



What a waste? An experience in a secondary school in Malaysia of a food waste management system (FWMS)[☆]

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A B S T R A C T

Food waste (FW) is not just a problem and challenge in Malaysia but world wide. According to a United Nation Environment Program report, approximately 931 million tonnes of food waste was produced globally in 2019. This included 61% from households, 26% from food services and the remaining 13%, from retail. The sheer magnitude of this wastage is very troubling; especially in the fact that there is no firm hope that the scale of the wastage will decrease in the near future. Most studies into food wastage have investigated the broader field of food industries such as food manufacturers, restaurants, food courts and others. This study, however, aimed to investigate FW among end-users who are students in a school, with data being collected from the school canteen. It investigated the amount of food waste before and after awareness of food waste in Malaysia was raised, and how the waste can be converted into cash. The study had four phases: 1) an awareness program for school students, 2) installation of the FW machine, 3) collection of food waste, and finally 4) data analysis. The food waste was collected, transformed into bio-fertilisers and sold to the parents. A total of 339.5 kg of food waste was collected in 38 days and this waste was transformed into 131.5 kg of bio-fertilisers for sale to parents in the same school. This simple FW conversion to bio-fertilisers undertaken in the school as a pilot project shed some light on the potential of the project to be carried out on a larger scale and with commercial interests for all schools in Malaysia. The school generated RM 1315 from the sale of the bio-fertilisers. The potential profits achievable from this conversion of FW to bio-fertilisers will be significant if the pilot study is expanded throughout Malaysia.

1. Introduction

“If food loss and waste were a country, it would be the third biggest source of greenhouse gas emissions (GHG),” declared the Executive Director of the United Nations Environment Programme, Ms Inger Anderson in a report entitled “The Food Waste Index Report” in 2021 [1]. In 2019, the report determined that approximately 931 million tonnes of food waste were produced in 2019 globally [2]. This comprised 61% from households, 26% from food services and the balance, 13%, from retail [1]. The sheer size of this waste is very troubling, especially due the fact that there is no firm hope that the figure will decrease in the near future. In addition, a report by the United Nations Environmental Program, 2021, stated that it believes food waste accounts for 8–10% of global greenhouse gas emissions [1]. About 1.3 billion tonnes, or one third of the food produced worldwide for human consumption each year, is wasted or lost, according to the Food and Agriculture Organization of the United Nations (FAO) [3].

In the meantime, there is a shift to a circular economy from a linear economy due to a growing need for energy and materials to support a rapidly growing resource-intensive population [4]. With a focus on considering garbage as a resource, rather than something we just wish to get rid of, the circular economy seeks to fundamentally alter the way we think about waste. It offers practical and innovative solutions that would restructure entire economies by moving away from a traditional linear economy (make, use, dispose)

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Table 1
Literatures on food waste behaviour between 2018 and 2022.

Name Of Journal	Title	Year	Measurement	Country	Findings
Journal of Enterprise Information Management	A consumer behavioural approach to food waste	2018	The study investigated consumers' food waste behaviour using factors in the Theory of Planned Behaviour (TPB) – Attitude, Subjective Norm and Perceived Behavioural Control. Other factors investigated include motives, financial attitudes, planning routines, food surplus, social relationships and Ramadan	Qatar	The study confirms that food waste behaviour can be explained by the TPB and other factors investigated. It is also found that the intentions to reduce waste helps to reduce the behaviour leading to food waste.
Sustainability, MDPI	The Management of Unsold Food in Outdoor Market Areas: Food Operators' Behaviour and Attitudes	2018	Investigates the food waste behaviour and attitudes of farmers, peddlers and hybrids	Italy	The study confirms that in line with other studies, literature on food waste has yet to be fully developed, leaving gaps still to be filled. The study found that profiling the actors involved in the food waste chain is a key step to successful implementation of various actions that can increase awareness and reduction of FW. Factors such as educational and cultural background significantly contribute to FW behaviour. The study concludes that awareness can be promoted by specific programmes included in the school syllabuses
Journal of Cleaner Production	Food waste matters - A systematic review of household food waste practices and their policy implications	2018	Systematic Literature Review on: i. Understandings and perceptions of food waste – Concern and Norms and perceived behavioural control ii. Food-related household practices and routines – Planning, Shopping, Storing, Cooking, Eating, Managing leftovers, Assessing edibility and Disposal iii. Socio-demographic characteristics	N/A	The review highlights analysis which shows that households are generally concerned and feel guilty about wasting food. However, the attitude of having guilt is a more of a personal concern that relates to financial loss instead of concerns about the environmental and social implications of FW.
Journal of Cleaner Production	Consumer behaviour types in household food waste	2018		UK	The findings found that non-aware consumers' are not careful about FW in their households. These consumers cannot recognize FW as a problem at both an individual and social level. These consumers' profiles confirm the findings of most of the literature that early education and knowledge of FW is crucial.
Appetite	Towards more sustainable food systems. Addressing food waste at school canteens	2018	Measuring FW among school students and teachers. Measurement includes: i. Kitchen discards ii. Service leftovers iii. Plate waste	Spain	The findings found that plate waste is the highest FW. School canteens are big generators of food waste and, at the same time, provide a great opportunity to improve habits regarding nutrition and education on sustainability, thus impacting the future of the food system.
Foods, MDPI	How Consumer Behaviour in Daily Food Provisioning Affects Food Waste at the Household Level in The Netherlands	2019	Measured the food (F) waste behaviour (Behv) based on planning. Factors including: i. Storage Behaviour ii. Purchase planning behaviour iii. Purchase behaviour in-store iv. Preparation planning behaviour v. Leftover consumption behaviour vi. Intention Not to Waste vii. Concern about FW Moderated by: viii. Household income ix. Educational level x. Household composition xi. Children's age in household xii. Age xiii. Gender	Dutch	The study confirms that consumers' lack of planning of food preparation is the most significant factor that contributes to FW. This affirms that when consumers plan their food purchases and have intention to not waste, less food is wasted. The study also found older consumers wasted less food. Hence, encouraging more awareness and education for the younger generation could reduce food waste

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Table 1 (continued)

Name Of Journal	Title	Year	Measurement	Country	Findings
Sustainability, MDPI	The Millennials' Concept of Sustainability in the Food Sector	2019	The study examined the interaction between Millennial students and what their perception of sustainability in the food sector. Respondents were grouped based on the category as below: i. Socio-Nature Sensitives – having a high level of consideration of socio-economic dimensions and sustainable ways of food production ii. Info-Supporter - very sensitive to labelling and warranty systems; iii. Proactive-Oriented – interested in innovative activities; iv. Indifferent Millennials - a low level of importance	Italy	The study found millennial students to be sensitive to sustainability matters, believe in labelling and certification systems as means of communication to convey information on types of production. These respondents also are hopeful that the current innovation processes will help reduce environmental impact.
Sustainability, MDPI	Decisional Factors Driving Household Food Waste Prevention: Evidence from Taiwanese Families	2020		Taiwan	The study indicates that household storing and cooking routines significantly mediate the effects of moral norms and food choices on household food wastage. The study further shows that the moderating effect of unplanned events significantly reduces food waste through household storage practices and cooking routines. Guilt plays a significant role in motivating families to make the effort to prevent FW. In addition, the attitude to have concern about their health and food safety, encourage them to practise food preservation and cooking routines which leads to a reduction in FW. Findings of this study encourage FW awareness and education of young children (from Kindergarten). The early education will help foster moral awareness that can help change the attitude to valuable food.
Sustainability, MDPI	Food Waste Behavior among Romanian Consumers: A Cluster Analysis	2020	The study looked into 3 clusters below: i. Careless ii. Precautious iii. Ignorant	Romania	The findings reveal the cluster known as the “careless and ignorant” wastage of food. Neither the environment nor education or income level were influential in encouraging them to reduce FW. The researchers predict that this could be due to the clusters having minimum information about the FW concept or not caring about it. They also do not feel guilty or consider FW to be an issue in terms of economic, social and/or environmental impact. The research concludes that these clusters will require basic information on the need to prevent food waste by raising their awareness. The findings also identified the “Precautious” who had certain childhood experiences that led them to appreciate food and its importance which led this cluster to not throw away food.
Sustainability, MDPI	Food Waste Behaviour at the Consumer Level: Pilot Study on Czech Private Households	2021	The study conducted an in-depth interview aimed at identifying the main factors of FW. The study measured the amount of food wasted, the frequency of purchases and the housing development which leads to FW. Other measurements include demographic factors such as income level, number of household members and age.	Czech	The study found that households living in urban developments waste the most due to limited possibilities of utilizing their biological waste. Hence, almost all their FW ends up in mixed municipal waste.

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Table 1 (continued)

Name Of Journal	Title	Year	Measurement	Country	Findings
Sustainable Production and Consumption	Perspectives on food waste management: Prevention and social innovations	2022	Systematic Literature Review to look at: i. Identifying the current state of food waste released and lost ii. assessing conventional food management techniques associated with food waste accumulation along the value chain iii. distinguishing various forms of food waste innovation in the food industry.	N/A	The review highlights consumers' perceptions of their behaviours, attitudes, beliefs and values towards food and waste that are the main drivers of food waste and loss. This finding also encourages having early education and awareness of the impact of FW. The review indicates the importance of reducing food waste along the food value chain by adopting innovative techniques to support a sustainable supply chain transition.

to a more sustainable model (reduce, reuse, recycle).

2. Background

2.1. Food waste in Malaysia

Waste management in Malaysia focuses on the general FW which includes food, plastic, materials etc. According to Lim et al. (2016), a method for storing and managing FW that is both affordable and environmentally beneficial is required. Studies indicate that the majority claim to have an intention towards pro-environmental behaviour [5–7]. However, where food is concerned, only a small minority claim to practise waste separation regularly [8]. According to the same poll, 32.6% of respondents claim to occasionally separate FW.

FW reduction and management attracts various stakeholders locally and globally. Malaysia is making many moves towards reducing FW. As trash is viewed as a valuable resource, (e.g. biomass and FW for power generation or utilised as an input for other products), one of the initiatives declared in the 11th Malaysia Plan [9], was to adopt sustainable consumption and production [10]. The Malaysian Government, through its 11 MP aims to achieve a 22% recycling rate among households in Malaysia. This target is far from reachable as, whilst the government has worked on various programs to enable better waste management systems, the practice at the grass roots level is seen to be more challenging as it requires an awareness and a readiness on the part of the community [11]. According to a study by the Economic Planning Unit, Malaysians must adopt better consumption and waste disposal habits for the country to advance towards becoming a developed country [10].

The Malaysian Water Forum, in collaboration with Solid Waste Management and Public Cleansing Corporation (SWCorp), implemented the “Upscaling Sound FW Management Practices through Youth and Community Education in Schools” under the Sustainable Lifestyles and Education (SLE) programme of the 10-Year Framework Programme (10YFP) for Sustainable Consumption and Production [12]. This represents a small step towards adopting more appropriate consumption and waste disposal behaviours. Following this, states like Sabah, Sarawak, Kedah, Penang, Kuala Lumpur, Melaka, and Pahang are currently introducing awareness of, and responsibility for, segregating FW from other garbage. Even while it was claimed that this was a good start for each homeowner to take charge of the handling of FW, the results are still unconvincing.

This problem, if not attended to immediately, will soon see the current Malaysian tagline as the country of “Food Paradise” becoming the country of “Food Waste Champions”. To combat this worrying affair, basic education must be implemented at a young age. Early education is viewed as the foundation and steppingstone for a child’s future as they develop.

2.2. Literature review

The definition of Food Waste (FW) has many variations [13] and is still found to be inconsistent in previous studies [4,14]. Waste of all types is included in FW which includes FW from overproduction, expiration, spoiling, overcooking, infected foods, and items dropped at the back of the house. According to Principato et al., 2015[15], FW starts at the beginning of the food supply chain (during production and industrial transformation). However, the author claims that in developing nations, FW takes place at the retail and consumer/consumption stages of the food supply chain. The FW by end-users is primarily due to inappropriate behaviour associated with food consumption and management. Most FW is due to excessive purchasing and cooking. Principato et al. (2015)[15] and Thi et al. (2015)[16] describe FW as unused food wasted during retail or final consumption, while Pinto et al. (2018)[17] and Stenmarck et al. (2016)[18] define FW as the last stage of the food lost in the food supply chain. Stenmarck et al. (2016)[18] in a report entitled “Estimates of European FW Levels” defines FW as fractions of “food and inedible parts of food removed from the food supply chain” to be recovered or disposed of (including - composted, ploughed in/not harvested, anaerobic digestion, bioenergy production, co-generation, incineration, disposal to sewer, landfill or discarded at sea) and inedible parts of food removed from the food supply chain.

In the past few years, many studies have focused on food waste. According to the statistics in SCOPUS, studies of food waste started in the late 18th century. It slowly gained momentum in the 1970s. However, a significant number of studies of food waste were on the

uptrend since the year 2000. A simple filtering in SCOPUS of full articles in English which were related to sustainable consumption behaviour and perceptions of food waste from 2018 up to 2022 showed a total of 255 articles. Although the number of articles on FW seem high and include many studies around the globe, it is still apparent that studies of FW needs extensive work and greater depth.

To further understand FW behaviour, the researchers drew on previous literature as presented in Table 1. The table presents an overview of global research into FW for 5 years ie. from 2018 until 2022.

In summary, the literatures on FW behaviour and attitude found that along the food chain, there are many who contribute to food wastage. However, the researchers are consistent in believing that awareness programs and early education about FW is necessary to help combat the FW problem globally.

2.3. Problem statement

FW is currently viewed as a global problem that has an impact on the social, economic and environmental factors with ramifications on a global scale [4,19]. It is understood that FW and losses use up an extensive number of natural resources. It is said that when food is lost or wasted, the natural resources utilised to produce it, including water, land, energy, labour and capital are also wasted [1]. Besides waste of resources, FW can also negatively impact food security and food availability while contributing to the increase in the cost of food. Approximately 25% of agricultural water and 23% of cropland [20] are used up by FW according to Searchinger et al. (2019)[21], whilst only producing 8% of the world's yearly greenhouse gas (GHG) emissions [22]. 95% of FW is disposed of in landfills, where it anaerobically decomposes and releases methane, a dangerous greenhouse emission [8].

The global FW problem has reached an alarming figure which significantly affects the environment, economy and society today [13,23]. Most of the FW that is disposed of is dumped in unhygienic landfills. Many of them have already surpassed capacity. According to SWCorp, Malaysia produces more than 11 million tonnes of municipal solid trash annually [24], creating a dire need to lessen the amount of waste that is dumped in landfills. This is an alarming issue, not just for the policy makers, but the general public as well. Additionally, the leachate produced by the decomposing food at landfills pollutes natural water sources such as rivers and lakes. By overproducing cropland, burdening the environment with pesticide use and increasing water demand, such waste has an economic cost. Since they are affordable and simple to use, landfills are a regularly used option for controlling FW. However, because so many landfills in Malaysia have reached capacity, managing FW through landfills has become more challenging. FW diversion can help cut greenhouse gas emissions, in addition to conserving limited landfill spaces.

FW is not just a topic of discussion, but a threat to many countries. Hence, the reduction in FW is an essential factor to achieve sustainable goals. In particular, Sustainable Development Goal (SDG) 12.3 calls for "reducing food losses along production and supply chains (including post-harvest losses) and halving per capita FW at the retail and consumer level by 2030." [25]. Few studies provide evidence from developing nations or rising economies; most of the research into FW usage findings are sourced from wealthy nations [26]. The same is seen in the case of Malaysia. A local newspaper, the New Straits Times, reports that a study by SWCorp in 2018 confirmed that Malaysians waste 16,687.5 tonnes of FW every day, which is enough to feed 12 million people three times a day [27], and that in a few years, there will be enough FW to fill 16 KLCCs (a 88-storey landmark building called the Kuala Lumpur Convention Centre in the capital of Malaysia). This figure includes 990 tons of unconsumed prepared food. Malaysia produces 38,000 tons of waste per day and currently 60% of the total waste is from FW [28]. Each person generates 0.544 kg of food trash per day (The Star, 2017) [29]. According to SW Corp, they frequently organize the 'Value Food No Waste' campaign to create awareness of food waste [30]. However, there has not been a significant reduction in FW in the past three years as shown in Table 2 below [30].

The Star, also reported that a quarter of the average Malaysian's salary is spent on food and drink (The Star, 2017). The same article stated that Malaysia's estimated food import expenditure ranged from RM35 billion to RM40 billion. This figure, however, is seen to be growing with a new report indicating that Malaysia's food import bill reached a whopping RM55.5 billion in 2020 (The Sun Daily, 2021)[31]. Hence, FW reduction and management seems to attract various stakeholders, not just globally, but also in Malaysia. Given that garbage is viewed as a valuable resource, the 11th Malaysia Plan [9] states that it will adopt sustainable consumption and production (e.g. biomass and FW for power generation or use it as an additive for other products). Malaysia continues to strive to eliminate waste as per its statement in its 12th Malaysia Plan which aims to ensure the FW generated will be recycled as compost or biogas [32].

Table 2
Solid waste (including FW) in Malaysia by SW Corp.

Year	Solid waste (including FW) generated in Malaysia (tonnes per day)	FW (tonnes per day)	Types of FW (tonnes per day)	
			Inedible (e.g. bones and fruit skin)	Edible (e.g. leftover meat and vegetables)
2019	38,120	16,964	12,893	4071
2020	38,294	17,041	12,952	4089
2021	38,219	17,007	12,926	4081

Source [30].

2.4. Objective of study

In tandem with the global and Malaysian call for reduction of FW, researchers have conducted a pilot study to raise awareness and enhance knowledge of FW from the grassroots level, starting in schools. This study aimed to raise awareness of FW among secondary school students and the neighbourhood (including parents and teachers) in Bangi, Selangor, where there is a population of over 100,000 people. Other objectives of the study were to inculcate entrepreneurial skill sets among school children, benefit the local community and the Malaysian government and eventually to a reduction in FW. Hence, this research aims to help various stakeholders to reduce FW by.

- i. Introducing the Food Waste Management System (FWMS);
- ii. creating awareness of FW at the school level and instilling good food management behaviour;
- iii. creating awareness of FW amongst the public (parents of the secondary school students and local community);
- iv. cultivating a FW reuse and recycling behaviour among young consumers;
- v. converting FW into bio-fertilizers using biodegradable methods;
- vi. encouraging entrepreneurship values among school children from a young age; and ??????

3. Methodology

3.1. Procedure at school

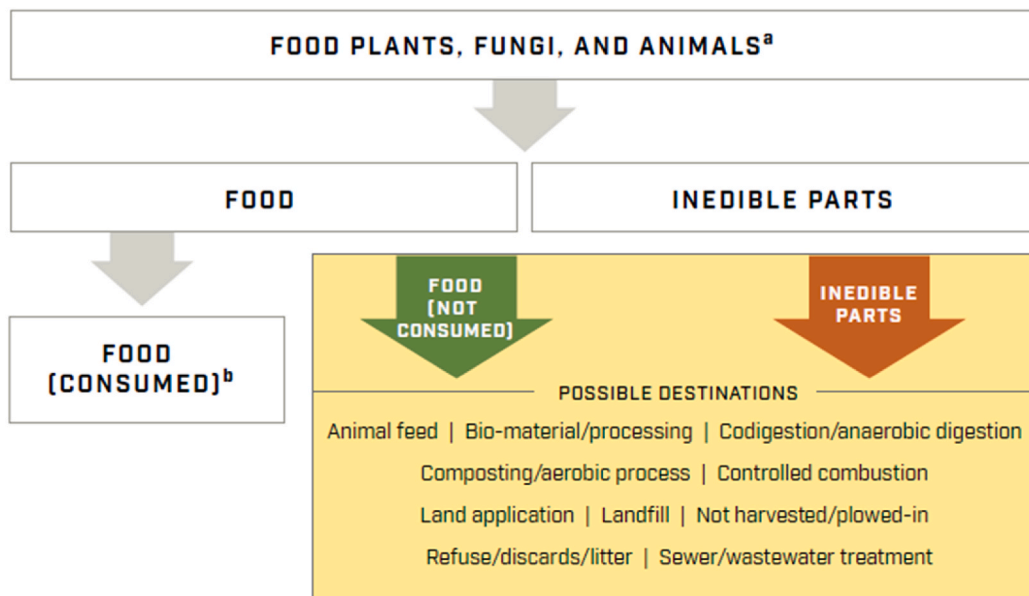
The study took place in a school (known as JESS) canteen located in a town called Bangi in the state of Selangor in Malaysia. This school population is an average student population size of schools in Malaysia. Hence, the study of food waste management in this school can be considered as representative of schools in Malaysia.

Although the study was scheduled for 12 months, due to the COVID 19 pandemic, the study was only conducted for 38 days. The FW management model for this study was based on the FAO framework of food loss as shown in Fig. 1 [33].

3.2. Summary of activities

3.2.1. Phase 1

The school principal was contacted to request permission to conduct the study. Upon receiving permission, the researchers met the



^a Intended for human consumption (i.e., excludes crops intentionally grown for bioenergy, animal feed, seed, or industrial use)

^b At some point in the food supply chain (including surplus food redistributed to people and consumed)

Source: Adapted from FAO. 2014. Definitional Framework of Food Loss. Working paper of the Global Initiative on Food Loss and Waste Reduction. Rome, Italy: FAO.

Fig. 1. FAO framework of Food Loss.

Source: Adapted from Ref. [33] - Definitional Framework of Food Loss. Working paper of the Global Initiative on Food Loss and Waste Reduction. Rome, Italy, FAO

teachers and students to carry out awareness programmes, including how to reduce and manage FW in Malaysia. Students were requested to share their views on FW within the community. The information gathered was disseminated via a dedicated bulletin board at the school. The researchers and teachers identified a group of 20 student volunteers to help run the project. The students were selected and called JESS Eco Warriors (JEW).

3.2.2. Phase 2

The project leased a FW composting machine (FWCM) from a Malaysian supplier for 12 months. The FWCM which transforms FW into soil in 24 h was placed in the school canteen. The FWCM uses controlled variables including temperature, agitation and airflow to digest all kinds of FW in an aerobic atmosphere. A bio-enzyme filtering system and ventilation are among features of the machine that help get rid of bad odours. The FWCM can combine both cooked and uncooked ingredients.

3.2.3. Phase 3

The supplier trained the researchers, JEW, schoolteachers and the gardener on the techniques of segregating FW before recycling. Fig. 2 shows the process for the FW collection and composting. The researchers hired the school gardener to help collect FW, weigh and deposit it in the FWCM. Subsequently, the gardener also helped collect the processed bio-fertiliser and weigh it. The JEWs then helped to record the data using a mobile application called a W2W (Waste to Wealth) calculator developed by the co-researchers, and packaged the bio-fertilisers to be sold.

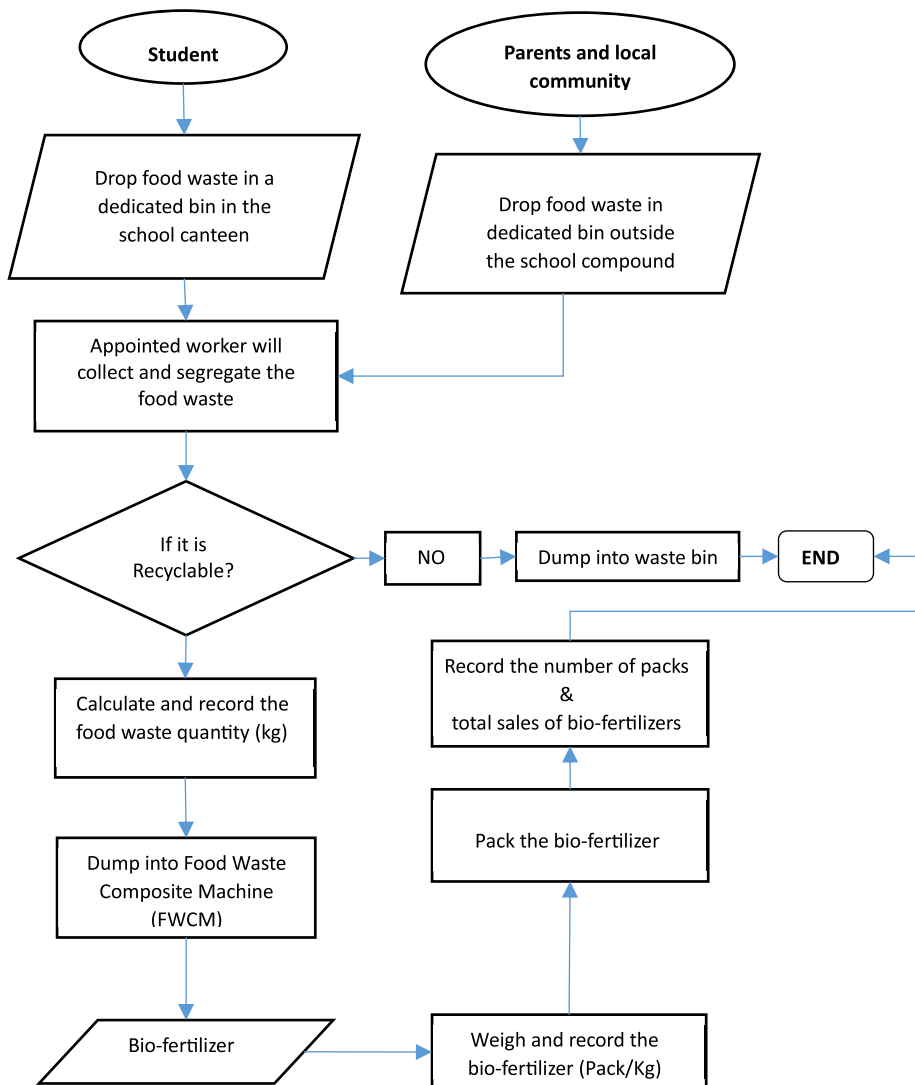


Fig. 2. Food waste management (FWM) at JESS, Bangi Selangor.

3.2.4. Phase 4

The final stage of the project was to analyse the amount of FW collected, quantify it and calculate the potential GHG emission saved.

4. Findings

4.1. Descriptive analysis

Before the start of the project, the researchers had several meetings with the teachers and students to establish the phases and activities of the study. During these meetings, the researchers suggested activities pertaining to knowledge transfer of sustainability as well as the various mechanisms that can be put in place to address the Green House Effect and achieve sustainability. Hence, the researchers undertook pre-test and post-test exercises. A simple survey was distributed to the students. The parents of the students were invited to the school for a briefing session during the launch of the project. At this session, they were advised of the project to be undertaken and the researchers sought their consent to undertake a pre-test and post-test study of their children's understanding of food wastage. After the project launch, 119 students were identified to take part in the study based on the consent letters received from their parents. At the end of the project's duration, students who participated in the pre-test were given the post-test questions to answer. The questions were based on validated past studies as shown in Table 3 and the findings for the pre-test and post-test is presented in Figs. 3 and 4 respectively.

Based on the results of the Pre-test of Food Wastage Avoidance Behaviours, it was patently obvious that the students had minimal awareness or concerns about food wastage. They bought food with no thought that they had bought far more than they needed, and they were oblivious to the fact that food wastage was a problem. They did not see the value of sharing leftover food with others such the needy and even animals, and they certainly had no conception that food wastage was reaching harmful levels in the country.

The Post-test of Food Wastage Avoidance Behaviours revealed a considerable contrast to the results of the Pre-test - the level of awareness had increased dramatically. By participating in the project's activities, they became more aware of the importance of food and why it should not be wasted. At the completion of the project, it was apparent that students had become more conscious of and concerned about food wastage in their daily lives (as seen in Fig. 5 on the reduction of food waste) and the implications of food wastage for the country as a whole.

The quantity of FW that was gathered from the beginning of the project up to 38 days is shown in Table 4. The data clearly shows the fluctuation of FW collected. The data also demonstrates that as student awareness increased as seen in Fig. 4, the quantity of FW collected reduced during the duration of collection. In the same vein, the quantity of bio-fertiliser converted from the FW proportionately reduced as well during the 38 days.

Fig. 5 shows the comparison between FW collected and conversion to bio-fertiliser from January–March 2020. The FW was highest in February at 170 kg; indicating that awareness of FW was still in its infancy stage 30 days after the start of the project. This data further illustrates that by the end of the period, the quantity of FW reduced by 40 kg and the bio-fertiliser converted was down to less than 20 kg.

5. Discussion

In 38 days, a total of 339.5 kg of FW was collected at the school and 131.5 kg of fertiliser was produced. A summary of the FW collection and generation of bio-fertiliser is shown in Table 5 below.

Effectively, for every kilogram of FW used, 0.3873 kg of fertiliser is produced (38.73% production rate). Using the process of rotating, the daily profit generated from the conversion of FW to bio-fertiliser is RM35.88 and the monthly profit is RM 1076.32. If considered annually, the potential profit is RM 12915.85. The Department of Statistics Malaysia (DOSM, 2020) confirms that there are a total of 10,220 schools in Malaysia (7780 primary and 2439 secondary).

This simple FW conversion to bio-fertiliser undertaken in the school, as a pilot project, shed considerable light on the potential of the project to be carried out on a larger scale and of commercial interest for all schools in Malaysia. The potential achievable profit from this conversion of FW to bio-fertiliser is more than RM2.6 million monthly and more than RM31.5 million annually.

Table 3
Pre and post test survey questions for school students.

Questions	
A1	I buy enough to avoid wasting food
A2	I think it is important that I do not waste food
A3	I am aware that wasting food is a big problem
A4	I donate the leftover food to the needy or animals
A5	I try to finish up all the food before its expiry date
A6	I try to reduce throwing out my leftover food by sharing with others
A7	I encourage my friends and family not to waste food
A8	I believe food waste in Malaysia is reaching a worrying level
A9	I am aware of the food waste campaigns in the Malaysia

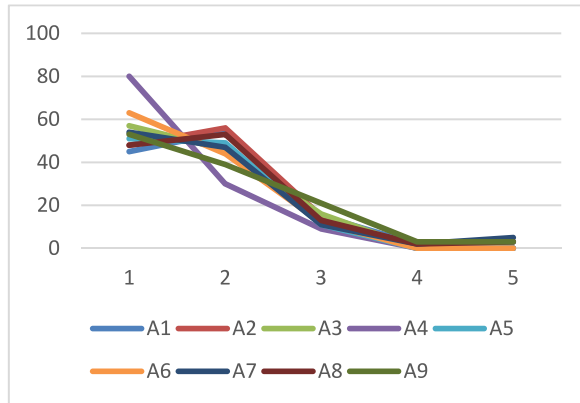


Fig. 3. Pre-test survey on Student's food waste awareness.

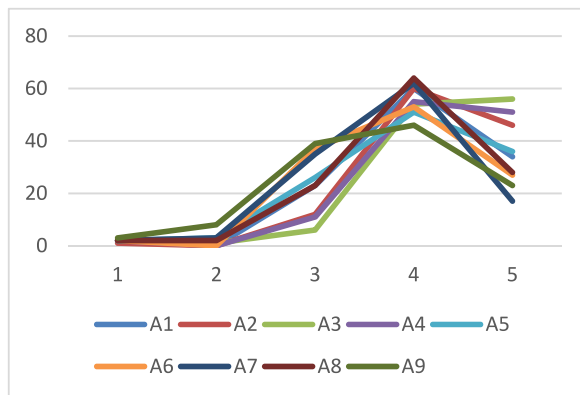


Fig. 4. Post-test survey on Student's food waste awareness.

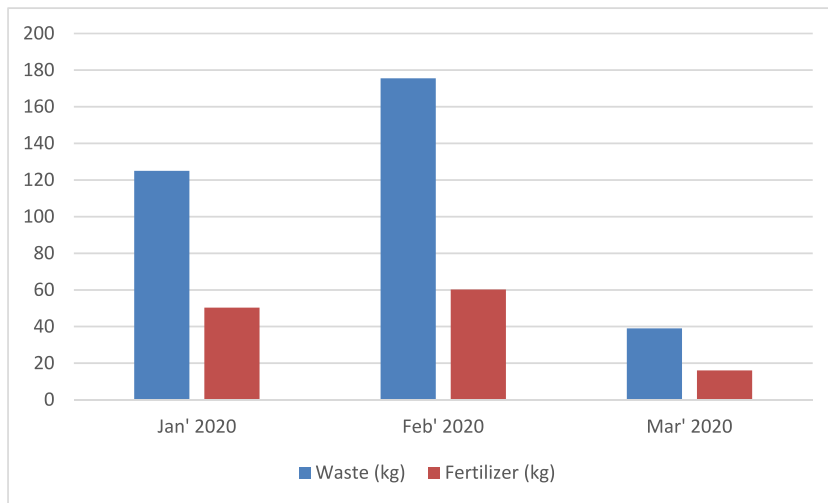


Fig. 5. Comparison of FW and fertiliser generation from Jan'20 – Mar'20.

5.1. Novelty and contribution of study

The data in Figs. 3 and 4 indicates that student's food wastage awareness prior to the food waste awareness campaign in the school was at a low level and increased tremendously by completion of the project. Hence, the first novelty of this study is that it has created

Table 4
Food waste & fertiliser generation record at JESS, Bangi Selangor.

Amount of FW					
Date	FW (Kg)	Fertiliser (Kg)	Date	FW (Kg)	Fertiliser (Kg)
13-Jan-20	6	2.5	13-Feb-20	8	2
14-Jan-20	12	4	14-Feb-20	15	6
15-Jan-20	9	5	17-Feb-20	9	3
16-Jan-20	13	5.5	18-Feb-20	13	6
17-Jan-20	10	3.3	19-Feb-20	8	3
20-Jan-20	13	5	20-Feb-20	8	2
21-Jan-20	14	5	21-Feb-20	6	2
22-Jan-20	10	4	24-Feb-20	6	2
28-Jan-20	9	5	25-Feb-20	7	2
29-Jan-20	15	5	27-Feb-20	6	2
30-Jan-20	5	2	28-Feb-20	5	3
31-Jan-20	9	4	03-Mar-20	7	3
03-Feb-20	13	5	04-Mar-20	5	2
04-Feb-20	15	5	05-Mar-20	4	2
05-Feb-20	9	3.2	06-Mar-20	5	1
06-Feb-20	15	3.5	09-Mar-20	4	2
10-Feb-20	10.5	4	10-Mar-20	5	2
11-Feb-20	11	3.5	13-Mar-20	5	2
12-Feb-20	11	3	17-Mar-20	4	2
Total FW	339.5 Kg		Total Bio-Fertiliser	131.5 Kg	

Table 5
Summary of FW collection and generation of bio-fertilisers in 38 days.

Item	Measurement
FW	339.5 kg
Fertilizer produced	131.5 kg
Machine leased	RM 633.33
*Revenue from sale of fertilizer	RM1315

Note: Retail sale price of bio-fertilizer = RM10 per kg.

food waste awareness among young food consumers in schools. The awareness instilled in these students can have a multiplying effect when these young consumers carry this awareness to their respective households and when they have their own families. This project is then deemed sustainable in terms of building a virtuous food waste management behaviour among young consumers. This factor is regarded critical as in a current news article, it was indicated that even recently, the food waste problem is still rampant globally [34]. This includes Malaysia as the author further reiterated that Malaysia is a world leader in wasted food with 3000 tonnes of edible food disposed of daily. Consequently, by implementing his project, the young consumers' awareness of the food waste problem will create a more sensitive food waste management behaviour including taking on board the habit of reusing leftover food and food sharing practices.

Besides awareness among young consumers, this pilot project also serves as a basis for stakeholders such as government agencies, researchers, universities and other food waste management implementers to replicate and extend this study to provide institutional food waste management systems as described in Fig. 2. This study will help stakeholders to identify methods to reduce and recycle food waste and consider potential returns from the sale of bio-fertilizers from the schools in Malaysia.

5.2. Policy implications

FW policy in Malaysia was included in the Eight Malaysia Plan, 2001–2005 (8 MP) onwards. According to Bala et al. (2014)[35], the policy on food security in Malaysia is focused on ensuring the availability, accessibility and utilization by society. This is reflected in the latest Malaysia Plan, 12 MP (Twelfth Malaysia Plan, 2021–2025) where the emphasis is also on food security [32]. Whilst the food crisis in 2008 drove the Malaysian government to adopt various policies to cushion the effect, none were introduced to address the issue of FW [36]. Hence, this study contributes to the implementation on a FW policy based on the administration of FW in schools and public areas such as food outlets. The policy should be under the purview of SW Corp and Department of Environment, Malaysia and entail the introduction of strategies and procedures to empower the administration of schools to undertake FW management initiatives in a coordinated, well-structured and systematic manner.

This study's primary contribution is that it aligns with the Environment, Social and Governance (ESG) strategies enshrined by the Malaysian government. Although this project was conducted in a school environment, the goal of this study is for the conversion of the FW to bio-fertilisers to be undertaken nationwide with proper administration. The biggest challenge for all parties concerned in implementing the conversion of FW to bio-fertilisers in schools is incorporating ESG principles in the administration of the project nationwide without a solid policy on FW. Therefore, this study promotes a sustainable model for institutional FWMS to be adapted by

stakeholders as a guide for future use.

FW being converted into bio-fertiliser can inspire Malaysian schools to start initiatives that help the country achieve a better lifestyle, consumption patterns and sustainable production as stated in the NPE [37]. The aim of the SDG 12.3, is to “decrease per capita FW at the retail and consumer level, and reduce food losses along production and supply chains (including post-harvest losses) by 2030.” [25].

This effort is not merely confined to minimising risk and reducing carbon footprint. Additionally, it entails a larger scope of administration in terms of enabling a significant change in behaviour, seeking new economic opportunities at the national level and improving the overall productivity and efficiency of the national FW management initiative. The administration of FW conversion to bio-fertiliser not only enables the creation of new businesses, its sustainable approach also goes a long way towards reducing costs incurred associated with traditional approaches. Ultimately, this will lead to a leaner, smarter and more efficient implementation of FW management in schools which could become the pillars of support for the setting up of ESG strategies for Malaysia. A national policy can be drawn up to build sustainable businesses that empower schools, promote the government’s collective responsibility, and subsequently reduce environmental degradation.

These efforts are in line with the circular economy which has become an important policy concept in recent years. National and international; policymakers have embraced the circular economy as the key to achieving multiple SDGs. The circular economy aims to fundamentally change how we think about waste: treating it as a resource rather than something we just want to get rid of. It offers practical and innovative solutions that would restructure entire economies by moving away from a traditional linear economy (make, use and dispose) to a more sustainable circular economy (reduce, reuse and recycle). While the circular economy is a policy concept that has gained prominence in Europe and other high-income countries, it is often overlooked that many countries in the global South have long-established circular economy systems in place (Van Niekerk & Wegmann, 2018)[38]. This study reinforces this evidence and provides the scaffolding for initial steps towards developing further policies on food waste in Malaysia.

The Malaysian Prime Minister recently highlighted the need for a circular economy which encourages ‘Increasing Resilience against Climate Change’ in the 12 MP [32]. The report also emphasised priority areas which include: 1) Moving Towards a Low-Carbon Nation, 2) Accelerating Transition to the Circular Economy, 3) Sharing Responsibility in Pollution Prevention and 4) Increasing Resilience against Climate Change and Disasters. In this context, the National Energy Policy, 2022–2040 (NEP) was conceptualised to enable Malaysia to take progressive steps to future-proof and position the country to capture advantages from energy transition; one of which includes establishing forward-looking targets and roadmaps for GHG emissions reduction, especially carbon emission [37].

5.3. Limitation of study, future research and conclusion

One of limitations of this study was that the lock down due to COVID 19 and the subsequent move to home schooling. This move interrupted the data collection process resulting in data only being collected for 39 working days (approximately 2 months) instead of 10 months as originally scheduled. Therefore, a suggestion for future research is to conduct a longitudinal study with a longer duration for demographic and behavioural change and data collection.

This study was based on creating awareness and the learning of new behaviours by school children with the expectation that eventually there will be a positive attitude towards food waste disposal leading towards a more ethical self. One of the limitations of the study was obtaining the buy-in and commitment of the students and parents especially at the start of the project. Future research should concentrate on targeting campaigns at school children and young adults to teach them how to reuse leftovers or share food, thereby changing their attitudes towards food waste, if necessary, through mobile applications.

This study does not build the connection between food and agriculture as it does not emphasise the influence of the food production process on the environment and society. Future research should focus on building the connection between food and agriculture by concentrating on food and farming education in schools. This would enable students and young adults to think critically and appreciate the importance of the environment and the circular economy.

Finally, this study was based on one primary school in the state of Selangor, Malaysia. Future research should replicate and advance this study to other schools in all the states of Malaysia so that awareness on food waste and the circular economy is enhanced.

In conclusion, this study was the first step towards increasing awareness of FW among students in a school. This study investigated the amount of food waste and was able to demonstrate how food waste from a school canteen could be translated into income for a school. It also acknowledges the importance of the circular economy in Malaysia as well as encourages ideas about how FW potentially increase income for schools. This study builds towards developing policies in line with the NEP to future-proof and position the country to capture advantages from energy transition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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