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Food waste recycling: Utilization, management, and innovation

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Abstract

This study assessed the nature of food waste and potential of food waste recycling in Ilesha West Local Government Area of Osun. Using descriptive research design aided by waste management hierarchy framework, this study gathered data using structured questionnaire distributed to a total sample size 210. The questionnaire was constructed and validated by the researcher's supervisor and two other experts with Cronbach's Alpha of 0.83, signifying reliability of the instrument's internal consistency. Data collected were analyzed using both descriptive and inferential statistics. Findings revealed that households, restaurants, and markets generate food waste in large quantities. This implies that large food waste types are generated from different food outlets and if not properly managed could cause environmental pollution, health risks, economic loss, food insecurity, climate change, resource waste, and greenhouse emissions. Innovative use of food waste can bring about improved waste management, economic benefits, environment conservation as well as food security. Theoretically, it can contribute to waste management theory, assessment of recycling technologies, and development of a sustainable food system and this study can form a framework for the development of policy and regulation that supports food waste recycling and reduction in Ilasha West Local Government of Osun state. It is recommended that educational campaigns and local community meetings be organized to educate households, markets, and restaurants about the risks associated with improper waste disposal and to emphasize the importance of adopting sustainable waste management practices.

Keywords: *food waste, waste recycling, utilization, innovative, management*

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1. Introduction

Food systems play a central role in all societies and are fundamental to ensuring sustainable development. Sustainable food systems are critical to resolving issues of food security, poverty alleviation, and adequate nutrition, and they play an important role in building resilience in communities responding to a rapidly changing global environment. However, food systems are under increasing pressure to respond to numerous complex challenges. These include growing demands for greater quantity, quality, and diversity of food. The world population is predicted to grow from 7.2 billion in 2010 to over 9 billion in 2050 with corresponding food demand predicted to increase by 60 percent and food loss and waste – roughly 30 percent of the food produced worldwide is lost or wasted every year (United Nations, 2019). Wastes arising from human and animal activities are normally solid and are discarded as useless, or unwanted and are broadly defined as solid waste. It includes municipal garbage, industrial, and commercial wastes, sewerage slug, agricultural and animal husbandry waste, demolition waste, and mining residues (Yadav, 2020).

Most items of waste that have been generated in various ways have resulted in many socio-economic problems that threaten public health. In urban areas, especially, in the primate cities of the developing world, issues of poor solid waste management (PSWM) have caused different problems. Currently, in most developing countries, the problems of poor solid waste management are exacerbated due to the rapid population growth of the urban center which overwhelms the capacity of municipal authorities to provide even the most basic service in the urban center. For this reason, most solid wastes generated in developing countries are not collected and most of the time, the uncollected waste of humans is dumped indiscriminately in the streets and in drains.

Cities and towns are facing the challenge of managing municipal waste. Solid waste collection systems in many countries cannot cope with the increasing volume of solid waste. Collection service coverage of less than 70% is not uncommon in developing countries. These improper solid waste management systems cause climate change, environmental (pollution), and public health problems (Gebrekidan et al., 2024). In addition to health risks derived from direct contact, healthcare waste can adversely impact human health by contaminating water bodies during waste treatment and by polluting the air through emissions of highly toxic gases during the incineration of waste products. When the waste products are disposed of in a pit that is not lined or too close to water sources, the water bodies may become contaminated.

Food waste is a problem to society, it is a worldwide issue causing huge losses to all and sundry economically, environmentally, and health-wise. They are part of solid waste being generated all over the world. The occurrence of food waste in households, restaurants, market food stalls, and other food outlets could be due to inappropriate planning/cooking methods, lack of proper storage facilities, and excessive food preparation (Pandey, 2021). The impact of food waste can be harmful to humans, and plants, likewise, the economy, environment, water, and land are threatened. According to Chirsanova and Calcatiniuc (2021), current estimations indicate that around one third of food produced worldwide for human consumption is wasted or lost, which generates significant economic and environmental costs (Pandey, 2021). Food wastage impacts food security in three main ways. First, a reduction in the availability of food. Second, a contribution to tightening the market and raising prices of food. Solid wastes are garbage/food refuse that are thrown away as trash/policy, with no effective means of proper waste disposal put in place (Obi-Anija, 2016). They arise as a result of unused food, left-over food, scraps, food materials that got spoiled and above all, peels, shells, among others from food. Food wastes are of different categories, some of which are, household waste (leftover food, organic waste, and beverage waste among others), restaurant waste (unsold food products, customer leftover foods, plastic and package wastes among others), and market waste (post-harvest loss). The wastes are disposed of indiscriminately, used in landfills, dumped in gutters during rainy periods, or even burnt. The attitude of residents on indiscriminate dumping of solid waste in strategic locations mounting to heaps of refuse and pervading dirty environments has bred concern. Indiscriminate dumping of solid waste (food waste) can constitute pollution, dirtiness, and hazards. It has become a great concern worldwide (Sewak et al., 2021).

Most of the problems in the environment are caused by man-made pollution which damages natural resources and it is equally dangerous to the populace. Common landfills, dump burnings, and incineration among others are the most popular means through which refuse is disposed of. Pollution caused by improper waste disposal is negatively affecting our ecosystem and biodiversity, the health of all living beings, and people's livelihoods that depend on natural resources (Environmental Protection Agency, 2020). Globally, researchers estimate that, in Food Supply Chains, the percentages of food loss in production, postharvest, and consumption stages are 24, 24, and 35 percent, respectively (Xue et al., 2017). Therefore, more than 80 percent of food gets wasted in these stages, which is quite alarming (Xue et al., 2017).

At a time when the demand for food of a growing population is a major global problem, more than a third of food is lost or wasted in post-harvest agricultural operations. As the volume of waste increases globally, so does the need for effective solid waste management systems (Avagyan, 2017; Environmental Protection Agency, 2020). Waste recycling is in line with the 12th United Nations' Sustainable Development Goals [SDG 12.3, 12.4, and 12.5], this concur with the report of Muluneh et al. (2018) that SDG also aims at reduction and proper waste management.

Reducing waste after harvest, especially in developing countries, can be a sustainable solution to increase food availability, reduce pressure on natural resources, eliminate hunger, and improve farmers' living conditions. A lack of knowledge and appropriate tools often leads to inappropriate practices such as waste dumping and uncontrolled burning. However, appropriate methods can transform waste into resources and even guarantee a revenue source (Vinti & Vaccari, 2022). Efforts are ongoing by both government and non-government agencies through various means to lower the menace of indiscriminate waste disposal (Sunday et al., 2022). This is an essential step to reduce the incidence of post-harvest thereby bringing succor to the populace, farmers, food business owners, and others (Ogedengbe et al., 2023). Food waste in restaurants is a significant issue in the food service sector. Various factors contribute to this waste, including purchasing, preparation, cooking, storage, and service processes. Food outlets such as restaurants have various waste which needs great attention (Esteves et al., 2024; Bjornsen, 2024). Food waste within restaurant operations, from over-ordering and improper storage to inefficient preparation practices and plate waste. Proffering solutions is paramount in order to maximize profit and also prevent adverse health effects of waste when not properly managed (McMahon, 2024). There are many effective means of dealing with waste such as recycling, and product development for value addition for a replacement to indiscriminate waste disposal methods such as incineration and landfilling (Makanjuola et al., 2020).

Food waste disposal is of great concern all over the world which is affecting all and sundry and it should be addressed sustainable strategies. According to Moraga et al. (2021), innovations circular economy (CE) is a notion born to support the responsible circularity of the available resources to attain sustainable development goals. This is very essential to reduce the harmful effect of arbitrary waste disposal; hence the CE will not only be reducing waste but redefining the current waste management practices of food waste and other waste types to

create new businesses and jobs (Rashid & Shahzad, 2021). Researchers have reported various types of sustainable products from food waste, such as compost otherwise known as organic fertilizers made from food waste (Waqas et al., 2018), utilization of waste for the production of bioenergy (Dahiya et al., 2018), production of compost, insect-based feed, biogas, bioethanol and biodiesel from waste (Guo et al., 2022).

Reducing food waste becomes a priority since waste will continue to be generated throughout the food supply chain if no action is taken. Households, food market stalls, restaurants, eateries, and other food outlets will continue to generate waste food as long as they process food. Importantly, food waste results in loss of time, effort, and the other resources that went into producing that food. Food waste recycling is a cornerstone of sustainable waste management as it reduces landfill usage, lowers greenhouse gas emissions, and promotes resource efficiency. Recycling this waste has the potential to significantly reduce environmental degradation and improve resource utilization. Manzoor et al. (2024) and Beretta et al. (2018) emphasize that food waste recycling plays a crucial role in achieving the United Nations' Sustainable Development Goals (SDGs), particularly Goal 12, which focuses on responsible consumption and production. The authors highlight that effective recycling not only minimizes waste but also generates value-added products, such as compost, bioenergy, and animal feed.

Innovative use of food waste plays a very crucial role in developing effective and sustainable food waste recycling. Food waste used in bioplastic inventions made from recycled food waste are used as sustainable alternatives to traditional plastics; processed to serve as alternatives to sugar; innovations in biotechnology can lead to the production of artificial tissues from food waste; companies use upcycled food products to create snacks, ready-to-eat meals, and cooking ingredients, (Food unfolded, 2020; Xiao, 2024). Creative designers are producing useful household products from food waste, including textiles made from banana, pineapple, and coconut fibers (AgReads, 2020). Candles can be produced from food waste by utilizing waste cooking oil and essential oil of sweet orange peel as aromatherapy (Ramadani & Kusumaningrum, 2024), cosmetic and skin care products can be produced from food waste like fruit peels, and vegetable oils (Morgati et al., 2022), and the textile can equally be produced biodegradable paper from food waste like fruit peels and vegetable scraps. This concurs with the research study of Buxoo and Jeetah (2020) on producing biodegradable disposable paper cup from pineapple peels, orange peels, and Mauritian hemp leaves with a beeswax coating.

Likewise, peeling fruit was utilized in the production of food packaging (Shinde et al., 2019). Flores and fragrances can also be produced from food waste such as fruit and vegetable peels (Maurya, 2022).

Several contextual factors may influence waste management practices such as the lack of adequate infrastructure for waste treatment and disposal, waste collection and transportation, water treatment and disposal, communication, and information technology to support waste management operations. Also, the lack of functional policies at the national and local level to implement effective waste management policies, standards and guidelines, environmental and health regulations, high taxation, and high charges discourage adequate and proper waste management, coupled with socio-economic factors such as increasing population density and growth, low income and high inflation rate, low education and awareness of appropriate waste management practices and cultural and social norms influence individuals attitude towards waste management (Kumar et al., 2012; Flynn et al., 2021). Only a dearth of information is available on appropriate waste management system and food waste recycling through the innovative utilization of the food wastes. Thus, this study identified types of food waste generated by various households, restaurants, and other food outlets, outlined existing waste disposal methods identified, and identified the level of awareness of the effects of improper waste disposal, and produced some household items from food waste.

The study investigated food waste recycling, including the utilization, management, and innovative uses of food waste in Ilesa West Local Government Area of Osun. Specifically, this study identified types of food waste generated by households, restaurants, markets, and other food outlets within the local government area, outlined existing methods of food waste disposal, identified effect of level of awareness of improper waste disposal and produced household items from food waste.

2. Literature Review

Food waste refers to food that is unfit for consumption but consciously discarded at the retail or consumption phase. It has been reported that about 17% of global food production may go wasted, according to the UN Environment Programme's (UNEP) (Food Waste Index Report, 2021), with 61% of this waste coming from households, 26% from food service and 13% from retail. Food waste generation in Nigeria presents a significant environmental and economic challenge. Currently, Nigeria loses about 40% of its annual food production, which

approximately amounts to 100 million tons of food per year (Obi, 2024). Globally, about 14% of food valued at an estimated USD 400 billion is lost from harvest up to, but not including, retail (Haruna, 2022). It is an indisputable fact that food waste occurs from all stages of the food chain right from harvest to the table bringing environmental problems. Food waste is not just an issue for the poor only but the rich as well, nor for the developing or underdeveloped nations but a global occurrence that needs to be addressed urgently.

Food waste is a great risk to the populace if not properly managed (Yoada et al, 2022). According to Hayudini (2022), waste disposal is a universal problem affecting both urban and rural areas worldwide (developed and developing countries). Consequences of indiscriminate food waste are contaminating the environment, clogging drainage and causing flooding, transmitting diseases, increasing respiratory problems from burning, harming animals that consume waste unknowingly, and affecting economic development. Large quantities of food waste end up in landfills, creating methane emissions, contributing to climate change, and occupying valuable space. Additionally, the loss of uneaten food represents a missed economic opportunity, as resources used for production and transportation are wasted (Pandey, 2021). Significant food waste coincides with a segment of the population facing food insecurity.

Considering all the challenges posed by food waste, proper waste disposal practices are important for building sustainable, reusing, reducing, and recycling solid waste to reduce the amount of solid waste that increases annually (Hayudini, 2022). These highlight the need for improved food waste management systems that can divert usable food waste to those in need while exploring innovative uses for the remainder. Food waste recycling has gained significant attention in recent years as a result of its potential to reduce greenhouse emissions natural resources conservation and promotion of sustainable development. Presently, food waste recycling has been limited to composting, anaerobic digestion, and vermicomposting. Previous research studies revealed the conversion of food waste into energy, composting, feeds, biofuel, biogas (Kumari et al., 2024; Guo et al., 2021; Paritosh et al., 2017). According to Kubriak (2024), potato peels are being turned into plastic in Canada, upcycling of flowers, berries, and fruit into perfume in Paris, production of shoes from chicken feet is being carried out in Indonesia, cutlery is being produced from avocado stone in Mexico, alcohol from tofu products in Singapore, clothes are made from discarded pineapple plant leaves in Spain, beer is being produced from recycled toast in the United Kingdom while the United States produces all-

purpose cleaners from food waste. There is a dearth of information and awareness on the recycling of food waste in the production of household items.

3. Research Methodology

3.1 Research Design

This paper adopted the waste management hierarchy (WMH) which is a widely acceptable framework for managing waste in friendly and environmentally sustainable ways. The theory gives priority to the most and least preference relating to environmental impact to conservation potential as well as utilization and innovative use of food waste. It implies that the populace should prioritize prevention, reduction, reuse, recycling, recovery, and disposal of food waste. This study employed this framework because it corresponds to the set objectives of this study.

The research design employed for this study was descriptive survey design. This design was adopted because descriptive studies do not attempt to manipulate variables, and it is concerned with describing and interpreting existing relationships, attitudes, and practical processes and tend to compare variables (Taherdoost, 2021).

3.2 Area, Population and Sample of the Study

The study was carried out in Ilesa West Local Government Area of Osun State. Osun State is divided into three federal senatorial districts, each of which is composed of two administrative zones. The main occupation of the Ilesa people is farming and trading. The women are more into trading in the study area.

The population of the study comprises all households and food outlets in Ilesa West Local Government Area of Osun State. The population of both households and food outlets could not be obtained as of the time of putting this report together. No recorded data could be obtained from the online databases, local government Area, and National Population Census.

The total sample size for this study was two hundred and ten (210). The size for all household and food outlets was one hundred and five (105) each. The sample size for both groups of respondents was determined using the Cochran formula. This technique was used because it provides the least significant sample size for an undefined population (Kothar, 2014).

$$N= \frac{P(I-P)z^2}{e^2} = \frac{0.1*(I-0.1)(1.71)^2}{(0.05)^2} = \frac{(0.09)(2.9241)}{0.0025}$$

$$= 105.3$$

Where n = Sample

P = assumed population percentage

I = tabulated = value confidence

E= level of significance (0.05)

A multistage sampling technique was used for respondents' selection; this is because it will ensure proper representation of the large population.

Stage A. A simple random sampling technique was used to select six (6) wards from the ten wards that exist in Ilesa west Local Government Area of Osun State.

Stage B. Accidental sampling technique was used to select 18 households and 17 food outlets from each of the selected six wards, giving a total of two hundred and ten (210) respondents all together.

Table 1

Demographic information

	Frequency (n)	Percentage (%)
Religion		
Islam	90	42.9%
Christianity	120	57.1%
Gender		
Male	100	47.6%
Female	110	52.4%
Age Range		
20 to 26 years	80	38.1%
27 to 33 years	90	42.9%
34 years and above	40	19.0%
Marital Status		
Single	100	47.6%
Married	90	42.9%
Divorced	10	4.8%
Educational Level		
Diploma/NCE	50	23.8%
Degree	100	47.6%
Masters	50	23.8%
PhD	10	4.8%

The data obtained on demographic information of the respondents as shown in table 1 revealed that the majority of respondents fell within the 27-33 years age range (42.9%), followed by younger (20-26 years) and older groups (34 years and above). This shows that young and middle-aged adults engage more in surveys and environmental programs, as they are often the most active demographic in community activities and policy advocacy. This correlates with the findings of Sallis and Glanz (2009) cited by Linton et al. (2014). A significant proportion of respondents held at least a bachelor's degree (57.1%), while fewer respondents had lower (Diploma/NCE: 19.0%) or higher (Master's: 19.0%, Ph.D.: 4.8%) qualifications. This distribution is consistent with the assertion of Nyampundu et al. (2020) that higher education levels correlate with greater awareness of waste management and sustainability issues. Educated individuals are often more equipped to understand the implications of improper waste disposal and are more likely to adopt sustainable practices. However, this finding is contradicted the report of Wapwera et al. (2022), in which it was reported that there was a low level of educational influence on educational awareness and people's attitude towards waste management. Education in promoting sustainable behaviors, noting that well-educated communities are more proactive in adopting innovative solutions, such as food waste recycling and composting, to address environmental challenges. While the study imply that education can be a tool to drive innovations in the management of food waste, awareness, new technology and ideas, and educated individuals can foster the development of new technologies and promote community engagement. Reducing food waste and a sustainable food system can be practicable for educated people (Hubel et al., 2023).

3.3 Research Instrument

A researcher-structured questionnaire was used to elicit information from the respondents. The research instrument was used because they are suitable for gathering both qualitative and quantitative data and it can be designed for measuring separate variables such as behaviors, preferences, and facts (Kabir, 2016, as cited by Taherdoost, 2021). The questionnaire was divided into four sections A, B, C, and D. Section A contains the demographic information or data, while sections B, C and D contain items on types of food waste generated, existing methods of waste disposal and level of awareness of the effect of ineffective waste disposal. Questions are rated using a four (4) Likert-scale of Strongly Agreed (SA), Agreed (A), Disagreed (D), and Strongly Disagree (SD).

The instrument was validated by the project supervisor and two (2) other lecturers from the Department of Home Economics, Adeyemi Federal University of Education, Ondo to ensure face and content validity. Their corrections, observations, suggestions, and comments were used to make constructive corrections in the final copy of the instrument.

The test-retest method was used to determine the internal consistency and level of precision of the instrument. Twenty copies of the questionnaire were administered and re-administered to the same set of respondents outside the research area. The period between the first and the second administration was two weeks. The first and second response instances were correlated. The reliability index was estimated using Cronbach alpha and a reliability coefficient (r) of 0.8 was obtained.

3.4 Data Collection

Two hundred and ten (210) copies of the questionnaire were produced and administered personally to the respondents with the assistance of two (2) research assistants and collected immediately to avoid loss in transit. This study was conducted under ethical standards. Participants' consent was sought before data collection, and their responses were kept confidential and anonymous.

3.5 Data Analysis

The responses to the questionnaire items were collated and analyzed using deviation and mean (x). The mean of the questionnaire was interpreted based on the statistical real limits of numbers. A cut-off point (COP) was used to determine accepted or rejected items obtained by adding up all the items. The formula for attaining the cut-off point is totaling the nominal values divided by the number of nominal values. That is, COP = 2.50. Any mean of 2.50 and above was considered as agreed, while any mean below 2.50 was considered as disagreed. All statistical analysis was carried out using the Statistical Package for Social Science (SPSS) version for statistical analysis.

5. Findings and Discussion

Findings presented in table 2 reveal that the mean responses on the type of waste generated by households, markets, and restaurants ranged between 2.5 and 3.8 and were all

above the cut-off point of 2.5. This implies that the respondents agreed with all the statement items as the type of waste generated by households and other food outlets.

Table 2

Types of food waste generated by households and other food outlets in Ilesa West Local Government Area of Osun State

Waste Source	Type of Waste	Applicability Level (Mean Score)	Standard Decision Deviation	
Household Waste	Leftover food	3.5	0.8	Agreed
	Organic waste	3.2	0.7	Agreed
	Composite materials	3.0	0.9	Agreed
	Beverage waste	2.5	1.0	Agreed
Market Waste	Unsold products	3.8	0.6	Agreed
	Meat and seafood waste	3.1	0.9	Agreed
	Waste Packaging Materials	2.9	1.1	Agreed
Restaurant Waste	Food scraps	3.7	0.7	Agreed
	Plate waste from customers	3.6	0.8	Agreed
	Packaging waste	2.8	1.0	Agreed

Table 3

Frequency of the food waste generated by household and other food outlets in Ilesa West Local Government Area of Osun State

Type of Waste	Frequency (n)	Percentage (%)
Leftover Food	70	33.3
Organic Waste	60	28.6
Composite Materials	40	19.0
Beverage Waste	20	9.5
Packaging Waste	20	9.5

The findings equally revealed the frequency of food waste generated as shown in table 3, leftover food (33.3%), organic waste (28.6%), composite (19%), and beverage waste (9.5%) while package waste equally carries (9.5%), indicating that leftover is the most common while beverage and packaging waste is the least generated food waste from households and other food outlets. Post-harvest losses from food stalls in the markets, and leftovers from food outlets

constitute the largest waste in developing countries. According to McMahon (2024), causes of food waste within restaurant operations range from over-ordering and improper storage to inefficient preparation practices and plate waste. These findings emphasize the need for intervention in food waste reduction which has economic implications on the profit of such restaurants, thus recycling of the food waste can serve as a means of taking care of the waste, production of new and useful products, and another means of income generation.

Table 4

Existing food waste disposal methods

Disposal Method	Frequency (n)	Percentage (%)
Landfill	65	31.0
Recycling	50	23.8
Composting	45	21.4
Incineration	25	11.9
Other (e.g., animal feed)	25	11.9

Table 5

Frequency of waste disposal of households in Ilesa West Local Government

Frequency of Disposal	Respondents (n)	Percentage (%)
Daily	85	40.5
Weekly	95	45.2
Monthly	**30**	**14.3**

The result in table 4 revealed that landfill disposal (31%) is the most common waste disposal method, followed by recycling (23.8%), incineration (11.9%), and other method such as the utilization of food waste as animal feed (11.9%) is the least waste disposal method. Mashudi et al. (2023) also asserted that various methods are employed in the waste disposal stage namely, sanitary landfill, incineration, composting, and discharge to sewer among others while Dharmaraj et al. (2021) reported that wastes are dumped in an open field, left just in ravines, or trash cans. These methods are regarded as inappropriate and can cause harmful effects to every living thing, and non-livings alike. Thus, a better approach to managing waste should be utilized such as the implementation of an integrated waste management system that involves waste sorting and recycling (Mashudi et al., 2023).

The result indicates an opportunity to increase the practice of recycling and composting, potentially through awareness campaigns and educational programs. The frequency of waste disposal (daily, weekly, monthly) indicates waste generation and management habits among respondents as indicated in table 5. A large proportion of respondents dispose of waste daily or weekly, suggesting high waste production rates. This frequent disposal rate aligns with appropriate waste management and recycling methods to reduce the volume and impact of waste. Food outlets rely more on landfill disposal due to limited awareness and infrastructure for alternative methods. The predominance of landfill disposal is supported by Climate Policy Watcher (2024), arguing that developing countries often lack structured waste management systems, leading to dependence on landfills. Similarly, Vinti and Vaccari (2022) emphasized that limited recycling and composting practices in such regions stem from inadequate facilities and a lack of public awareness of the fact that appropriate waste management can make a valuable resource income source. The outcome of some other research stressed that promoting recycling and composting requires government-supported educational campaigns and the provision of accessible recycling facilities. Increasing public-private partnerships could mitigate the infrastructural challenges contributing to heavy reliance on landfills (Earth Care, 2024; Green.org, 2024).

Table 5
Effects of ineffective waste disposal

Impact	Mean Awareness Score	Standard Deviation
Environmental Impact	**3.5**	**0.8**
Pollution	3.4	0.8
Climatic Change	3.0	0.9
Water Contamination	3.1	0.8
Soil Degradation	2.9	1.0
Human Health Impact	**3.2**	**0.7**
Respiratory Problems	2.8	1.0
Infections	3.0	0.9
Economic Impact	**3.1**	**0.9**
Resource Loss	2.8	0.9
Increased Health Care Costs	3.0	0.8
Decreased Property Values	2.7	1.0
Economic Losses Due to Pollution	3.0	0.9

The findings shown in table 5 indicated that the respondents exhibited the highest awareness in environmental categories, suggesting that environmental impacts are more immediately understood compared to health or economic impacts. Awareness of increased healthcare costs and economic losses due to pollution was moderate, whereas resource loss,

infections, and respiratory problems among others. It can also be deduced from the research findings that the extent of enlightenment of the respondents is high. These research findings correspond with the assertion of Comighud and Lalamonan (2022) that the respondents' extent of awareness of solid waste management practices of the teachers and students is quite high so also is the implementation. The findings also align with Onuoha et al. (2022) that environmental awareness is often more prevalent among households, as individuals directly experience the effects of waste mismanagement, such as pollution and soil degradation. The findings align with the report of Ezerie et al. (2017) who reported that indiscriminate waste disposal brings about climatic change, phytochemical reactions, and degradation of non-living natural resources while Ogunniran (2022) opined that extreme weather events like global warming produced by the breakdown of greenhouse gases generated from chemical and radioactive wastes. Likewise, Nnatu (2018) asserted that indiscriminate refuse disposal can result in environmental degradation, danger to environmental beauty, and environmental pollution. This reflects the influence of increased environmental education and media campaigns targeting domestic households. Thus, increasing knowledge about economic opportunities, such as recycling and the creation of new products from waste, can significantly boost awareness in these domains and prevent the adverse effects of indiscriminate waste disposal.

The findings of this study imply that education can be a tool to drive innovations in the management of food waste. Reducing food waste and a sustainable food system can be practicable for educated people (Hubel et al., 2023). The implications of the type of food waste generated by households and other food outlets can have negative effects on the climate, health, and economy. Large quantities of food waste end up in landfills, creating methane emissions, contributing to climate change, and occupying valuable space. Additionally, the loss of uneaten food represents a missed economic opportunity, as resources used for production and transportation are wasted (Pandey, 2021). However, innovative uses of food can reduce waste generation by converting them to valuable and useful items, and conserving natural resources by utilizing food waste as raw material rather than using new materials thereby reducing greenhouse emissions, it also creates employment opportunities, income generation, and local economy stimulation. Innovations in the use of food waste promote sustainable consumption. Additionally, it brings forth decreased environmental health risks associated with proper waste

management such as air pollution, water pollution, pests, and the spread of diseases (Aït-Kaddour, 2024; Saha, 2023).

This study produced household items from food waste (eggshell and plantain peel) such as abrasive and organic soap.

Materials in the production of abrasive (cleaning agent) from food waste (egg shell) include egg shells collected from various households, eateries, restaurants, while detergent was obtained from Oja-Igele market, Ondo town. Abrasive was produced by collecting egg shells from households, eateries and other food outlets. The collected egg shells were sundried, milled after which detergent was added to it. The mixture was sealed in an airtight container. The flow chart for the production is as shown in figure 1.

Figure 1

Flow chart for the production of abrasive

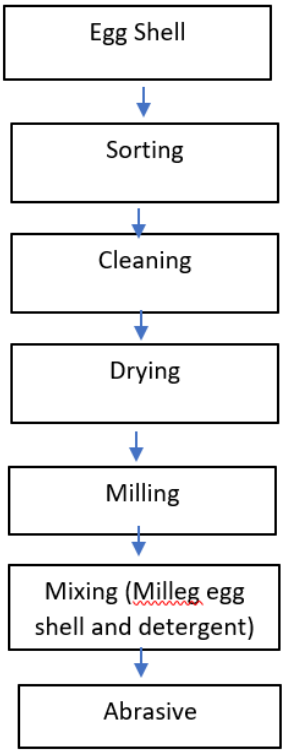
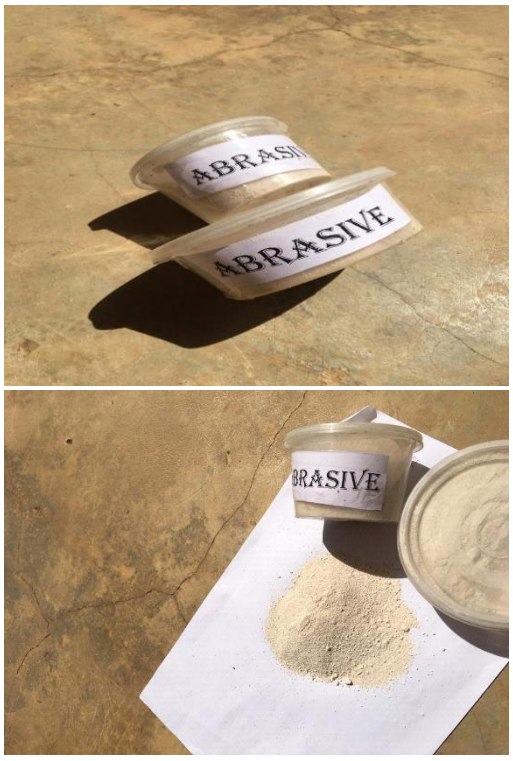


Figure 2

Cleaning agent produced from eggshell



Production of organic soap from food waste (plantain peels) was produced by collecting plantain peels from households and ingredients procured from Oja-Igele and Oja-Oba in Ondo and Ilesha respectively. The collected plantain peels were sundried, pounded and all the remaining ingredients such as honey, turmeric, garlic, cinnamon powder, vitamin E, bi

carbonate, palm-oil, ginger, charcoal, lime, lemon, Aloe Vera soap and Aloe Vera were added. It was a sealed air tight container. The flow chart for the production is shown in figure 3.

Figure 3

Flow chart for the production of organic soap

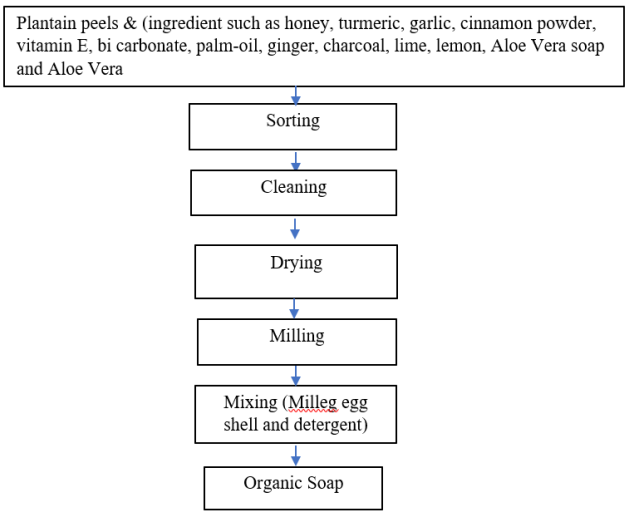


Figure 4

Organic soap from plantain peels

5. Conclusion

Food waste recycling is a critical approach to reducing the environmental, economic, and social impact of food waste. This study has established that recycling food waste into homemade products is a holistic way to manage and utilize food waste to bring about sustainable development, a healthy environment, and revenue generation. Based on the findings of the study, the following recommendations are proposed to address the challenges and opportunities in food waste recycling, utilization, management, and innovative uses in Ilesa West Local Government Area:

Evaluate present waste management strategies (food waste generation, disposal methods) in the study area, and then work-able food waste recycling steps encompassing collection, organizing/sorting, and utilization should be organized.

Organize workshops for food waste programs involving stakeholders from different works of life such as private sectors, restaurants, caregivers, government agencies, the populace, and research institutes with the notion of educating them on innovative use of food waste in product development and involving them in the recycling activities.

Develop and implement policies mandating food waste recycling and the reduction of food waste generation.

The Circular Economic (CE) model should be adopted by policy and decision-makers to curb the menace of indiscriminate waste disposal, be a means of revenue generation to the economy, and create new jobs and employment.

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Institutional Review Board Statement

This study was conducted in accordance with the ethical guidelines set by Adeyemi Federal University of Education, Ondo, Ondo State, Nigeria. The conduct of this study has been approved and given relative clearance(s) by Adeyemi Federal University of Education, Ondo, Ondo State, Nigeria.

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References

Ag.reads. (2020). *10 most commonly produced products out of food waste*. http://agreads.com/2020/05/21/10-most.commonly-produced-products-out-of-food-waste

Aït-Kaddour, A., Hassoun, A., Tarchi, I., Loudiyi, M., Boukria, O., Cahyana, Y., Ozogul, F., Khwaldia, K. (2024). Transforming plant-based waste and by-products into valuable products using various “Food Industry 4.0” enabling technologies: A literature review, *Science of The Total Environment*, 955, 176872, https://doi.org/10.1016/j.scitotenv.2024.176872

Aming-Hayudini, M. A. E., & Jaddani, M. Y. T. & Habibun, S. I. (2022). Practices on waste disposal and its environmental effects. *International Journal of Multidisciplinary: Applied Business and Education Research*. 3(8). 1569-1576. https://doi.org/10.11594/ijmaber.03.08.19

Buxoo, S., Jeetah, P. (2020). Feasibility of producing biodegradable disposable paper cup from pineapple peels, orange peels and Mauritian hemp leaves with beeswax coating. *SN Appl. Sci.*, 2, 1359. https://doi.org/10.1007/s42452-020-3164-7

Bjornsen, N. (2024). *Effective strategies to minimize food waste in restaurants*. https://nilsbjornsen.com/strategies-minimize-food-waste-restaurants/

Climate policy watcher (2024). *Garbage in developing countries*. https://www.climate-policy-watcher.org/waste-management/Garbage-Challenges-in-Developing Countries.html

Comighud, S. M. T & Lalamon, E. (2020). *Awareness and implementation of solid waste management (SWM) practices*. https://www.academis-edu/42743091/Awareness_and_implementation_of_solid_waste_mangement_SWM_practices

Dahiya, S., Kumar, N. A., Sravan, J. S., Chatterjee, S., Sarkar, O. S. & Venkata Mohan, (2018). Food waste biorefinery: Sustainable strategy for circular bioeconomy. *Bioresource Technology*, 248, (A), 2-12. https://doi.org/10.1016/j.biortech.2017.07.176

Dharmaraj, S., Ashokkumar, V., Pandiyan, R., Munawaroh, H. S. H., Chew, K. W., Chen, W. H., & Ngamcharussrivichai, C. (2021). Pyrolysis: An effective technique for degradation of COVID-19 medical wastes. *Chemosphere*, 275, 130092. https://doi.org/10.1016/j.chemosphere.2021.130092

Earth Care (2024). *Government strategies for promoting composting and reducing land filling*. https://www.ecepl.com/government-strategies-for-promoting-composting-and-reducing-land-filling

Environmental Protection Agency (2020). *Sustainable materials management*. https://www.epa.gov/smw

Esteves, A., Ribeiro, C., Soares, K., & Castro, M. (2024). Plate Waste and Leftovers: An Emerging Concern in Restaurant Industry. https://wastelesseu.com/plate-waste-and-leftovers-an-emerging-concern-in-restaurant-industry/

Ezerie, H., E, Nwabuko, C. G., Ogbonna, C. E., nyinnaya, O. C., Babington, C. J. (2017). Municipal solid waste management in Aba, Nigeria: Challenges and prospects. *Environ. Eng. Res*. 22(3), 231-236. https://doi.org/10.4491/eer.2017.100

Flynn, R., Mrklas, K., Campbell, A., Wasylak, T., & Scott, S. D. (2021). Contextual factors and mechanisms that influence sustainability: a realist evaluation of two scaled, multi-component interventions. *BMC health services research*, 21(1), 1194. https://doi.org/10.1186/s12913-021-07214-5

Food unfolded (2020). *Recycling food waste*: *6 unusual food waste inventions*. https://www.foodunfolded.com/article/recycling-food-waste-6-unusual-food-waste-inventions

Gebrekidan, T, K., Weldemariam, N. G., Hidru, H. D., Gebremedhin, G. G., Weldemariam, A. Kk (2024). Impact of improper municipal solid waste management on fostering One Health approach in Ethiopia — challenges and opportunities: a systematic review. *Science in One Health*, 3, 100081. https://doi.org/10.1016/j.soh.2024.100081

Geneva Environment network (2024). *Environment: what's up in Geneva*. https://www.genevaenvironmentnetwork/org/resources/newsletter/environment/what's-up-in-geneva

Green.org (2024). *The role of education in fostering a recycling-conscious society*. https://green.org/2024/01/30/the-Role-of-Education-in-Fostering-a-Recycling-Conscious-Society

Guo, H., Tong, L., Guo, Y. &Shin, T. (2021). Research on transforming food waste into valuable products. *IOP conference service earth and environmental science*, 766(1), 012061. https://doi.org/10:1088/1755-1315/766/1/012061

Haruna, U. A., Luther, M. L., Zubairu, M., Abonyi, E. E., Dibal, S. M., Gegele, T. A., Gambo, J., Garba, S. A., Musa, S. S., Manirambona, E., & Lucero-Prisno, D. E. (2022). Food loss and waste in Nigeria: Implications for food security and environmental sustainability. *Advances in Food Security and Sustainability*, 8, 217-233. https://doi.org/10.1016/bs.af2s.2023.07.003

Hubel, S. R., Tasente, T., & Stan, M. R. (2023). Education of levels as a catalyst for socio-economic development: Observations from human resources viewpoints in sustainable community growth. *Technium Sustainability*, 4(1): 94-105. https://doi.org/10.47577/sustainability.v4i.10233

Kabir, S. M. S. (2016). *Methods of data collection basic guidelines for research: An introductory approach for all disciplines* (first ed., pp. 201-275). Book Zone Publication.

Kothari, C. R. (2014). *Research methodology: Methods and techniques* (3rd ed.). New Delhi: New Age International (P) Limited.

Kubraik, M. (2024). *10 most creative ways people are battling food waste around the globe*. https://www.gotenzo.com/resources/insight/10-most-creative-ways

Kumar, S., Kumar, R., & Pandey, A. (2020). Solid waste and wastewater management: A social and global perspective. *Current Developments in Biotechnology and Bioengineering*, 1-22. https://doi.org/10.1016/B978-0-12-821009-3.00004-X

Kumari, R., Singh, A., Sharma, R. & Malaviya, P. (2024). Conversion of food waste into energy and value-added products: a review. *Environ Chem Lett*, 22, 1759–1790. https://doi.org/10.1007/s10311-024-01742-2

Linton, L. S., Edwards, C. C., Woodruff, S. I., Millstein, R. A., & Moder, C. (2014). Youth advocacy as a tool for environmental and policy changes that support physical activity and nutrition: an evaluation study in San Diego County. *Preventing chronic disease*, 11, E46. https://doi.org/10.5888/pcd11.130321

Mashudi, & Sulistiowati, R., Handoyo, S., Mulyandari, E, Hamzah, N. (2023). Innovative strategies and technologies in waste management in the modern era integration of sustainable principles, resource efficiency, and environmental impact. *International Journal of Science and Society*. 5. 87-100. https://doi.org/10.54783/ijsoc.v5i4.767

Manzoor, S., Fayaz, U., Hussain A. D., Dash, K. K., Shams, R., Bashir, I., Pandey, V. K., & Abdi, G. (2024). Sustainable development goals through reducing food loss and food waste: A comprehensive review. *Future Foods*, 9, 100362 https://doi.org/10.1016/j.fufo.2024.100362

Maurya, R., Patel, H., Dhruti, B., Shakhreliya, S., Gohil, N., Bhatta, G., Lam, C. L., Alzahrani, K. J., Gyanchander, E., & Singh, V. (2022). Microbial production of natural flavors and fragrances. In: *Recent Advances in Food Biotechnology* (pp. 139-159).

McMahon, D. (2024). *Essential facts about food waste and how restaurants can combat it*. https://altermetrics.com/topics/essential-facts-about-food-waste-and-how-restaurant-can-combat-it

Moraga, G., Huysveld, S., De Meester, S., & Dewulf, J. (2022). Resource efficiency indicators to assess circular economy strategies: A case study on four materials in laptops. *Resources, Conservation and Recycling*, 178, 106099. https://doi.org/10.1016/j.resconrec.2021.106099

Morganti, P., Gao, X., Vukovic, N., Gagliardini. A., Lohani, A., & Morganti, G. (2022). Food loss and food waste for green cosmetics and medical devices for a cleaner planet. *Journal of cosmetics*, 9(1), 19. https://doi.org/10.3390/cosmetics901001019

Muluneh, B., Schneider, M., Faso, A., Amerine, L., Daniels, R., Crisp, B., Valgus, J., & Savage, S. (2018). Improved adherence rates and clinical outcomes of an integrated, closed-loop, pharmacist-led oral chemotherapy management program. *Journal of Oncology Practice*, 14(6), e324–e334. https://doi.org/10.1200/JOP.17.00039

Nnatu, S.O. (2018). Health implication of ineffective solid waste disposal for urban residents: A study of Awka town, Anambra state. *International journal of health and social inquiry*, 4(1), 23-44.

Nyampundu, K., Mwegoha, W. J. S. & Millanzi, W. C. (2020). Sustainable solid waste management Measures in Tanzania: an exploratory descriptive case study among vendors at Majengo market in Dodoma City. *BMC Public Health*, 20, 1075. https://doi.org/10.1186/s12889-020-08670-0

Obi, (2024). *World Food Day: Tackling 40% food wastage in Nigeria as a solution to food insecurity*. Business day. https://businessday.ng

Obi-Anija, F. N. (2016). *Fundamental of environmental education and management.* Calabar: University of Calabar press

Ogedengbe, T., Olorunfe, M. & Akanji, N.E. (2023). Post-harvest losses and reduction techniques in crop production: A review. *The Journal of Agricultural Education & extension*. 12(4), 223-225.

Ogunniran, B. I. (2022). Harmful effects and management of indiscriminate solid waste disposal on humans and its environment in Nigeria: A Review. *International Journal of Humanities and Social Science*, 6(4), 1427-1431.

Onuoha, C.A., Chinedu, N., Ochekwu, E. & Onuoha, P. (2022). Environmental challenges awareness in Nigeria: A review. *African Journal of Environment and Natural Science Resources*, 5(2), 1-14.

Pandey, A. (2021). Food waste: Causes, impact and solutions. *Science Heritage Journal*, 5(1), 17-20. https://doi.org/10:26480/gws.01.2021.17.20

Paritosh, K., Yadav, M., Chawade, A., Kushiwaha, S., Pareek, N. & Vivekanand, V. (2017). Food waste to energy: An overview of sustainable approaches for food. *Waste management and nutrient recycling*, 2, 1-19. https://doi.org/10:1155/2017/2370972

Ramadani, S.D. & Kusumaningrum, S. B. C. (2024). Transforming waste cooking oil into aromatherapy candles to enhance environmental conservation and support entrepreneurship programs in Sirahan village. *GUYUB Journal of Community Engagement*, 5(4), 945-957. https://doi.org/10.33650/guyub.v5i4.9481

Rashid, M. I. & Shahzad, K. (2021). Food waste recycling for compost production and its economic and environmental assessment as circular economy indicators of solid waste management. *Journal of Cleaner Production*, 317, 128467. https://doi.org/10.1016/j.jclepro.2021.128467

Saha, A. (2023). Circular economy strategies for sustainable waste management in the food industry. *Journal of recycling economy and sustainable policy*, 2(2), 1-15.

Sallis, J.F., & Glanz, K. (2009). Physical activity and food environments: solutions to the obesity epidemic. *Milbank Q*, 87(1), 123–54. https://doi.org/10.1111/j.1468-0009.2009.00550.x

Sewak, A., Deshpande, S., Rundle-Thiele, S., Zhao, F., & Anibaldi, R, (2021). Community perspectives and engagement in sustainable solid waste management (SWM) in Fiji: A socioecological thematic analysis. *Journal of Environmental Management*, 298. https://doi.org/10.1016/j.jenvman.2021.113455

Shinde, M., Sonawane, S. K. & Patil, S. (2019). Fruit peel utilization in food packaging. Indian *Food Industry Mag*, 1(5), 19-24.

Sunday, C.O., Sowunmi, F.A., Obayelu, O.A., Awoyemi, A.E., Omotayo, A.O., & Ogunniyi, A.I. (2022). Disentangling drivers of food waste in households: Evidence from Nigeria. *Foods*, 11, 1103. https://doi.org/10.3390/foods11081103

Taherdoost, H. (2021). Data collection methods are tools for research: a step-by-step guide to chosen data collection techniques for academic and business research projects. *International journal of academic research in management (IJARM)*, 10(1), 10-38.

United Nations Environmental Programme (2024). *Food waste report*. https://www.unep.org/

Vinti, G. & Vaccari, M. (2022). Solid waste management in rural communities of developing countries: An overview of challenges and opportunities. *Clean Technology*, 4(4), 1138-1151. https://doi.org/3390/clean technology4040069

Wapwera, S. D. & Akintunde, E. A., &Samson, C. (2022). Impact of environmental education and awareness on effective management of solid waste among residents of Jos-Bukuru Plateau State, Nigeria. *Global Journal of Earth and Environmental Science*, 7(3), 59-72. https://doi.org/1031248/GJEES2022.122

Xiao, N., Kong, L., Wei, M. Hu, X. & Li, O. (2024). Innovations in food waste management: from resource recovery to sustainable solutions. *Waste Disposal & Sustainable Energy*, 6, 401–417. https://doi.org/10.1007/s42768-024-00201-6

Xue, L., Liu, G., Parfitt, J., Liu, X., Van Herpen, E., Stenmarck, Å., & Cheng, S. (2017). Missing food, missing data? A critical review of global food losses and food waste data. *Environmental science & technology*, 51(12), 6618-6633. https://doi.org/10.1021/acs.est.7b00401

United Nations, (2019). United Nations. (2019). *World Population Prospects: The 2019 Revision*. New York: United Nations.

Yadav, R. (2020). *Classification of waste and their characteristics*. https://www.slideshow.net

Yoada, R.M., Chirawurah, D. & Adongo, P.B. (2014). Domestic waste disposal practice and options of private sector waste management in urban Accra. *BMC Public Health*, 14, 697. https://doi.org/10.1186/1471-2458-14-697