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Tackling food waste in a university food service operation: a case study

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Abstract: The challenge of food waste in the university food service setting, especially from a systems perspective is understudied. This is a major gap as the effective management of food waste requires a holistic approach as the parts of the system are interdependent. This exploratory study applies a systems theory to investigate food waste prevention. Organisational documents were analysed, in-depth interviews, focus group discussions and participant observations were conducted. The study reveals that even though food waste remains a challenge in the case university, prevention efforts were implemented. These include automated stock forecasting, use of specifications, appropriate receiving and storage practices, stock monitoring, use of standardised recipes, production of good quality meals in correct quantities, temperature and time controls, meal auditing and correct portioning. The study's findings can be applied in the development of food waste management policies and procedures in the universities and the wider catering sector.

Keywords: food waste; sustainability; university food service operation; food waste prevention; environment.

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1 Introduction

Food waste (FW) is a complex agenda within the food service sector that threatens achieving sustainable development goals (SDGs). Specifically, FW poses a challenge in the attainment of SDG 2 on zero hunger, SDG 12 on sustainable consumption and production and SDG 13 on climate change (United Nations, 2024). Globally, around 17% of food produced is wasted between retail and the consumption level, yet 1.26 billion people are food insecure (Food and Agricultural Organisation, 2023). Approximately 10% of global greenhouse gas emissions (GHGs) are attributed to food loss and waste, and this worsens the effects of climate change (FAO, 2023; Leal Filho et al., 2023). Research demonstrated that FW causes not only economic losses but also leads to the loss of resources (water, energy, labour, land) used in the production of food that ends up being wasted (Qian et al., 2021).

Recently, there has been increasing attention given to FW in higher education institutions, in part due to the growth of the university population and the increasing amount of FW generated (Leal Filho et al, 2021). However, previous studies on FW primarily focus on plate waste in universities. For example, a study conducted by Qian et al. (2021) shows that FW amounted to 61.03 g per student per meal in university canteens in China. In another study, FW generated by Chinese university students who were less familiar with the FW awareness campaign was 63.07 g per student per meal (Qian et al., 2024). The average plate waste generated by Beijing University students was 73.7 g per capita per meal, with staples and vegetables contributing the most (Wu et al., 2019). A study conducted by Li et al. (2021) shows that the amount of FW quantified in three canteens at the Taiyuan University of Technology in China was 913.88 kg within the study period. The proportion of FW observed in university canteens in Portugal was as high as 10% of the food served (Aires et al., 2021). In addition, an excessive amount of 135 ± 114 g per capita per meal was produced by students in the university canteens in Wuhan, emitting an equivalence of 134 kilotons of CO2e per year (Zhang et al., 2021). In another Portuguese university, a total amount of 189.5kg of FW was generated within 10 days (Martinho et al., 2022). This was equivalent to an estimated economic loss of €3,100 per month, and an ecological footprint of 2.8 gha (Martinho et al., 2022). In a study conducted at Midwestern University, USA, as much as 88.23g of food per meal was wasted before educational materials on FW were provided (Ellison et al., 2019). Fewer

studies have quantified kitchen waste and/or total FW from procurement to service. The total amount of FW generated in a case university in Turkey was approximately 577 tonnes per year (Maçin et al., 2023). In Canada, a study conducted at the University of Northern British Columbia indicated that kitchen FW made up the second largest component (32%) of total FW generated by the University food service facility (Rajan et al., 2018). In the context of South Africa, two empirical studies have been conducted to establish the magnitude of FW generated. At Rhodes University in South Africa, an estimated volume of 450 tonnes of FW was generated annually (Painter et al., 2016). According to Marais et al. (2017), the amount of FW generated at the Stellenbosch University residence dining halls and cafeterias was increasing, with approximately 26.7% production and plate waste generated from two residential food service units. Given the magnitude of FW generated in universities, reducing it has large environmental, economic, and social implications. The reduction in the amount of FW generated can be achieved through multiple strategies implemented in the different parts of the food service system.

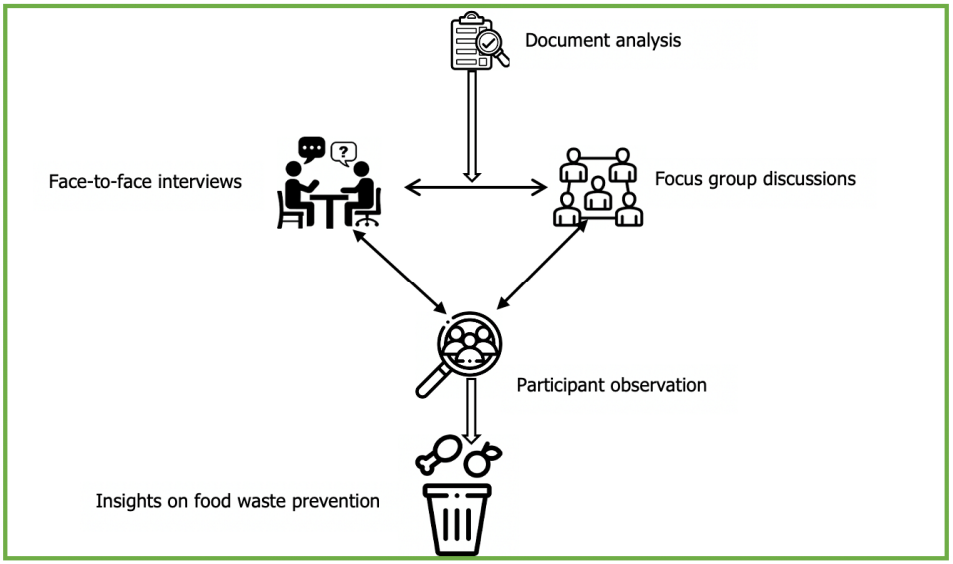
While most of the recent studies have quantified FW, identified causes and drivers and investigated consumer FW behaviour in the university food service sector (Painter et al., 2016; Marais et al., 2017; Abdelaal et al., 2019; Monteiro et al., 2020; Qian et al., 2021; Börühan and Ozbiltekin-Pala, 2022; Mui et al., 2022), a few have focused on FW prevention strategies from a systems perspective (Pinto et al., 2018; Ellison et al., 2019; Leal Filho et al., 2023). FW prevention and reduction in university settings has been widely covered from the consumer perspective to address plate waste (Thongplew et al., 2021; Cui et al., 2023; Jayasekara et al., 2024). Following a systems approach, the current study explored the strategies applied in a university food service operation to holistically prevent FW. The study presents strategies adopted by the case University food service operation to prevent and reduce FW from the point of procurement to service.

2 Methodology

2.1 Study design and study area

Qualitative research design was used to gain an in-depth understanding of the phenomenon investigated by naturalistic inquiry. The lack of understanding of the FW prevention strategies in the university food service sector from the systems theoretical perspective pinpoints the need for an exploratory investigation. Past studies on FW in university settings have also utilised naturalistic inquiry and qualitative approaches to research (Cui et al., 2023; Leah Filho et al., 2023). The largest residential food service operation at a South African university was selected as the study site for this research. This food service operation alone services a population of approximately 900 students residing at six of the residence halls. It is also a central production kitchen, that is, it produces and distributes meals to four satellite residential food service operations.

Figure 1 Methodological approach of the study (see online version for colours)



2.2 Data collection procedure

Data was generated through an integration of four different data collection methods; document analysis, semi-structured interviews, focus group discussions, and participant observation (Figure 1). The first activity undertaken was an analysis of existing records at the organisation which informed the researcher about the FW prevention practices of the operation. This included FW records, monthly financial reports, food specifications, suppliers' evaluation reports, stock issuance reports, inspection reports, stock movement records, meal statistics, recipes, and food check sheets. The second activity was the semi-structured interviews. A total of five interviews were conducted, one with each of the five members of management who were responsible for managing different functions (general, procurement, production, distribution, and service) of the operation. Qualitative face-to-face interviews were particularly suitable for this study as these enabled the researcher to obtain detailed information from the interviewees. This covered an account of historical information that could not have been easily observed or gathered through alternative methods (Creswell and Creswell, 2018). For the third activity, the researcher conducted three focus group discussion sessions at the research site. Participants with the most involvement in FW-related activities were purposively sampled and this included personnel responsible for receiving, inventory control, preparation and production, distribution, and service. The data saturation in both face-to-face interviews and focus group discussions determined the sample size and duration of the study (Filimonau et al., 2023). The focus group discussion technique was particularly selected for this study to explore multiple viewpoints or perceptions of the participants regarding issues of FW and FW management practices with their experiences in the food service operation. Focus group sessions were held during staff lunch breaks to minimise the interruption of activities of the food service operation. The fourth activity was participant observation. This enabled the researcher to investigate situations and/or people in their usual work

setting and everyday context through exposure to or involvement in the participants' daily activities in the natural research setting.

2.3 Data analysis

The data was thematically analysed using Braun and Clarke's (2012) guidelines. The analysis was conducted electronically using ATLAS. ti (version 22). The quality and trustworthiness of the data were enhanced through the application of the neutrality approach wherein the data was analysed, coded, and compared by two independent members of the research team (Filimonau et al., 2023). To confirm the accuracy and meaningfulness of the findings respondent validation was applied. Two participants were re-contacted and requested to confirm if the coding results reflected the true meaning of the study. The next section discusses the findings of the study.

3 Findings and discussion

The findings are organised into the major phases of the functional subsystem: purchasing, receiving, storage and inventory control, issuing, production, holding and distribution, and service. Under each of these headings, the related themes on FW prevention strategies as applied in the functional subsystem of the university food service operation are presented and then discussed in relation to the existing literature.

3.1 Purchasing

Accurate stock forecasting was identified as an important factor in preventing FW. An automated stock control system enabled the food service operation to accurately forecast the amount of food to purchase, based on the stock movement and stock levels (stock on order, and stock on hand) (Hennchen, 2019; Okumus et al., 2020; Filimonau et al., 2021a; Strotmann et al., 2022). This helped in avoiding overstocking and ordering appropriate amounts of food for a given period. The development and adherence to food specifications by suppliers minimised FW (Charlebois et al., 2015). Food deliveries from suppliers, who failed to comply with food specifications, were rejected to avoid the absorption of FW by the university food service operation (Wu and Teng, 2022). However, this prevented FW at the food service level but generated waste for the supplier. This illustrates the necessity to employ a life cycle assessment (LCA) approach and consider the potential environmental impact throughout a product's life, hence preventing FW at all stages of the food product's life cycle. The implication is that the interdependency of the different systems in the food supply chain is critical in FW prevention.

This is supported by one of the participants:

> "We have specifications in place. The products that we buy are of very high quality: we do not go for cheap products and bad quality. Where suppliers do not meet specifications, we reject the products". [Erika, Snowy]

Further, accurate purchase orders were identified as an important factor in FW prevention, as this ensured that the right products were ordered and the correct quantities delivered, hence avoiding overstocking and stock mismatches. The food service operation

requested the supply of perishable food with a sufficiently long shelf life; this helped prevent waste that could occur due to food spoilage (Principato et al., 2021). The selection of reputable suppliers ensured the purchasing of quality food products, which enabled the production of good-quality menu items, hence curbing food wastage (Filimonau et al., 2021). Having a wide option of suppliers also optimised the availability of food items in the quantity and quality as promised to the customer, hence customer satisfaction and FW reduction (outputs). In agreement to this, the participant mentioned:

> "I think the management of quality starts with supplier selection and there the Purchasing Consortium Southern Africa (PURCO) plays a big role in selecting reputable suppliers. We also evaluate suppliers onsite, new suppliers are visited to check their facilities, check their products and even contact some of the previous buyers that have used the supplier". [Malebogo]

3.2 Receiving

Frequent food deliveries made on specific scheduled hours prevented FW in that the availability of the receiving staff at the scheduled hours was always guaranteed, which ensured prompt receiving and movement of stock to the appropriate storage areas, hence minimising food temperature abuse and food spoilage (Filimonau et al., 2020b). Consistent with past research (Charlebois et al., 2015), the inspection of food deliveries prevented FW, as this enabled food service workers to identify poor-quality products immediately and reject those that failed to meet the requirements. The temperature of perishable food items was checked upon delivery, and if found to be at incorrect temperatures were rejected. This avoided wastage that could result from spoilage or microbial growth (Bilska et al., 2020). Labelling food products upon delivery was identified as an important factor that assisted in inventory management (Ghanem, 2020). Additionally, the prompt transfer of deliveries to the appropriate storage areas prevented food spoilage by maintaining the appropriate temperatures, hence waste reduction. This is confirmed by one of the participants:

> "If the suppliers deliver bad quality products, we reject them. We complete the receipt-return voucher, it goes back and then automatically they will send the payment to finance. Another thing is to check the temperature on the delivery trucks, and of perishable food delivered, so if the temperature is incorrect, we do not take the foodstuff". [Patience]

3.3 Storage and inventory control

Generally, good storage and inventory control practices were linked to FW prevention. Adequate storage space and facilities or equipment (inputs) prevented FW, as this maintained the quality of food and ensured the easy arrangement of food, which enhanced inventory management (De Moraes et al., 2020; Filimonau et al., 2020a). Additionally, the dry storage areas had windows that opened, doors, and fans that allowed storage areas to stay cool and well-ventilated. In this way, the temperature and humidity remain constant (Rostami et al., 2020). Regular cleaning of storage spaces lessened the risk of food contamination and the introduction of pathogenic microbes in food, which preserved the quality and safety of food thus preventing FW (outputs) (Her et al., 2019). Further, the regular maintenance of the premises to prevent the entry of pests, routine inspections for pests and the application of pest control methods where needed, prevented

FW from contamination and damage (De Moraes et al., 2020). Storing food items under the correct conditions, and separately from chemicals and cleaning agents, maintained the quality and safety of food (Faour-Klingbeil et al., 2020). This indicates the importance of the correct storage and management of each of the material inputs in the food service system. The organisation and separation of food items in the storage areas were an important factor in FW prevention (Ghanem, 2020; Okumus, 2020). For example, raw food items were stored separately from cooked or ready-to-eat food items, thus preventing cross-contamination. Previous studies (Filimonau and Uddin, 2021; Kattiyapornpong et al., 2023) show that applying the first-in, first-out (FIFO) approach, ensured that the old stock was used before the newly purchased food products, thus minimising storage waste. Filimonau et al. (2020a) explain that adopting the FIFO approach, i.e., prioritising the earlier foodstuffs purchased or those nearing the expiry date in meal preparation, was important in reducing FW, due to spoilage or expiry during storage. It was further established that the continuous tracking and accurate recording of stock levels helped with repurposed or flexible menu planning using food items available in stock hence avoiding overstocking (Filimonau et al., 2020b; Kattiyapornpong et al., 2023; Lévesque et al., 2024). In addition, storage practices such as covering the food during storage avoided the loss of aesthetic appeal of food. Different participants noted that various practices prevented FW at the point of storage as shown below:

> "At the storage point, we have a cleaning programme and schedule, and this helps prevent food contamination and spoilage". [Thabo]

> "The policy is that before we close at the end of the semester, pest control specialists come and apply pesticides for common pests. Every month the pest control specialists inspect the food service premises and the reports are filed in the pest control files. The food service workers also promptly report pests and insects as soon as they are identified and thus help prevent FW from damage by pests and insects". [Erika]

> "We store food products in different storage areas according to food type. Vegetables are kept in a specific cold storage separately from meat products. Cooked food items are also stored isolated from raw food items, and this prevents cross-contamination." [John]

> "During storage, I think applying FIFO prevents FW". [Snowy]

> "FIFO, is very important that is why we count stock every week so that we can check the expiry dates. If the stock is standing for too long, I usually talk to the production supervisor and ask her to utilise the products somewhere in her menu". [Erika]

3.4 Issuing

The use of a requisition form with quantities of the ingredients requested, enabled effective stock monitoring, hence FW prevention as only the required quantities for production were issued. Consistent with past research (Filimonau et al., 2020a), it was identified that measuring ingredients before issuing, ensured the accuracy at this stage. Where ingredients issued did not match the standardised recipes or requisition form, unused or excess ingredients were returned to the storage area.

3.5 Production

Production involved the transformation of ingredients into dishes to be served to customers. FW prevention strategies identified included the use of a production schedule, which served as an important internal communication tool to the food production team and facilitated the division of food production labour. In this way instructions on food production were clear, thus reducing food wastage. The proficiency of the kitchen staff had a bearing on the accurate measurement of ingredients, prevention of preparation losses through proper thawing and temperature control as well as precisely following standardised recipes (Vizzoto et al., 2021). These strategies reduced the overproduction of meals and ensured the production of good quality meals.

> "Adherence to the standardised recipes helps in attaining quality". [Martha]

> "The fact that our recipes are standardised, ensures that we get the exact quantities". [Erika]

In terms of safety, time, and temperature control, checking and recording the internal temperatures throughout the production element played a critical role in FW prevention.

During the preparation and production of food using the cook-chill and cook-freeze production systems, appropriate procedures were followed to preserve the safety and quality of the food. Even though these systems somewhat contributed to the generation of FW, due to the loss of food quality, they also prevented FW that might have occurred due to the overproduction of food. Excess food produced was treated using the cook-chill or cook-freeze methods, thus reducing food safety risks and preserving food for later use. In line with this, one of the participants noted that:

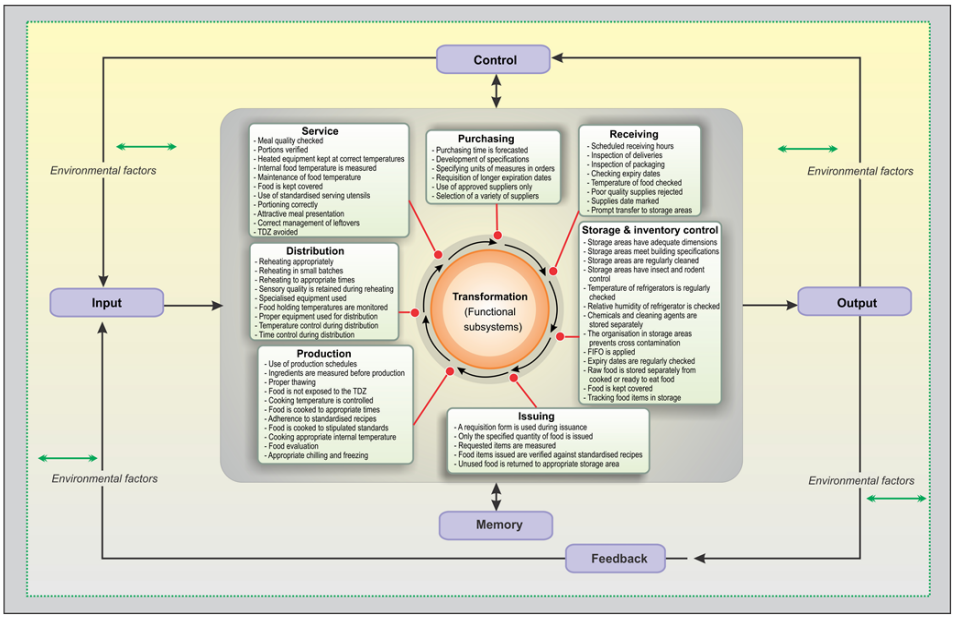
> "Let's say production gives me six pans of lasagne, or I see them producing food and I can tell it is too much; I ask them to cook-freeze some and I take them in small batches depending on demand, so we do not have waste". [Martha]

From a safety perspective, the document analysis revealed that the university food service operation regularly checked and recorded the internal temperature of cooked meals. Checking the internal food temperature and maintaining acceptable temperature ranges is critical in preventing FW; this conserves the safety and quality of food, which possibly minimises the chances of spoilage and food disposal. In support of the findings, Mercier et al. (2017) indicated that the internal food temperature, food safety and FW were linked; failing to maintain an acceptable internal temperature can stimulate the growth of pathogens and spoilage micro-organisms and render the food product inedible. It was observed that at the end of each food production process, the products were evaluated. The evaluation focused on the aesthetic factors of the food. The participants of the study indicated that product evaluation helped determine the acceptability of the food products by the food service workers and supervisors before the food was distributed to the customers. Where the acceptable level of food quality was not reached, the food was taken back to production to be modified thus reducing the likelihood of FW, due to poor quality. The product evaluation process also involved recording information about the quality standards of the evaluated product on the required form. Such records (memory) served as a feedback mechanism that informed the food service operation about the quality of the food products, and if the predetermined quality standards were not frequently met, the recipe standardisation process was revisited.

3.6 Holding and distribution

The appropriate time and temperature control during reheating, positively impacted the quality and safety of food thus preventing food wastage. Additionally, reheating in small batches minimised the chances of discarding excess food that may be left over after service, as the food safety policy (control) did not allow the reuse of reheated leftover food. The use of appropriate meal distribution equipment (inputs) with temperature controls played an important role in preventing FW (Thyberg and Tonjes, 2016). Similarly, maintaining the proper temperature during hot-and cold-holding, ensured that the food was within the safe temperature range, prevented food spoilage and retained the quality of food, hence reducing chances of discarding food. In a decentralised delivery-service system, the use of insulated cabinets (inputs), which maintained the appropriate temperature, and checking and recording the temperature of food throughout the distribution process, ensured the safety of the food served and minimised wastage in this regard.

Figure 2 Food waste prevention strategies in the university food service system (see online version for colours)



3.7 Service

At the service point, the quality of the food was evaluated (control) upon receiving from the food production unit. This allowed the food service workers to rectify quality issues before service, hence minimising FW that could have occurred because of the non-acceptance of the food by the customers due to the poor quality (Strotmann et al., 2022). A note of caution is due here, as not all menu items can be reworked once the quality has been affected. It is, therefore, advisable to put control measures in place that will ensure food quality and safety before the end of the food service system processes.

Effective portion control strategies, including verification of portions upon receipt from the food production unit and the use of standardised portioning tools, increased the accuracy of portioning thus reducing food wastage (Alcorn et al., 2020; Principato et al. 2021; Vizzoto et al., 2021; Strotmann et al., 2022). Oversised portions and inconsistencies when serving food were major reasons for wastage during service. The finding possibly suggests the need for more intense training and supervision in portion control guides, to ensure that proper tools and techniques are followed. Monitoring and maintaining the appropriate temperatures by using the appropriate equipment and regular temperature checking, ensured that the food did not fall within the temperature danger zone and that it was served at the correct temperature (Okumus et al., 2020). Food was also kept covered to maintain its safety and aesthetic quality. This contributed to FW prevention as both the quality and safety of the food were well maintained. Attractive meal presentation was used as a strategy to attract customers to purchase meals thus reducing leftovers at the service point (Ofei et al., 2014; Betz et al., 2015). The proper management of leftovers and repurposing them for other dishes was an important factor in reducing FW (Akhter et al., 2024).

> "…when the food comes from back-of-the-house (BOH) I have to check them first and secondly I have to taste it. If it is not well seasoned, I go to the production unit and find out who prepared the food and ask them to modify it before I sell it to students to avoid complaints". [Mary]

> "What we usually do is to check the temperature of food before service. I also taste the food before we serve it". [Tshepho]

> "When we receive food from BOH we check the food temperature using the probe to ensure it is at the appropriate temperature. There is a front-of-the-house (FOH) checklist that we use to assess quality, I think that's also quality management and it prevents FW". [Thabo]

> "Bain-Maries are cleaned when FOH staff arrive in the morning then they fill them with clean water. They then switch on the bain-maries to keep them hot. It is rare to receive complaints about food not being hot enough". [Kgotso]

> "You know for us in FOH we get food from back-of-house, when we get them, like if they gave us pork chops for example, we have a form in which we have to write the number of portions they gave us and count them as well". [Kgotso]

> "We have portion guidelines and tools which prescribe to us how to portion, we have standardised serving spoons. We do not have the power to increase the portions". [Thabo]

> "We just do as we are ordered. If they say two spoons of rice, I serve two spoons". [Mary]

> "… rice has its own scoop, gravy has its own scoop, and vegetables have their own serving scoops. When it is a red scoop we fill it full to the brim that is how we do it. If we have minced meat for example, we know we should have 20 portions from a pan and not less than that". [Tshepho]

> "… the use of serving spoons is helpful because otherwise serving staff would dish as they wish". [Erika]

> "When the food is left, we count everything, we find out how many portions are left and record them, and then we sell them again, we do not prepare food while these other ones are still available". [Tshepho]

> "… let's say we have 6 pans of Hungarian stew left over, if we cannot use it immediately, we call other units who will be able to use at least one pan of stew. So, what we do, first, we call other units who can be able to utilise the stew, then if they cannot, we immediately freeze them for future use because if it is frozen within a reasonable time, it is still okay for consumption". [Mary]

From the practical viewpoint, this paper showed several strategies adopted by the university food service operation to prevent FW from the point of purchasing until service. The findings are summarised and illustrated in Figure 2.

4 Conclusions

The prevention of FW throughout the entire food service system is considered a challenging task, due to its complexity, the interdependencies of the parts of the system and the permeability of the boundaries of the food service system. The existing literature and tools to address FW are limited in that they do not view the food service system holistically. This study introduced a holistic approach to understanding how to address FW in the food service system. The study considered how FW is prevented in each of the stages of the functional subsystem. The study advocates that the first step towards a more sustainable resolution to the FW issue is to adopt an approach that tackles FW throughout the entire food service system. These FW prevention strategies benefit the environment and are the most sustainable. The application of the FW prevention strategies, therefore, can reduce the negative environmental impacts associated with FW, including GHGs, which contribute to global warming, as well as reduce the waste of water and energy. The application of the FW prevention strategies, as suggested by this study, may contribute to the attainment of the SDGs, which were approved in 2015 by the United Nations General Assembly.

Despite the contributions of the study, there are some limitations. The study applied a qualitative case study approach focusing on one South African university food service operation; therefore, generalisability is limited, and the findings may not apply to other food service operations. There results of this study must therefore be interpreted in accordance with the generalisability limitations that were faced. Further research in the area must include the collection of data from a significant sample of diverse food service operations to apply the findings in different settings of the food service sector. It is further recommended that future research consider extending the study by developing a tool for FW prevention applying the strategies suggested, and empirically testing the reliability and validity of the tool in practice. It is further suggested that a FW prevention implementation manual be developed to guide the use of the strategies in the food service sector.

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