability (Switzerland)*, 12(3): 1–19. (also available at https://doi.org/10.3390/su12030907)

Stenmarck, Å., Werge, M., Hanssen, O. J., Silvennoinen, K. & Katajajuuri, J.-M. 2011. *Initiatives on prevention of FW in the retail and wholesale trades.* Nordic Council of Ministers. Copenhagen. (also available at http://norden.diva-portal.org/smash/get/diva2:701989/FULLTEXT01.pdf)

Tomaszewska, M., Bilska, B., Tul-Krzyszczuk, A., Koło˙zyn-Krajewska, D. 2021. Estimation of the scale of food waste in hotel food services – A Case Study. *Sustainability*, 13,421. (also available at https://www.mdpi.com/2071-1050/13/1/421)

Warshawsky, D. N. 2015. The devolution of urban food waste governance: Case study of food rescue in Los Angeles. *Cities*, *49:* 26–34. (also available at https://doi.org/10.1016/j.cities.2015.06.006)

Warshawsky, D. N. 2016. Food waste, sustainability, and the corporate sector: case study of a US food company. *Geographical Journal*, *182*(4): 384–394. (also available at https://doi.org/10.1111/geoj.12156)

WasteMINZ. 2018. *Food waste in the cafe and restaurant sector in New Zealand. (also available at* http://www.wasteminz.resturant-food-waste-WasteMINZ-2018.pdf)

Annexes

Annex 1: *Kitchen waste diary (maintained by the chefs/households)*

Date							
Time							
Meal	Breakfast		Lunch		Dinner		
	Grams						Reason
Discarded items		status					
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Status C: Cooked/Leftovers, P: Prepped (chopped or prepared, but not cooked), W: Whole, I: Inedible Parts, Other.

Annex 2: *Primary data collection format*

Organization									
Day	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Total	Typical destination
Time									
Weight	In kg								
Before sorting									
Food - Edible									
1. Edible – meat & fish: uncooked or cooked meat (with mostly edible components) unmixed with other types of food. Examples include beef, pork, and fish.									
2. Edible – dairy & eggs: solid dairy or egg products unmixed with other food types or in original form. Examples include milk, cheese, butter, and eggs.									
3. Edible – fruits & vegetables: solid uncooked or cooked vegetables and fruits (with mostly edible components) unmixed with other types of food. Examples include apples, lettuce, and fresh herbs.									
4. Edible – baked goods: baked goods and bread-like products unmixed									
with other food types or in original form, including pastries. Examples include bread, cake, and tortillas.									

5. **Edible – dry foods:** cooked or uncooked grains, pastas, legumes, nuts, or cereals unmixed with other food types or in original form. Examples include flour, nuts, lentils, and cereal.									
6. **Edible – snacks, condiments, and others:** includes confections, processed snacks, condiments, and other miscellaneous items. Examples include candy, chips, and sauces.									
7. E**dible – liquids/oils/grease:** items that are liquid, including beverages. Examples include cooking oil, liquid coffee, and soda.									
8. Edible – cooked/prepared items/leftovers: items that have many food types mixed as part of cooking or preparation. Examples include lasagna, burritos, falafel, stir-fry, sandwiches, and pizza.									
Inedible parts:									
Unidentifiable: used only if necessary									
Total									

Source: Adapted from Darby Hoover (2017) Estimating quantities and types of FW at the city level, Natural Resources Defense Council.

Annex 3: *Nutritional loss of FW generated at the case study hotel*

Nutrition		Vegetable		Fruit		Meat		Rice		Starch	
		Amount (nutrition)	person/ day - equivalents	Amount (nutrition)	person/day - equivalents	Amount (nutrition)	person/ day - equivalents	Amount (nutrition)	person/ day - equivalents	Amount (nutrition)	person/ day - equivalents
Energy	(kcal)	41 653	21	26 033	13	65 893	33	346 750	173	179 670	90
Protein	(g)	768	15	480	10	4 812.27	96	6 773	135	7 250	145
Carbohydrates	(g)	10 426	35	6 516	22	-	-	75 952	253	37 698	126
Fiber	(g)	1 642	66	1 026	41	-	-	1 235	49	-	-
Calcium	(mg)	14 666	15	9 166	9	4 480	4	26 600	27	18 020	18
Choline	(mg)	7 025	13	4 390	8	4 368	8	5 510	10	-	-
Copper	(mg)	53	27	33	17	13.53	7	209	105	293	147
Food folate	(mg)	14 226	36	8 891	22	1 960	5	7 600	19	22 790	57
Iron	(mg)	318	18	198	11	331	18	4 094	227	1 865	104
Magnesium	(mg)	11 000	28	6 875	17	5 226	13	23 750	59	76 320	191
Manganese	(mg)	129	65	80	40	3	2	1 033	517	1 596	798
Niacin	(mg)	424	21	265	13	1 455	73	3 982	199	3 571	179
Panto acid	(mg)	138	14	86	9	195	20	963	96	495	50
Phosphorus	(µg)	20 680	21	12 925	13	47 133	47	109 250	109	269 240	269

Potassium	(mg)	206 360	59	128 975	37	69 346	20	109 250	31	228 430	65
Riboflavin	(mg)	47	28	29	18	48	29	46	27	64	38
Selenium	(mg)	264	4	165	2	5 133	73	14 345	205	47 382	677
Sodium	(mg)	15 546	6	9 716	4	18 386	8	4 750	2	1 060	0
Thiamin	(µg)	42	28	26	18	78	53	547	365	222	148
Vit A	(IU)	3 685 440	737	2 303 400	461	6 160	1	-	-	-	-
Vit B6	(mg)	117	59	73.52	37	100	50	155	78	222	111
Vit B12	(µg)	-	-	-	-	292	49	-	-	-	-
Vit C	(mg)	6 644	111	4 152	69	65	1	-	-	-	-
Vit D	(µg)	-	-	-	-	9	1	-	-	-	-
Vit E	(mg)	277	10	173	6	36	1	104	4	-	-
Vit K	(µg)	24 156	302	15 097	189	494	6	95	1	-	-
Zinc	(µg)	124	8	77	5	649	43	1 035	69	2 204	147

Note: Equivalent daily values (based on 2000 kcal diet from US FDA); the nutritional content of FW is obtained from a publicly released Standard Reference database available through the United States Department of Agriculture. https://www.fda.gov/Food/GuidanceRegulation/Guidance.html

Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Annex 4: *Nutritional loss of FW generated at the five food outlets of the Food Court*

Nutrition		**Vegetable**		**Fruit**		**Meat**		**Rice**		**starch**	
		Amount (nutrition)	**person/ day - equivalents**	**Amount (nutrition)**	**person/ day - equivalents**	**Amount (nutrition)**	**person/ day - equivalents**	**Amount (nutrition)**	**person/ day - equivalents**	**Amount (nutrition)**	**person/ day - equivalents**
Energy	(kcal)	1 893	1	25 560	13	941.33	0	29 200	15	339.00	0
Protein	(g)	34	1	471	9	68	1	570	11	13	0
Carbohydrates	(g)	473	2	6 398	21	-	-	6 396	21	71	0
Fiber	(g)	74	3	1 008	40	-	-	104	4	-	-
Calcium	(mg)	666	1	9 000	9	64	0	2 240	2	34	0
Choline	(mg)	319	1	4 311	8	62	0	464	1	-	-
Copper	(mg)	2	1	32	16	0.19	0	17	9	0.55	0
Food folate	(mg)	646	2	8 730	22	28	0	640	2	43	0
Iron	(mg)	14	1	195	11	4	0	344	19	3	0
Magnesium	(mg)	500	1	6 750	17	74	0	2 000	5	144	0
Manganese	(mg)	5	3	79	40	0.05	0	87	44	3	2
Niacin	(mg)	19	1	260	13	20	1	335	17	6	0
Panto acid	(mg)	6	1	84	8	2	0	81	8	0.94	0
Phosphorus	(µg)	940	1	12 690	13	673	1	9 200	9	508	1
Potassium	(mg)	9 380	3	126 630	36	990	0	9 200	3	431	0
Riboflavin	(mg)	2	1	29	17	0.69	0	3	2	0.12	0
Selenium	(mg)	12	0	162	2	73	1	1 208	17	89	1
Sodium	(mg)	706	0	9 540	4	262	0	400	0	2	0
Thiamin	(µg)	1	1	26	17	1.13	1	46	31	0.42	0

Vit A	(IU)	167 520	34	2 261 520	452	88	0	-	-	-	-
Vit B6	(mg)	5	3	72	36	1	1	13	7	0.42	0
Vit B12	(µg)	-	-	-	-	4	1	-	-	-	-
Vit C	(mg)	302	5	4 077	68	0.93	0	-	-	-	-
Vit D	(µg)	-	-	-	-	0.13	0	-	-	-	-
Vit E	(mg)	12	0	170	6	0.52	0	8	0	-	-
Vit K	(µg)	1 098	14	14 823	185	7.07	0	8	0	-	-
Zinc	(µg)	5	0	76	5	9	1	87	6	4	0

Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Annex 5: *Nutritional impact of FW at Manning market*

Nutrition		**Vegetable**		**Fruit**		**Meat**	
		Amount (nutrition)	**person/day - equivalents**	**Amount (nutrition)**	**person/day - equivalents**	**Amount (nutrition)**	**person/day - equivalents**
Energy	(kcal)	17 513	9	10 886	5	108 253	54
Protein	(g)	323	6	200	4	7 905	158
Carbohydrates	(g)	4 383	15	2 725	9	-	-
Fiber	(g)	690	28	429	17	-	-
Calcium	(mg)	6 166	6	3 833	4	7 360	7
Choline	(mg)	2 953	5	1 836	3	7 176	13
Copper	(mg)	22	11	13	7	22	11
Food folate	(mg)	5 981	15	3 718	9	3 220	8
Iron	(mg)	133	7	83	5	544	30
Magnesium	(mg)	4 625	12	2 875	7	8 586	21
Manganese	(mg)	54	27	33	17	5	3
Niacin	(mg)	178	9	111	6	2 391	120
Panto acid	(mg)	58	6	36	4	321	32
Phosphorus	(µg)	8 695	9	5 405	5	77 433	77
Potassium	(mg)	86 765	25	53 935	15	113 926	33
Riboflavin	(mg)	20	12	12	7	79	47
Selenium	(mg)	111	2	69	1	8 433	120
Sodium	(mg)	6 536	3	4 063	2	30 206	13
Thiamin	(µg)	17	12	11	7	129	86
Vit A	(IU)	1 549 560	310	963 240	193	10 120	2
Vit B6	(mg)	49	25	30	15	165	83
Vit B12	(µg)	-	-	-	-	479	80
Vit C	(mg)	2 793	47	1 736	29	107	2
Vit D	(µg)	-	-	-	-	15	2
Vit E	(mg)	116	4	72	3	59	2
Vit K	(µg)	10 156	127	6 313	79	812	10
Zinc	(µg)	52	3	32	2	1 067	71

Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version.

Annex 6: *Nutritional impact of FW at Narahenpita Dedicated Economic Centre*

Nutrition		Vegetable		Fruit		Meat	
		Amount (nutrition)	person/day - equivalents	Amount (nutrition)	person/day - equivalents	Amount (nutrition)	person/day - equivalents
Energy	(kcal)	94 193	47	10 886	5	9 413	5
Protein	(g)	1 737	35	200	4	687	14
Carbohydrates	(g)	23 578	79	2 725	9	-	-
Fiber	(g)	3 714	149	429	17	-	-
Calcium	(mg)	33 166	33	3 833	4	640	1
Choline	(mg)	15 886	29	1 836	3	624	1
Copper	(mg)	121	61	13	7	1	1
Food folate	(mg)	32 171	80	3 718	9	280	1
Iron	(mg)	719	40	83	5	47	3
Magnesium	(mg)	24 875	62	2 875	7	746	2
Manganese	(mg)	292	146	33	17	0.49	0
Niacin	(mg)	960	48	111	6	207	10
Panto acid	(mg)	312	31	36	4	27	3
Phosphorus	(µg)	46 765	47	5 405	5	6 733	7
Potassium	(mg)	466 655	133	53 935	15	9 906	3
Riboflavin	(mg)	108	64	12	7	6	4
Selenium	(mg)	597	9	69	1	733	10
Sodium	(mg)	35 156	15	4 063	2	2 626	1
Thiamin	(µg)	96	64	11	7	11	8
Vit A	(IU)	8 334 120	1 667	963 240	193	880	0
Vit B6	(mg)	266	133	30	15	14	7
Vit B12	(µg)	-	-	-	-	41	7
Vit C	(mg)	15 024	250	1 736	29	9	0
Vit D	(µg)	-	-	-	-	1	0
Vit E	(mg)	626	23	72	3	5	0
Vit K	(µg)	54 625	683	6 313	79	70	1
Zinc	(µg)	281	19	32	2	92	6

Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version

Annex 7: *Nutritional impact of FW at the small fruits and vegetables stall*

Nutrition		Vegetable		Fruit	
		Amount (nutrition)	person/day - equivalents	Amount (nutrition)	person/day - equivalents
Energy	(kcal)	22 246.67	11	1 420.00	1
Protein	(g)	410.47	8	26.20	1
Carbohydrates	(g)	5 568.72	19	355.45	1
Fiber	(g)	877.33	35	56.00	2
Calcium	(mg)	7 833.33	8	500.00	1

Choline	(mg)	3 752.17	7	239.50	0
Copper	(mg)	28.59	14	1.83	1
Food folate	(mg)	7 598.33	19	485.00	1
Iron	(mg)	169.98	9	10.85	1
Magnesium	(mg)	5 875.00	15	375.00	1
Manganese	(mg)	69.17	35	4.42	2
Niacin	(mg)	226.85	11	14.48	1
Panto acid	(mg)	73.71	7	4.71	0
Phosphorus	(µg)	11 045.00	11	705.00	1
Potassium	(mg)	110 215.00	31	7 035.00	2
Riboflavin	(mg)	25.54	15	1.63	1
Selenium	(mg)	141.00	2	9.00	0
Sodium	(mg)	8 303.33	3	530.00	0
Thiamin	(µg)	22.72	15	1.45	1
Vit A	(IU)	1 968 360.00	394	125 640.00	25
Vit B6	(mg)	62.82	31	4.01	2
Vit B12	(µg)	-	-	-	-
Vit C	(mg)	3 548.50	59	226.50	4
Vit D	(µg)	-	-	-	-
Vit E	(mg)	148.05	5	9.45	0
Vit K	(µg)	12 901.50	161	823.50	10
Zinc	(µg)	66.58	4	4.25	0

Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version

Annex 8: *Nutritional impact of FW at the supermarket*

Nutrition		**Vegetable**		**Fruit**		**Meat**		**Rice**		**Starch**	
		Amount (nutrition)	**person/day - equivalents**	**Amount (nutrition)**	**person/day - equivalents**	**Amount (nutrition)**	**person/day - equivalents**	**Amount (nutrition)**	**person/day - equivalents**	**Amount (nutrition)**	**person/day - equivalents**
Energy	(kcal)	14 200	7	7 100	4	2 353	1	29 200	15	27 120	14
Protein	(g)	262	5	131	3	171	3	570	11	1 094	22
Carbohydrates	(g)	3 554	12	1 777	6	-	-	6 396	21	5 690	19
Fiber	(g)	560	22	280	11	-	-	104	4	-	-
Calcium	(mg)	5 000	5	2 500	3	160	0	2 240	2	2 720	3
Choline	(mg)	2 395	4	1 197	2	156	0	464	1	-	-
Copper	(mg)	18	9	9	5	0.48	0	17	9	44	22
Food folate	(mg)	4 850	12	2 425	6	70	0	640	2	3 440	9
Iron	(mg)	108	6	54	3	11	1	344	19	281	16
Magnesium	(mg)	3 750	9	1 875	5	186	0	2 000	5	11 520	29
Manganese	(mg)	44	22	22	11	0.12	0	87	44	240	120
Niacin	(mg)	144	7	72	4	51	3	335	17	539	27
Panto acid	(mg)	47	5	23	2	6.98	1	81	8	74	7

Phosphorus	(µg)	7 050	7	3 525	4	1 683	2	9 200	9	40 640	41
Potassium	(mg)	70 350	20	35 175	10	2 476	1	9 200	3	34 480	10
Riboflavin	(mg)	16	10	8	5	1	1	3	2	9	6
Selenium	(mg)	90	1	45	1	183	3	1 208	17	7 152	102
Sodium	(mg)	5 300	2	2 650	1	656	0	400	0	160	0
Thiamin	(µg)	14	10	7	5	2	2	46	31	33	22
Vit A	(IU)	1 256 400	251	628 200	126	220	0	-	-	-	-
Vit B6	(mg)	40.10	20	20.05	10	3	2	13	7	33	17
Vit B12	(µg)	-	-	-	-	10	2	-	-	-	-
Vit C	(mg)	2 265	38	1 132	19	2	0	-	-	-	-
Vit D	(µg)	-	-	-	-	0.33	0	-	-	-	-
Vit E	(mg)	94	4	47	2	1	0	8	0	-	-
Vit K	(µg)	8 235	103	4 117	51	17	0	8	0	-	-
Zinc	(µg)	42	3	21	1	23	2	87	6	332	22

Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version

Annex 9: *Nutritional impact of FW at the CSTH*

Nutrition		**Vegetable**		**Meat**		**Rice**		**wheat**	
		Amount (nutrition)	**person/day - equivalents**	**Amount (nutrition)**	**person/day - equivalents**	**Amount (nutrition)**	**person/day - equivalents**	**Amount (nutrition)**	**person/day - equivalents**
Energy	(kcal)	17 040	9	2 353	1	120 450	60	1 356	1
Protein	(g)	314	6	171	3	2 352	47	54	1
Carbohydrates	(g)	4 265	14	-	-	26 383	88	284	1
Fiber	(g)	672	27	-	-	429	17	-	-
Calcium	(mg)	6 000	6	160	0	9 240	9	136	0
Choline	(mg)	2 874	5	156	0	1 914	3	-	-
Copper	(mg)	21	11	0.48	0	72	36	2	1
Food folate	(mg)	5 820	15	70	0	2 640	7	172	0
Iron	(mg)	130	7	11	1	1 422	79	14	1
Magnesium	(mg)	4 500	11	186	0	8 250	21	576	1
Manganese	(mg)	52	26	0.12	0	359	180	12	6
Niacin	(mg)	173	9	51	3	1 383	69	26	1
Panto acid	(mg)	56	6	6	1	334	33	3	0
Phosphorus	(µg)	8 460	8	1 683	2	37 950	38	2 032	2
Potassium	(mg)	84 420	24	2 476	1	37 950	11	1 724	0
Riboflavin	(mg)	19	12	1	1	16	10	0.48	0
Selenium	(mg)	108	2	183	3	4 983	71	357	5
Sodium	(mg)	6 360	3	656	0	1 650	1	8	0
Thiamin	(µg)	17	12	2	2	190	127	1	1
Vit A	(IU)	1 507 680	302	220	0	-	-	-	-
Vit B6	(mg)	48	24	3	2	54	27	1	1

Vit B12	(µg)	-	-	10	2	-	-	-	-
Vit C	(mg)	2 718	45	2	0	-	-	-	-
Vit D	(µg)	-	-	0.33	0	-	-	-	-
Vit E	(mg)	113	4		0	36	1	-	-
Vit K	(µg)	9 882	124	17	0	33	0	-	-
Zinc	(µg)	51	3	23	2	359	24	16	1

Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version

Annex 10: *Profile of the household case study samples*

	Middle Income	**Low Income**
Income Level (LKR)		
Mean	214 000	42 000
Minimum	200 000	25 000
Maximum	300 000	65 000
Family Members		
Mean	4	4
Minimum	3	2
Maximum	5	6
Age Profile		
Mean	38	36
Minimum	3	2
Maximum	71	65
Source of Income		
Employment	60%	20%
Business	40%	30%
Self		50%
Buying Pattern		
Daily	-	80%
Weekly	60%	20%
Fortnightly	40%	-
Cooking Pattern		
Separate three time	10%	0%
Separate two time	60%	30%
One time only	30%	70%

Annex 11: Nutritional loss due to FW by middle and low-income households

Middle-income group households

Nutrition		Vegetable		Fruit		Meat		Rice		Starch	
		Amount (nutrition)	person/ day - equivalents	Amount (nutrition)	person/ day - equivalents	Amount (nutrition)	person/ day - equivalents	Amount (nutrition)	person/ day - equivalents	Amount (nutrition)	person/ day - equivalents
Energy	(kcal)	40 233	20	31 240	16	7 060	4	215 350	108	30 510	15
Protein	(g)	742	15	576	12	515	10	4 206	84	1 231	25
Carbohydrates	(g)	10 071	34	7 819	26	-	-	47 170	157	6 401	21
Fiber	(g)	1 586	63	1 232	49	-	-	767	31	-	-
Calcium	(mg)	14 166	14	11 000	11	480	0	16 520	17	3 060	3
Choline	(mg)	6 785	12	5 269	10	468	1	3 422	6	-	-
Copper	(mg)	51	26	40	20	1	1	129	65	49	25
Food folate	(mg)	13 741	34	10 670	27	210	1	4 720	12	3 870	10
Iron	(mg)	307	17	238	13	35	2	2 542	141	316	18
Magnesium	(mg)	10 625	27	8 250	21	560	1	14 750	37	12 960	32
Manganese	(mg)	125	63	97	49	0.37	0	641	321	271	136
Niacin	(mg)	410	21	318	16	155	8	2 473	124	606	30
Panto acid	(mg)	133	13	103	10	20	2	598	60	84	8
Phosphorus	(µg)	19 975	20	15 510	16	5 050	5	67 850	68	45 720	46
Potassium	(mg)	199 325	57	154 770	44	7 430	2	67 850	19	38 790	11
Riboflavin	(mg)	46	27	35	21	5	3	28	17	10	6
Selenium	(mg)	255	4	198	3	550	8	8 909	127	8 046	115
Sodium	(mg)	15 016	6	11 660	5	1 970	1	2 950	1	180	0
Thiamin	(µg)	41	27	31	21	8	6	339	227	37	25
Vit A	(IU)	3 559 800	712	2 764 080	553	660	0	-	-	-	-
Vit B6	(mg)	113	57	88	44	10	5	96	48	37	19
Vit B12	(µg)	-	-	-	-	31	5	-	-	-	-
Vit C	(mg)	6 417	107	4 983	83	7	0	-	-	-	-
Vit D	(µg)	-	-	-	-	1	0	-	-	-	-
Vit E	(mg)	267	10	207	8	3	0	64	2	-	-
Vit K	(µg)	23 332	292	18 117	226	53	1	59	1	-	-
Zinc	(µg)	120	8	93	6	69	5	643	43	374.40	25

Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version

Low-income group households

Nutrition		Vegetable		Fruit		Meat		Rice		Starch	
		Amount (nutrition)	person/ day - equivalents	Amount (nutrition)	person/ day - equivalents	Amount (nutrition)	person/ day - equivalents	Amount (nutrition)	person/ day - equivalents	Amount (nutrition)	person/ day - equivalents
Energy	(kcal)	17 513	9	5 206	3	7 060	4	94 900	47	20 340	10
Protein	(g)	323	6	96	2	515	10	1 853	37	820	16
Carbohydrates	(g)	4 383	15	1 303	4	-	-	20 787	69	4 267	14
Fiber	(g)	690	28	205	8	-	-	338	14	-	-
Calcium	(mg)	6 166	6	1 833	2	480	0	7 280	7	2 040	2
Choline	(mg)	2 953	5	878	2	468	1	1 508	3	-	-
Copper	(mg)	22	11	6	3	1	1	57	29	33	17
Food folate	(mg)	5 981	15	1 778	4	210	1	2 080	5	2 580	6
Iron	(mg)	133	7	3	2	35	2	1 120	62	211	12
Magnesium	(mg)	4 625	12	1 375	3	560	1	6 500	16	8 640	22
Manganese	(mg)	54	27	16	8	0.37	0	282	141	180	90
Niacin	(mg)	178	9	53	3	155	8	1 089	54	404	20
Panto acid	(mg)	58	6	17	2	20	2	263	26	56	6
Phosphorus	(µg)	8 695	9	2 585	3	5 050	5	29 900	30	30 480	30
Potassium	(mg)	86 765	25	25 795	7	7 430	2	29 900	9	25 860	7
Riboflavin	(mg)	20	12	6	4	5	3	12	7	7	4
Selenium	(mg)	111	2	33	0	550	8	3 926	56	5 364	77
Sodium	(mg)	6 536	3	1 943	1	1 970	1	1 300	1	120	0
Thiamin	(µg)	17	12	5	4	8	6	149	100	25	17
Vit A	(IU)	1 549 560	310	460 680	92	660	0	-	-	-	-
Vit B6	(mg)	49	25	14	7	10	5	42	21	25	13
Vit B12	(µg)	-	-	-	-	31	5	-	-	-	-
Vit C	(mg)	2 793	47	830	14	7	0	-	-	-	-
Vit D	(µg)	-	-	-	-	1	0	-	-	-	-
Vit E	(mg)	116	4	34	1	3	0	28	1	-	-
Vit K	(µg)	10 156	127	3 019	38	53	1	26	0	-	-
Zinc	(µg)	52	3	15	1	69	5	283	19	249	17

Source: Authors' elaboration, based on seven-day FW audit data, 2020, based on FReSH-FW Value Calculator beta V.1.0 version

Food waste prevention and reduction is a key to the progress of the whole sustainable development agenda. Food waste analysis (i.e., quantities, causes, and characteristics) is needed to identify interventions for FW prevention and reduction in different sectors. This study applied a case study approach to gain insights on the FW context in different sectors targeting food services, wholesale markets, retailers, caterers, and households.

Methods and mechanisms to monitor the effectiveness of food waste interventions are needed to demonstrate effectiveness of required investments. The measure-act-monitor approach applied for the case studies, is an effective tool to trigger food waste prevention and reduction interventions. The applied method identified sector-specific solutions and quantified food waste, giving thus an overview of, for instance, the direct financial loss due to wasted edible quantities.

FAO Representation in Sri Lanka
Email: FAO-LK@fao.org
Website: www.fao.org/srilanka
Food and Agriculture Organization of the United Nations
Colombo, Sri Lanka

International Water Management Institute
Email: iwmi@cgiar.org
Sunil Mawatha,
Battaramulla, Sri Lanka
Website: www.iwmi.cgiar.org

ISBN 978-92-5-135672-2
9 789251 356722
CB8396EN/1/07.23