

Adoption of Circular Economy Practices for Food Waste Management in Lagos State, Nigeria.

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Research Article

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Abstract

Food waste is a significant part of urban solid waste and represents a lost source of food, nutrients, energy, and income. This study sought to examine the adoption of circular economy practices for food waste management in Lagos State, Nigeria. In this study, an explanatory sequential mixed-methods design was used, which comprised a quantitative survey of 196 stakeholders and qualitative interviews with 15 key informants drawn from food production, markets, hospitality, manufacturing, collection, recovery, regulation and civil society. Frequencies, percentages, means, standard deviations, Cronbach's alpha, Spearman's rank correlations and non-parametric tests were used to analyse quantitative data. Interview data were analysed thematically and integrated with survey data by creating a joint display. Based on the study results, awareness of the circular economy was moderate: 57.7% of respondents had heard of the concept, and 24.5% indicated good or very good knowledge. 40.3% reported using circular recovery methods, while record-keeping of food waste was rare (7.1%). Willingness to adopt was high, with 87.8% moderately, very or extremely willing to adopt circular practices. The study identified limited access to finance and credit (mean = 4.23), high equipment and facility costs (mean = 4.12), inadequate collection and processing facilities (mean = 4.08), and a lack of financial incentives and government support (mean = 4.00) as the main barriers. The most frequently selected business opportunities were the production of compost and organic fertiliser (22.4%), followed by animal feed (17.9%), biogas (13.8%) and the redistribution of edible surplus (13.3%). Nine qualitative themes accounted for the ways in which finance, contamination, poor logistics, inadequate measurement, market uncertainty, and institutional fragmentation limit the progression of willingness to continue adoption. The integrated findings support phased source separation, green finance, decentralised treatment, quality standards, better data systems, and inclusive participation of formal and informal actors.

1. Introduction

Food loss and food waste undermine the efficiency of the food system as they use land, water, energy, labour and capital without providing the intended nutrition or economic benefits. Food loss generally refers to the loss of food quantity or quality before retail, while food waste is commonly associated with retail, food service, and household consumption (Food and Agriculture Organization of the United Nations [FAO], 2019). While the difference is analytically valuable, the two processes are intertwined in urban food systems. When food products get spoilt during transportation, they enter the market being sold with a limited shelf life; inadequate refrigeration can speed up spoilage, and excess production in restaurants and institutions can produce unnecessary cooked-food waste. A circular approach should thus not only consider waste as a municipal collection problem, but also the entire chain from production to consumption and back to recovery.

The challenge is increasing significantly. In 2022, the United Nations Environment Programme estimated that 1.05 billion tonnes of food were lost at the household, food service and retail levels, which is approximately one-fifth of the food available to consumers (UNEP, 2024). Food waste also contributes to greenhouse-gas emissions, puts strain on collection and disposal systems, and exists alongside hunger

and lack of access to healthy diets (FAO, 2019; UNEP, 2024). These challenges are especially evident in fast-growing cities, where food systems are extensive, informal food markets play a key role, and municipal services may not keep pace with population and commercial activities.

Studying this transition matters given the setting and peculiarities of Lagos State. It is a mix of high population density, major wholesale and retail markets, food-processing hubs, restaurants, hotels, schools and hospitals, and a large network of formal and informal waste actors. In 2025, the Lagos State Government reported daily waste production in the state at about 13,000 to 14,000 tonnes per day (Lagos State Government, 2025). A large portion of this waste stream is organic, although the quantities and destinations of food waste are hard to determine because of limited source separation, regular weighing, and traceability. Food residues are often collected with plastics, paper, and other trash, making them less likely to be composted, used for animal feed, anaerobically digested, or processed for higher value.

The prevailing linear sequence can be summarised as generation, collection, transport and disposal. Circular economy thinking provides an alternative logic. Its priority is to avoid spoilage, retain edible food for human consumption, use suitable residues as animal feed, and recover nutrients, materials, or energy from unavoidable waste. The approach does not presume that all recovery activities are good. One must consider food safety, contamination, transportation distance, energy consumption, product quality and end-market demand. In general, prevention and redistribution are more valuable than treatment and composting and anaerobic digestion offer valuable options for residues that cannot safely remain in the food chain (Papargyropoulou et al., 2014; Tamasiga et al., 2022).

Nigeria already shows the footprints of circular food-waste initiatives through market-based recovery, composting, small-scale bioenergy, informal reuse, food redistribution, and technology-enabled collection. However, transitioning from isolated practices to a reliable system remains challenging. Common challenges identified in studies of Nigerian enterprises and urban markets include finance, infrastructure, technical skills, market demand, and regulation and coordination (Ezeudu et al., 2021; Rezk et al., 2024; Adesua-Lincoln, 2025). These constraints are interdependent. Without clean feedstock, a treatment plant cannot function reliably; without reliable collection, generators may not separate the waste; without contracts, collectors may not invest in dedicated vehicles; without standards and market development, recovered products may not be sold.

Previous studies in Nigeria have provided valuable data on municipal waste, enterprise sustainability and barriers to the circular economy. However, few studies have combined different viewpoints from generators, collectors, recovery enterprises, regulators, informal workers and civil-society groups in a single food-waste study. In addition, some scholarly works focus on awareness, barriers, or technologies, which makes it challenging to understand how willingness, capacity, infrastructure and governance interact. This scenario makes a mixed-methods approach suitable, because numerical patterns can show the relative strength of practices and barriers, and qualitative interviews can explain

in detail why the same barrier may operate differently across markets, hotels, factories, collection firms, and public institutions.

Therefore, this study used an explanatory sequential mixed-methods design to examine the adoption of the circular economy in Lagos food-waste management. While the quantitative strand established patterns in current practices, policy preferences, awareness, barriers, willingness, and business opportunities, the qualitative strand provided detailed explanations of the operational and institutional conditions behind the observed patterns.

Hence, the current study adopted an explanatory sequential mixed-methods design to explore the adoption of the circular economy in food-waste management in the city of Lagos. The quantitative phase identified patterns in current practices, awareness, barriers, willingness, business opportunities and policy preferences, and the qualitative phase provided detailed explanations of the operational and institutional conditions underlying those patterns. In this study, the authors followed ethical procedures and obtained ethical approval from relevant institutions, including the University of Bolton, and participants provided informed consent before taking part.

Moreover, five objectives were addressed in this study: characterising current food-waste management practices and system actors; assessing awareness and understanding of circular economy principles; identifying economic, technological, institutional and social barriers; evaluating perceived business and recovery opportunities; and developing policy and implementation priorities to accelerate circular food-waste management. The core thesis is that good intentions and known opportunities do not necessarily result in adoption. Sustainable transition requires aligning finance, source separation, collection, treatment capacity, product markets, regulation, information, and stakeholder inclusion.

2. Literature Review

2.1 Circular economy and the food-waste hierarchy

The circular economy is frequently seen as an alternative to the traditional linear economy: extract, produce, consume and dispose. It aims to minimise waste and retain value and natural systems by design, maintenance, reuse, redistribution, repair, remanufacturing, recycling and biological recovery. This concept has evolved in industrial ecology, resource efficiency, cleaner production, and sustainability research, and it is applied at the product, organisational, city, and national levels (Geissdoerfer et al., 2017; Kirchherr et al., 2017). Because it is widely used, it risks conceptual dilution. Recycling alone is not sufficient evidence of circularity, particularly when little value is retained or new environmental and social impacts are generated.

Food systems require attention because food is perishable, biologically active, and subject to strict safety requirements (Paritosh et al., 2017; FAO, 2024). The food-waste hierarchy provides a practical ordering of interventions. It is better to prevent because it avoids embedded costs and the environmental burden of producing food that is not consumed. Redistributing safe, edible surplus and using it as animal

feed are the next priorities. This is followed by material extraction, composting and anaerobic digestion for unavoidable residues, with disposal being the least preferred option (Papargyropoulou et al., 2014; European Commission, 2020). The hierarchy also helps distinguish edible but commercially surplus food from material that is spoiled or contaminated. This distinction matters in markets in Lagos, hospitality, and institutional kitchens, where timing, refrigeration, transport, and liability determine safe redistribution.

Value can be created in several ways through circular food-waste management. Prevention saves money on purchasing, storing and disposing of food. Redistribution can contribute to food security if safety and dignity are ensured. Animal-feed conversion may substitute for traditional feed ingredients, but contamination and control regulations are important. Composting returns organic matter and nutrients to soils, and anaerobic digestion generates biogas and digestate. Relatively clean industrial by-products can be used for higher-value processing to recover pectin, oil, fibres, flavours, and other compounds (Tamasiga et al., 2022; Rabbi & Amin, 2024). The selection of the appropriate pathway will depend on the composition, volume, concentration, predictability, position and market demand of the feedstock.

Source: Author's conceptualisation, adapted from Papargyropoulou et al. (2014) and European Commission (2020).

2.2 Governance, awareness and behavioural conditions

Circular food-waste management crosses several regulatory domains. Waste agencies regulate collection and disposal, environmental regulators handle pollution and nuisance, food safety bodies handle consumer protection, agricultural authorities handle animal feed and fertiliser, energy authorities may play a role in biogas, and local municipalities handle markets and street hygiene. Fragmentation creates overlapping permits, unclear responsibilities, and enforcement that is not consistent. Akomea-Frimpong et al. (2024) highlight governance, finance, technology, awareness, and market conditions as recurring barriers in the broad solid-waste literature, with particularly fragile implementation in the Global South.

While awareness matters, knowledge of the term circular economy must be translated into circular practices to ensure effectiveness. Traders may already be finding useful ways to prevent food waste. For example, by selling very ripe produce cheaply, donating extra food, or giving food leftovers to farmers to feed their animals, even though they may not use the term “circular economy” to describe what they are doing. In contrast, a respondent may understand the idea of recycling but lack the space, the finance, the collection infrastructure or a ready buyer. Adesua-Lincoln's (2025) survey among Nigerian SMEs shows that ambition for sustainable practices is limited by resource, institutional, and practical business pressures. Therefore, effective education is needed to connect familiar practices to measurable operational changes, rather than relying on abstract environmental messages.

Furthermore, convenience, trust, social norms, and service reliability shape behaviour. Sorting and segregation imply appropriately designed bins, clear communication, and the expectation that waste

sent 'separate' will stay that way, rather than ending up as mixed waste for landfill and a waste contractor to whom material is shipped in trust. Customers in the hospitality industry may link abundance to service quality, while consumers may refuse safe food because of its appearance. Weighing and sorting can be seen as additional work by staff unless the procedures are built into routine operations. While incentives can help to get people to participate, they should not be designed to produce systems that fall apart once payments cease. Changes in stable behaviour are more likely when rules, infrastructure, leadership, feedback and visible outcomes are aligned.

2.3 Nigerian evidence and study framework

Research on the circular economy in Nigeria is increasing but unevenly distributed across sectors and regions. Ezeudu et al. (2021) identified finance, infrastructure, policy, market, and stakeholder barriers to urban solid-waste valorisation. According to Rezk et al. (2024), Nigeria's transition offers opportunities for innovation, employment, and resource efficiency, but it also faces institutional and investment constraints. Adesua-Lincoln (2025) found that Nigeria's challenges lie in integrating environmental sustainability and circular practices into the day-to-day business of Nigerian enterprises. These studies support a systems interpretation in which adoption depends on the performance of generators, collectors, processors, regulators, financiers, and product markets.

There are five domains of the analytical framework used in this study. The first is current practice, such as waste type, causes of waste, separation, waste management methods, and record keeping. The second is cognitive readiness, which includes awareness, understanding, and the ability to identify circular options. The third is capacity enabling, which includes finance, equipment, infrastructure, skills, government support, and coordination. The fourth is market opportunity, which includes prevention, redistribution, animal feed, compost, biogas, special collection, digital matching and product development. The fifth is intention to adopt and policy preferences. The framework assumes that awareness can help increase willingness, while adoption is dependent on operational capacity and a value chain that is functioning.

This literature raises three expectations. First, finance and infrastructure should become key constraints, since they affect all stages from separation to product sale. Second, a gap may exist between awareness and willingness and actual adoption, since stakeholders may be aware of circular ideas and willing but lack the resources to implement them. Third, no single recovery model will be suitable for all food waste. The most suitable should reflect the food-waste hierarchy and the quality, concentration and location of each food-waste stream.

3. Methodology

3.1 Research design and study setting

The study used an explanatory sequential mixed-methods design, which is represented as QUAN → qual. The quantitative strand determined the distribution of practices, awareness, barriers, willingness and

policy preferences, followed by the qualitative strand to explain the observed patterns and determine the contextual and organisational conditions influencing adoption (Creswell & Plano Clark, 2018). Given the mixed-method approach, integration occurred during interpretation by comparing convergence, complementarity, expansion, and dissonance. Because circular food-waste adoption includes both measurable patterns and context-specific organisational realities, this design approach was appropriate.

The quantitative part of the study involved 196 respondents who were stakeholders in the 20 local government areas of Lagos State and who completed the questionnaires. The qualitative aspect consisted of 15 key informant interviews with actors across key elements of the food-waste system. The two components were linked by the study objectives and merged during analysis and interpretation to provide breadth and contextual depth.

Lagos State was not chosen at random; it was selected because of its high population density, commercial value, extensive food-distribution networks, and large daily waste stream, especially given the current report of 13,000 tonnes of waste generated daily in the state (Lagos State Government, 2025). The study targeted stakeholders who had first-hand experience in food production, selling, preparing, collecting, treating, regulating, researching, or community waste management.

3.2 Quantitative component

The quantitative instrument was divided into six parts. The first recorded sex, age, education, stakeholder category, sector experience and local government area. The second section explored the primary type of food waste, primary cause, frequency of separation, management method and record-keeping. The third examined whether respondents had heard of the circular economy, their self-assessed understanding, and their choice of definition. The fourth section included 10 barrier items rated on a scale of 1 (not a barrier) to 5 (a severe barrier). The fifth section evaluated the highest-potential circular opportunity and willingness to adopt circular practices. The final section allowed respondents to identify up to three policy priorities.

Purposive quota sampling was employed to select the respondents who have first-hand experience of the Lagos food-waste system, ensuring that there was representation across the 10 stakeholder categories, including market traders/wholesalers or retailers, restaurant, hotel or catering operators, waste collectors or waste-management companies, food processors or manufacturers, recyclers, composters or bioenergy operators, government or regulatory officials, farmers or food producers, researchers, civil-society or environmental organisations, consumers or community representatives, and other relevant actors. The sampling approach was suitable for gaining informed stakeholder views, although it does not support statistical generalisation for every Lagos resident or business.

Questionnaire items were developed from relevant literature on the circular economy and food waste and aligned with the five study objectives. The instrument was examined for relevance, clarity, and coverage before administration. The 10 barrier items were checked for internal consistency and yielded a Cronbach's alpha of 0.83, which is considered acceptable for this study sample.

3.3 Qualitative component

Key informants were purposively selected, with 15 representing government waste management, environmental regulation, local government sanitation, market leadership, food distribution, food processing, hospitality, institutional catering, formal collection, informal recovery, composting, biogas, food redistribution, circular technology entrepreneurship, and research or advocacy. A sample of 15 key informants was considered sufficient because the study used purposive rather than probability sampling and wanted to gain deeper insight rather than statistical representation. In addition, the semi-structured interview guide included 10 open-ended questions on current practices, understanding of the circular economy, adoption, economic conditions, technology and infrastructure, behaviour, regulation, business models, and policy actions. Interviews were conducted in English, lasted about 45 to 90 minutes, and were audio-recorded with participants' consent. The recordings were transcribed and verified against the interview notes before analysis.

Thematic analysis was employed to analyse the interview transcripts, following the six phases of familiarisation, initial coding, candidate-theme development, theme review, definition and reporting (Braun & Clarke, 2021). The researcher team started by grouping similar answers together. As the iterative process continued, the team adjusted groups/themes whenever they noticed new patterns or different opinions. Coding frequencies refer to the number of key informants who mentioned a theme, and they should not be interpreted as population prevalence estimates. Key-informant codes were used to anonymise participant identities and organisational details.

3.4 Data analysis and integration

In the quantitative strand, frequencies and percentages were used to analyse categorical variables and means and standard deviations for barrier ratings. A circular recovery category was created from animal feed, composting, donation or redistribution, reduced-price sale, processing into another product, and biogas or energy conversion. The internal consistency of the 10 barrier items was measured by Cronbach's alpha. Willingness to adopt was measured on a scale of 1 (not willing) to 5 (extremely willing). Exploratory Spearman correlations were conducted between willingness and the following variables: awareness, understanding, separation frequency, education and experience, which were coded ordinally.

Because stakeholders were unequally distributed and the outcome variables were ordinal, the research team deemed it inappropriate to assume normally distributed group means and instead used Kruskal–Wallis tests. A p-value of < 0.05 was statistically significant. The analysis was descriptive and exploratory; no causal conclusions were made. No data was missing for the principal analytical variables used in the reported analyses.

The mixed-methods integration followed the joint display approach outlined by Fetters et al. (2013). The quantitative results were compared with the qualitative themes to determine whether they converged, complemented each other, expanded the explanation or appeared inconsistent. The integrated

interpretation emphasised the relationship between awareness and willingness, the interaction between financial barriers and infrastructure and market conditions, and how policy preferences correspond to the key-informant interviews.

3.5 Ethical considerations

The Research Ethics Committee of the University of Bolton, United Kingdom, approved the study under certification number AUTOYEHP00347 on 07/02/2025. Information on the study was given to all the respondents and key informants, and informed consent was obtained prior to participation. Participation was voluntary, and participants were told that they could refuse to answer any question or drop out without penalty. To ensure confidentiality, identifying information was omitted from the dataset, and the qualitative interviews were coded anonymously.

4. Results

4.1 Respondent profile

A total of 196 target audience members responded to the survey. Of the respondents, 56.1% were male, and 43.9% were female. Respondents aged 35–44 years were the largest group (33.7%), followed by those aged 25–34 years (30.6%). One-third of the respondents (33.7%) had a bachelor's degree or Higher National Diploma, and 15.3% had postgraduate qualifications. Experience in the sector was widely spread, with 38.8% having 1 to 5 years, 29.6% having 6 to 10 years, and 25.5% having over 10 years. The largest stakeholder group was market traders, wholesalers, and retailers (23.5%), followed by restaurant, hotel, and catering operators (19.4%). The respondents were selected from all 20 local government areas in Lagos State.

Table 1
Selected characteristics of survey respondents (n = 196)

Characteristic	Category	n	%
Sex	Male	110	56.1
	Female	86	43.9
Age	18–24 years	15	7.7
	25–34 years	60	30.6
	35–44 years	66	33.7
	45–54 years	41	20.9
	55 years and above	14	7.1
Education	No formal education	2	1.0
	Primary education	9	4.6
	Secondary education	43	21.9
	Diploma/NCE	39	19.9
	Bachelor's degree/HND	66	33.7
	Postgraduate degree	30	15.3
	Other	7	3.6
Experience	Less than 1 year	12	6.1
	1–5 years	76	38.8
	6–10 years	58	29.6
	More than 10 years	50	25.5

Table 2
Respondents' categories (n = 196)

Stakeholder category	n	%
Market trader, wholesaler or retailer	46	23.5
Restaurant, hotel or catering operator	38	19.4
Waste collector or waste-management company	25	12.8
Food processor or manufacturer	22	11.2
Recycler, composter or bioenergy operator	16	8.2
Government or regulatory official	14	7.1
Farmer or food producer	14	7.1
Researcher, civil-society or environmental organisation	12	6.1
Consumer or community representative	7	3.6
Other	2	1.0

4.2 Food-waste types, causes and current management

Fruits and vegetables were the most frequently identified food-waste type (25.5%), followed by tubers, peels, bones and other residues (17.3%), cooked food and plate leftovers (16.3%), and meat, fish and poultry waste (15.3%). The most frequently selected case was damage during transportation or handling (19.4%). Electricity failure (18.4%), poor storage or refrigeration (17.9%) and expiry or spoilage (16.3%) followed closely. These results clearly identify waste problems across logistics, energy, storage, and demand rather than at consumption alone.

Source separation was inconsistent. One-third of respondents indicated they sometimes separated food waste, while 31.6% reported separating it often or always. A further 35.2% reported never or rarely separating. The most common single management method was disposal with general waste (27.6%), followed by collection by a formal waste operator (26.0%). Circular recovery methods collectively accounted for 40.3% of respondents: animal feed (14.8%), composting (11.2%), donation or redistribution (6.1%), reduced-price sale (3.1%), processing into another product (3.1%), and biogas or energy conversion (2.0%). Open dumping or burning accounted for 6.1%.

Record keeping was a major weakness. About 7.1% maintained food-waste records regularly, 26.5% did so occasionally, and 64.3% kept no records. The absence of routine quantity and destination records limits operational control, investment planning, evaluation and public accountability.

Table 3
Current food-waste practices (n = 196)

Variable	Response	n	%
Main food-waste type	Fruits and vegetables	50	25.5
	Tubers, peels, bones and other residues	34	17.3
	Cooked food and plate leftovers	32	16.3
	Meat, fish and poultry waste	30	15.3
	Grains, bread and bakery products	20	10.2
	Food processing by-products	12	6.1
	Expired or spoiled packaged food	12	6.1
	Other	6	3.1
Main cause	Damage during transportation or handling	38	19.4
	Electricity failure	36	18.4
	Poor storage or refrigeration	35	17.9
	Expiry or spoilage	32	16.3
	Overproduction	20	10.2
	Poor demand forecasting	16	8.2
	Other	10	5.1
	Customer plate leftovers	9	4.6
Management method	Disposal with general waste	54	27.6
	Formal waste operator	51	26.0
	Animal feed	29	14.8
	Composting	22	11.2
	Donation or redistribution	12	6.1
	Open dumping or burning	12	6.1
	Reduced-price sale	6	3.1
	Processing into another product	6	3.1
	Biogas or energy conversion	4	2.0
	Record keeping	14	7.1
<i>Note. Circular recovery methods were reported by 79 respondents (40.3%).</i>			

Variable	Response	n	%
	Occasionally	52	26.5
	No records	126	64.3
	Not applicable	4	2.0
<i>Note. Circular recovery methods were reported by 79 respondents (40.3%).</i>			

4.3 Awareness, understanding and willingness

Table 4 results showed that awareness of the circular economy was moderate. Most respondents (57.7%) had heard of the concept, 33.7% had not, while 8.7% were unsure. The results also showed lower self-rated understanding: 24.5% reported good or very good understanding, 25.5% had moderate understanding, and half of the population (50%) had limited or no understanding. When respondents selected a description, 57.7% chose the statement that circular food-waste management involves preventing waste and recovering value through reuse, recycling, composting or energy production.

It was also found that adoption willingness was very much higher than current capacity. In general, 87.8% of respondents were moderately, very or extremely willing to adopt circular practices, including 51.5% who were very or extremely willing. The mean willingness score was 3.60 out of 5. Spearman analysis showed that willingness was positively associated with having heard of the circular economy (Spearman's $\rho = 0.382$, $p < 0.001$), self-rated understanding (Spearman's $\rho = 0.558$, $p < 0.001$) and separation frequency (Spearman's $\rho = 0.248$, $p < 0.001$). Education (Spearman's $\rho = 0.011$, $p = 0.875$) and sector experience (Spearman's $\rho = -0.065$, $p = 0.368$) were not significantly associated with willingness.

Using exploratory Kruskal–Wallis tests, it was found that there was no statistically significant difference in overall willingness across the 10 stakeholder categories, $H(9) = 13.11$, $p = 0.158$. The pattern observed suggests that favourable attitudes were not confined to one sector, although the unequal and purposive group structure limits inferential interpretation.

Table 4
Awareness, understanding and adoption willingness (n = 196)

Variable	Response	n	%
Heard of circular economy	Yes	113	57.7
	No	66	33.7
	Not sure	17	8.7
Understanding	No understanding	39	19.9
	Limited understanding	59	30.1
	Moderate understanding	50	25.5
	Good understanding	34	17.3
	Very good understanding	14	7.1
Willingness	Not willing	7	3.6
	Slightly willing	17	8.7
	Moderately willing	71	36.2
	Very willing	54	27.6
	Extremely willing	47	24.0

4.4 Perceived barriers

Cronbach's alpha was 0.83 for the 10 barrier items, indicating acceptable internal consistency. Mean scores were above the 3-point level on the 5-point scale, meaning respondents felt each item was a meaningful barrier. Lack of finance and credit was the top constraint with a mean score of 4.23, followed by high equipment and facility costs (4.12) and poor collection and processing facilities (4.08). The lack of financial incentives and government support was ranked fourth at 4.00.

The lack of enforcement of waste-management rules was a problem but was not the top issue. It was followed by a lack of government coordination and high demand for recovered products. The ranking prioritized economic and operational capacity, low public awareness, resistance to changing habits, lack of technical knowledge, and weak awareness and market demand. An exploratory Kruskal–Wallis test revealed that the composite barrier score was not significantly different between stakeholder groups, $H(9) = 14.10$, $p = 0.119$.

Table 5
Ranking of perceived barriers to circular food-waste adoption

Rank	Barrier	Mean	SD
1	Limited access to finance and credit	4.23	0.70
2	High cost of equipment and facilities	4.12	0.76
3	Inadequate collection and processing infrastructure	4.08	0.77
4	Absence of financial incentives and government support	4.00	0.76
5	Weak enforcement of waste-management regulations	3.86	0.82
6	Poor coordination among government agencies	3.80	0.85
7	Low public awareness of circular economy	3.79	0.77
8	Resistance to changing disposal habits	3.61	0.81
9	Limited technical knowledge and skills	3.49	0.81
10	Weak demand for recovered products	3.48	0.82

Scale: 1 = not a barrier; 5 = severe barrier. Cronbach's alpha for the 10-item scale = 0.83.

4.5 Opportunities and policy preferences

22.4% of respondents identified compost and organic fertiliser production as the highest-potential opportunity. Animal-feed production followed closely at 17.9%, followed by biogas and renewable energy at 13.8% and redistribution of edible surplus at 13.3%. 12.2% of the respondents selected specialized food-waste collection. Notably, digital platforms, prevention services, and new-product development received smaller shares. Since the respondents chose only one opportunity, the figures show relative preference rather than total support for each option.

Policy preferences were used to show barrier ranking. Most respondents (41.8%) agreed with grants and low-interest loans, and 41.3% chose investment in collection and processing facilities. Respondents selected tax incentives (35.2%), public-private partnerships (30.6%), stronger enforcement (30.1%), training and technical support (29.6%), and mandatory source separation (28.1%). Since the question required respondents to choose multiple responses, the percentages do not total 100%. The results show that while enforcement is desired, respondents expected it to operate alongside finance, facilities, and technical support.

Table 6
Circular opportunities and policy priorities

Measure	Option	n	%
Highest-potential opportunity	Compost and organic fertiliser	44	22.4
	Animal-feed production	35	17.9
	Biogas and renewable energy	27	13.8
	Redistribution of edible surplus	26	13.3
	Specialised collection services	24	12.2
	Prevention and reduction services	15	7.7
	Digital matching platforms	13	6.6
	New products from food waste	10	5.1
	Other	2	1.0
Policy priority	Grants and low-interest loans	82	41.8
	Collection and processing facilities	81	41.3
	Tax incentives	69	35.2
	Public-private partnerships	60	30.6
	Stronger enforcement	59	30.1
	Training and technical support	58	29.6
	Mandatory source separation	55	28.1
	Awareness and behavioural campaigns	51	26.0
	Standards for recovered products	28	14.3
	Food-donation support	22	11.2
	Informal-sector integration	21	10.7
	Other	2	1.0
<i>Note. Opportunity was single-choice. Respondents could select up to three policy priorities.</i>			

4.6 Qualitative thematic findings

Nine themes were identified across the 15 key-informant interviews. The themes provide contextual explanations for the quantitative patterns and show how barriers and opportunities differ across parts of the food-waste value chain.

Table 7
Qualitative themes from the key-informant interviews

Theme	Informants mentioning theme	Interpretive summary	Objective Addressed
Mixed collection and weak source separation	13	Food waste frequently enters the municipal stream with plastics, packaging and other refuse, and separation may be lost during collection.	Objective 1
Finance and uncertain project economics	13	Capital cost, expensive credit, operating expenditure and uncertain revenue limit investment and continuity.	Objective 3
Collection, storage and treatment gaps	13	Stakeholders described shortages of bins, storage, dedicated vehicles, transfer arrangements and treatment capacity.	Objectives 1 and 3
Awareness, skills and behaviour	12	Knowledge is uneven; participation depends on convenience, incentives, trust, training and visible service reliability.	Objectives 2 and 3
Weak data, measurement and traceability	10	Quantities and destinations are rarely measured consistently, reducing planning and investment confidence.	Objectives 1 and 5
Institutional fragmentation and inconsistent enforcement	11	Responsibilities cross waste, food safety, agriculture, energy, environmental regulation and local government.	Objectives 3 and 5
Market and quality concerns	10	Compost, digestate, feed and upcycled products require standards, certification, safety assurance and dependable buyers.	Objectives 3 and 4
Differentiated business opportunities	15	Prevention, redistribution, feed, compost, biogas, logistics and digital coordination suit different waste streams.	Objective 4
Integration of informal workers	8	Informal actors provide recovery services but require safety, contracts, representation and fair compensation.	Objectives 3 and 5
<i>Note. Counts show the number of key informants who discussed each theme and are not population estimates.</i>			

The first theme hovers in the ongoing dominance of mixed collection. A good number of the informants described limited sorting at the point of generation and re-mixing of organics during collection. This pattern diminishes the value of the residues, as plastics, glass, tissues and chemicals impact the composting process, feed conversion and digestion. The interview results also revealed existing food-

waste recovery activities, such as reduced-price sales, staff meals, animal feed, donation, by-product sales, composting, and used-oil collection. The limitation is not one of the absences of circular activity, but of the fragmentary and unreliable nature of the activity.

Together, the second and third themes illustrate the high quantitative ranking of finance, equipment, and infrastructure. Market and small business informants highlighted cash flow, storage, and collection fees. Collectors highlighted fuel, vehicles, and route economics. Land, equipment, maintenance, quality control and uncertain markets for compost and biogas products were mentioned as challenges by compost and biogas operators. The interviews revealed that finance cannot be separated from contracts. A treatment facility needs predictable clean feedstock, while collectors need dependable tariffs and generators need assurance that separated waste will be collected.

The awareness theme showed that knowledge was often based on practice. Technical and policy profiles used a broad circular-economy definition that covered prevention, redistribution, and resource recovery. A few market actors had not heard the term, but they understood the practices after they were explained. Space, time, hygiene, trust, and the possibility of government projects not continuing were linked to behavioural resistance. In the hospitality industry, an abundance at buffets and customers' expectations led to overproduction. In markets, people's visual preferences reduced demand for substandard goods.

The governance and data themes referred to a system where responsibilities are shared between waste, environment, food safety, agriculture, energy and local government. The informants requested clear standards for storage, transport, donation, feed, compost and digestate, consistent approval procedures and digital records of quantity and destination. Data was not only considered an academic pursuit but also as a tool to be used for facility sizing, contractual assurance, and performance monitoring.

The opportunity theme affirmed that different streams require different responses. Clean market residues can be used for composting, animal feed or for combined digestion. Rapid identification, safe transport and recipient capacity are required for edible surplus. The higher value by-product recovery may be supported by food processors due to the more concentrated and consistent residues. Sorting, storage, vehicles and treatment were viewed as enabling services, and informants repeatedly warned that an application cannot replace these services.

The integration of the informal sector was less commonly reported than the finance and infrastructure sector but had significant social implications. Informal workers already collect and recover useful materials and could help bring together these activities within neighbourhoods or markets. Exclusion may lead to lost livelihoods and the loss of practical knowledge from the system. Integration would require registration that is not overly cumbersome; it should include protective equipment, transparent weighing, joint cooperation, and access to contracts.

4.7 Mixed-methods integration

The quantitative and qualitative components were very consistent in their convergence on finance, equipment cost and infrastructure. They also complemented each other by clearly explaining why high willingness does not translate to immediate adoption. While awareness and understanding were positively associated with willingness, the interviews indicated willingness depending on reliable collection, affordable finance, technical support, and visible benefits. The methods also highlighted a helpful shift in focus: while inclusion in the informal sector was not a high priority in quantitative policy selection, it was a significant qualitative policy concern for equity, service coverage, and livelihoods.

Table 8
Joint display of quantitative and qualitative integration

Quantitative result	Qualitative explanation	Relationship	Integrated interpretation
Finance was the highest-rated barrier, with a mean of 4.23.	Actors described expensive credit, working-capital pressure, long payback periods and uncertain revenue.	Convergence	Financial support should be linked to contracts, performance and market development rather than equipment purchase alone.
Equipment cost and infrastructure ranked second and third.	Informants identified bins, storage, vehicles, land, laboratories, maintenance and treatment capacity as interconnected needs.	Convergence and expansion	A functioning value chain must be funded from source separation through treatment and product sale.
87.8% were moderately to extremely willing.	Willingness was frequently conditional on external support, service reliability and reduced operational burden.	Complementarity	Attitude is favourable, but willingness should not be interpreted as independent implementation capacity.
57.7% had heard of circular economy; 24.5% reported good or very good understanding.	Practical recovery knowledge sometimes existed without familiarity with formal terminology.	Complementarity	Training should use sector-specific examples and connect familiar practices to an integrated hierarchy.
Compost was the leading single opportunity at 22.4%.	Composting informants stressed contamination, transport, quality standards and end-market demand.	Expansion	Compost potential depends on clean feedstock and market creation, not only on available organic waste.
Informal-sector integration was selected by 10.7% as a top policy.	Eight informants emphasised livelihood, safety and service roles for informal workers.	Dissonance with contextual explanation	Policy design should not equate lower survey priority with low system importance.

5. Discussion

5.1 Finance, equipment and infrastructure as the central constraint

The analysis shows that finance, equipment costs, and infrastructure are the main barriers to adopting circular food waste management. Weak regulatory enforcement was important but not the most-rated barrier. Lack of access to finance, equipment costs and poor infrastructure were the top three challenges, followed by the absence of incentives. This is in line with the practical demands of organic waste management. Circularity requires more than environmental commitment. It requires containers, storage, weighing, vehicles, transfer arrangements, treatment facilities, testing, maintenance and working capital. These costs arise before revenue from compost, energy, feed or service contracts becomes dependable.

This finding aligns with research on circular-economy barriers in developing economies. For instance, Gedam et al. (2021) identified that finance, technology, coordination and supply-chain conditions reinforce one another. Similarly, Ezeudu et al. (2021) also reported financial, infrastructural and market constraints in the valorisation of urban waste in Nigeria. According to Adesua-Lincoln (2025), the incorporation of environmental and circular practices in Nigeria's Small and Medium Enterprises (SMEs) faces significant resource pressures. The present analysis adds a food-waste perspective by showing that capital cost is not limited to treatment machinery. This applies to source separation, cold storage, collection frequency, vehicle hygiene, contamination and product certification.

The qualitative results also show why grants alone do not seem sufficient. Equipment can be donated to a composter, but if the separated feedstock is inconsistent, it will not be used to its full potential. A biogas plant can be commissioned but stop operating if replacement parts, operator skills or energy buyers are out of place. A food-rescue service may have access to donated food but lack refrigerated transport and recipient storage. Therefore, financing should be linked to viable operating models, feedstock agreements, maintenance plans, product markets and measurable outcomes. This interpretation supports respondents' desire for grants and low-interest loans, as well as public-private partnerships and infrastructure investment.

5.2 Current practice shows partial circularity within a disposal-oriented system

Disposal with general waste was the most frequently reported single management method (27.6%), and collection by a formal waste operator was 26.0%. Circular recovery methods accounted for 40.3% in total. This pattern is more nuanced than a strict linear system. At the system level, food-waste management in Lagos remains largely disposal-oriented, but circular practices are already implemented in animal feed, composting, redistribution, sale at reduced prices, product recovery, and biogas. The network of these practices is not yet robust on the city scale.

The distinction between individual practice and system performance is important. A kitchen waste collection may be kept separate at a hotel but may be mixed with other waste at a general waste collection. A market trader may leave residues for livestock collection, although the arrangement may end if the buyer is not available. A food processor might sell a by-product, but the off taker might turn down the food product when market prices shift. Continuity, quantity, quality and final destination should therefore be used to evaluate circular adoption, instead of a single self-reported practice.

Record keeping was particularly poor, with only 7.1% keeping records regularly. This adds to the uncertainty at each step. Loss that can be prevented is not known to the generator, and the generator has no way to measure prevention. Collectors cannot plan specialised routes accurately. Investors cannot estimate feedstock availability. Government cannot determine diversion rates or treatment gaps. This result is in support of a phased data system that begins with major markets, food manufacturers, hotels, institutions and recovery centers. Measurement should be practical: weight, category, contamination, collection date and destination are more useful than complicated forms that organisations are unlikely to complete.

5.3 Awareness and willingness do not equal capacity

The results show that 57.7% of respondents have heard of the circular economy, but only 24.5% have a good or very good understanding of it. However, 57.7% selected the correct broad description. This suggests that participants may recognise the operational idea even when their confidence with the terminology is limited. This is confirmed by the qualitative interviews. Market actors described overripe produce being sold at a discount and residues being used as feed for cattle farmers, as well as containers being reused, though they did not always use the term circular economy.

There was a high level of willingness: 87.8% of participants were moderately to extremely willing to adopt. Willingness was positively related to awareness and understanding and separation frequency but not related to education or years of experience. These associations must be interpreted with caution as this was a cross-sectional study and is not causal. The pattern suggests, however, that there is more to it than just formal education. The pattern also suggests that existing separation practices and practical knowledge may matter more than formal education alone. Training should therefore target specific decisions, such as preventing spoilage, recognising edible surplus and unsafe waste, separating organics without contamination, and identifying authorised collection or treatment partners.

Financial and infrastructural barriers, combined with high willingness, represent a motivation-capacity gap. It would be misleading to frame the transition mainly as a public awareness problem. Awareness campaigns can have an impact on awareness, but they are not a solution for the provision of bins, vehicles, storage facilities, and a buyer for compost. Reliable services and incentives should be integrated with behavioural interventions. People are unlikely to maintain separation when collection is irregular or when material is mixed after pickup. The policy implication is to align communication with service design, leadership, feedback, and evidence that participation leads to different outcomes.

5.4 Opportunities require feedstock-specific business models

Compared to all single-choice opportunities, compost and organic fertiliser were the most popular, with 22.4% of respondents selecting them. The distribution across compost, animal feed, biogas, redistribution and collection suggests that respondents did not view one solution as dominant. This is in line with the food-waste hierarchy and the physical diversity of the waste stream. Fruits, vegetables, peels and market residues may be suitable for compost or digestion. By-products from clean processing can be used for feed or ingredients. Safe edible surplus should remain in the human food chain. Mixed plate waste might need treatment after contamination controls.

In addition, while composting presents an accessible biological pathway, its viability is dependent on contamination, land, processing time, odour management, quality assurance, and transport to end users. Compost cannot be regarded as a free by-product and should not be demanded automatically. Public landscaping, rehabilitation of soil and agricultural demonstrations can be used to support market development but requires standards and testing. Anaerobic digestion is more capital-intensive and operationally demanding. It is most suitable where wet feedstock is concentrated, its daily supply is predictable, and energy can be used near the facility. The management of digestate must be considered when planning gas production.

Redistribution has significant social value, and it is important not to mix edible surplus with waste. Safe holding temperatures, increased communication, transport, recipient storage and liability guidance are required. Specialised collection was ranked below the treatment options but is a key enabler business. All composters, biodigesters, and feed processors require clean, reliable feed. While digital platforms can help consolidate routes, check quantities, and link generators to users, their real strength lies in supporting physical logistics. A business-to-business service offering collection, traceability, compliance reporting, and verified recovery may be the most promising model, rather than a stand-alone application.

5.5 Governance, enforcement and market confidence

Weak enforcement ranked fifth, and poor government coordination ranked sixth. The findings do not mean governance is unimportant. They show that stakeholders view regulation as part of the overall operating environment. If there is no dedicated service to separate waste, enforcement without infrastructure may penalise generators for not separating waste. Infrastructure without regulation can leave treatment plants without feedstock because generators continue to use cheaper disposal routes. Incentives without monitoring may fund equipment that never operates. The transition needs to be a balanced process of support, standards, service provision and enforcement.

In addition, institutional coordination is essential for food waste because recovered materials may exceed regulatory categories. A residue can turn to food, feed, fertiliser, fuel or waste depending on its quality and intended use. Moreover, businesses require clear approval pathways and timelines that can become predictable. A single coordinating mechanism can help harmonise reporting, permits, food

donation guidance, compost and digestate standards, as well as list of approved collectors and treatment facilities. While the mechanism is important, it should not remove the legal responsibilities of existing agencies, rather it should help identify and reduce contradictory requirements and any information gap that exists.

In a similar vein, market confidence is also a regulatory issue. Farmers and landscapers need uniform information regarding the quality of compost. Donation partners need to build confidence and assure food businesses of their capacity to manage safety. Investors require payment agreements and feedstock that are reliable. Community members need to be assured that treatment facilities will control pests, odour, traffic and safety risks. Standards should be accompanied, therefore, by a clear mechanism for monitoring and technical assistance, rather than merely punitive requirements.

5.6 Informal-sector inclusion and a just transition

10.7% of the target audience identified informal-sector integration as one of their top policy priorities, a lower share than finance, facilities, or enforcement. However, the qualitative interviews expanded the contextual importance of the issue. This represents meaningful mixed-methods divergence, where respondents from the qualitative strand tended to prioritise immediate organisational needs, and the qualitative strand highlighted system roles and social consequences that were less visible in a ranked policy list.

Furthermore, informal collectors and waste pickers can make provision for neighbourhood access, material knowledge and aggregation services. Their exclusion may not only lead to less recovery, but also to loss of livelihoods without offering appropriate alternatives. Inclusion should not mean leaving workers in unsafe conditions or using informality as a substitute for public service. It should include collaborative support, protective equipment, training, clear weighing, equitable compensation, and representation in planning and pathways to formal service contracts. Registration requirements should ensure the protection of health and accountability without acting as barriers that only large organizations can meet.

A just transition also requires attention to gender, youth employment, and community impacts, which this study did not measure. Further studies are needed to examine people who carry out sorting and collection activities, who benefit from the sale of recovered products, and whether new technologies displace or enhance current livelihoods. Assess environmental outcomes alongside social outcomes rather than treating employment as an automatic benefit of circularity.

5.7 Policy implications

The findings suggest introducing changes gradually, in clear stages.

First, Lagos should establish a reliable picture of how much food waste is being produced and where it comes from. Efforts should first focus on places that produce large amounts of relatively clean food waste, such as major fruit and vegetable markets, food-processing businesses, hotels, event centres,

institutional caterers, and selected groups of homes or businesses. Waste producers or generators should be grouped based on the actual amount of waste they generate, the risks involved, and the type of business, rather than using a fixed waste limit that is not supported by local evidence.

Second, financial support should focus on businesses and projects that can operate successfully over the long term. A circular food-waste fund could offer affordable loans, matching grants, vehicle financing and technical support. To qualify, projects should have a clear business plan, a reliable source of food waste, a plan for maintaining equipment, proper environmental safeguards, a clear market for their products, and measurable targets for reducing waste sent to disposal. Support should be available to private businesses, public-private partnerships and organised cooperatives. Funding should support both successful operations that are ready to expand and well-designed pilot projects.

Third, Lagos needs the right infrastructure and collection services. Colour-coded waste bins will only be useful if there are reliable systems for collecting and treating the waste separately. The state should develop collection routes for organic waste, local transfer or treatment facilities, systems for weighing waste, and a list of approved service providers. The size and type of treatment facility should depend on the actual type and amount of waste available, transport distances, available land and utilities, workers' skills, and the market for the final products. Government should not decide the size of treatment plants without first carrying out proper feasibility studies.

Fourth, stronger markets and clear rules are needed. Standards should be developed for products such as compost, digestate, recovered animal feed and donated food. Government purchasing can help create an early market for approved compost by using it in landscaping, erosion control and public agriculture projects. Hotels, restaurants and other food-service businesses can also develop guidelines for preventing and measuring food waste. Digital records for large waste producers can help track where food waste goes while keeping commercially sensitive information private.

Finally, government policy should combine enforcement with support for businesses and communities as they adjust. Separating food waste at the source should become mandatory gradually, after proper collection services, clear guidance, and approved treatment or disposal options are available. During enforcement, focus should be on large generators or waste producers and those that repeatedly mix or contaminate their waste. More also, the government should provide education and technical support to address problems early. In order to measure whether the system is reducing waste, operating at a reasonable cost, providing reliable services, creating jobs, and protecting workers and local communities, there is a need for independent reviews.

5.8 Limitations and directions for future research

While this study revealed several significant results, it is essential to acknowledge certain limitations encountered in the study. Firstly, the study employed purposive quota sampling to include knowledgeable stakeholders from different parts of the food-waste value chain, but probability sampling was not utilized and therefore does not support statistical generalisation to everyone in Lagos State.

Moreover, the results from the quantitative strand reflect self-reported practices and perceptions of the respondents which may be affected by recall bias. Also, the cross-sectional design of this study prevents causal conclusions or assessment of whether stated willingness results in sustained adoption over time.

Unequal stakeholder recruitment across subgroups did not allow comparison between subgroups. While the study instrument helped identify the principal waste type and management method, it did not directly weigh the quantities that were generated, and it did not independently verify collection destinations. In addition, the study results produced stakeholder perspectives but cannot establish the prevalence of those views among the general population.

Based on the foregoing, it is important for future research to combine stakeholder surveys and interviews with waste audits, route and destination tracking, facility performance records and business-model analysis. Longitudinal studies can evaluate whether finance, infrastructure and training change adoption over time.

6. Conclusion

Conclusively, the empirical mixed-method approach of this study has shown that while there is a presence of circular food-waste practice in Lagos State, it remains fragmented. Regular record-keeping is uncommon; awareness is moderate, and willingness to adopt is high. Limited access to finance, high equipment cost, and inadequate infrastructure remain the principal barriers in this study. Composting emerged as the most frequently chosen opportunity, but diverse responses across areas such as animal feed, redistribution, specialised collection, and digital services show that different waste streams require different pathways.

The qualitative strand has succinctly explained why willingness does not automatically translate to sustained adoption. Clean feedstock, reliable collection, operating finance, maintenance, product standards, market demand, data and institutional coordination must function together. Policy should go beyond one-off awareness campaigns or temporary technology projects. A step-by-step approach should bring together funding for environmentally friendly projects, proper collection systems, local treatment facilities, stronger markets, clear standards, ways to track materials, and fair inclusion of informal workers.

When the survey patterns are integrated with stakeholder explanations, this study suggests a practical way to improve how food waste is managed. The findings are relevant and support government agencies, businesses, investors and community actors in designing practical and inclusive circular food-waste interventions in Lagos State and, by extension, in Nigeria.

Declarations

Ethical approval and consent to participate

The Research Ethics Committee of the University of Bolton, United Kingdom, approved the study under certification number AUTOYEHP00347 on 07/02/2025. All survey respondents and key informants provided informed consent before participation. Participation was voluntary, and confidentiality and anonymity were maintained throughout data collection, analysis and reporting.

The study was conducted in accordance with the Declaration of Helsinki and relevant guidelines and regulations of the Research Ethics Committee of the University of Bolton, United Kingdom.

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Conflict of interest

The author declares no conflict of interest.

Data availability

The anonymised quantitative dataset and qualitative coding framework may be obtained from the corresponding author supporting the findings are publicly available in Zenodo at (<https://doi.org/10.5281/zenodo.22924624>)

Author contributions

The author conceptualised the study, developed the instrument, coordinated data collection, conducted the analysis, interpreted the findings and prepared the manuscript.

Study design: Explanatory sequential mixed-methods study (QUAN → qual)

Research ethics: Approved by the Research Ethics Committee of the University of Bolton, United Kingdom (Certification No. AUTOYEHP00347; 7 February 2025). Informed consent was obtained from all participants.

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Figures

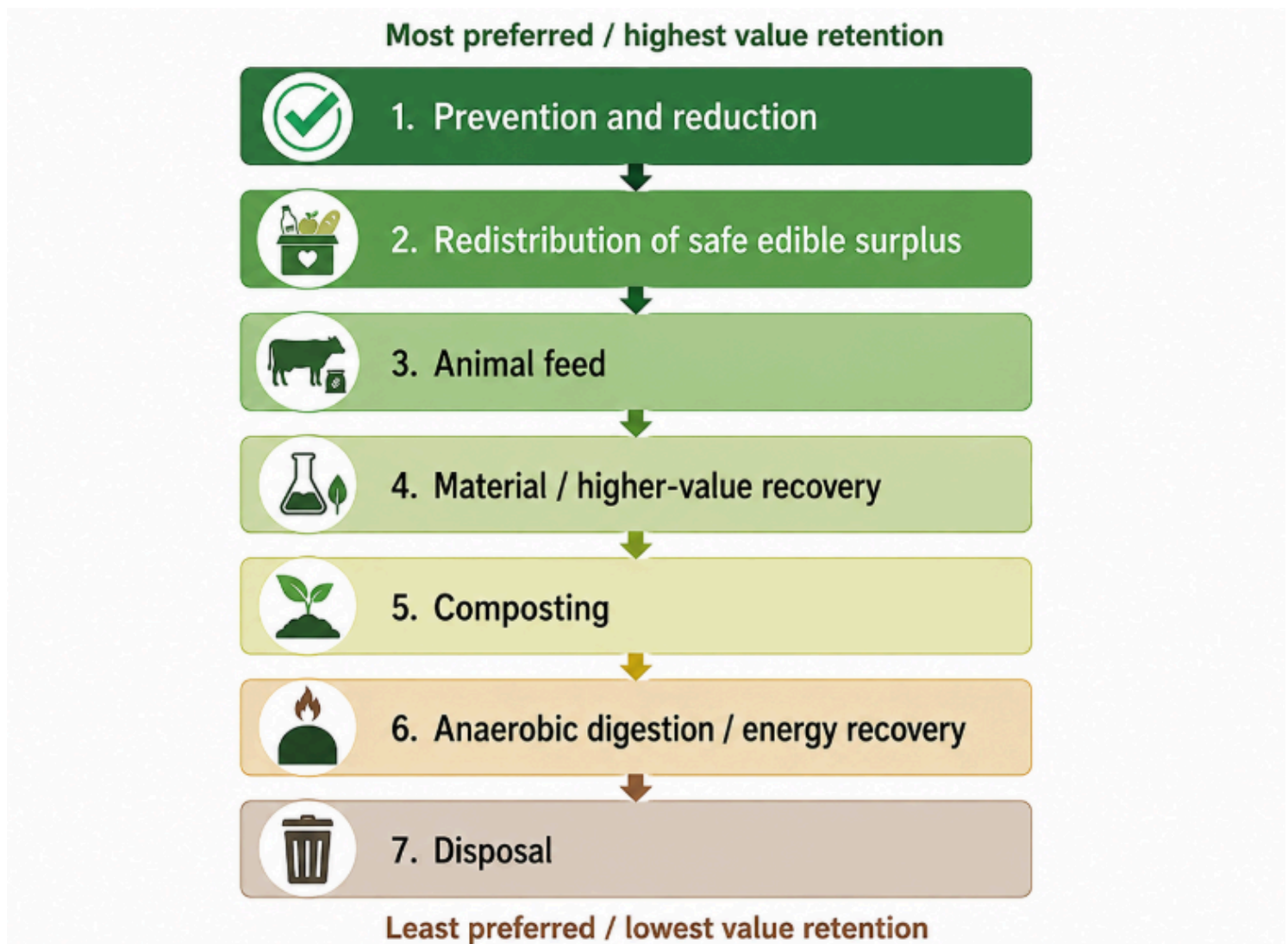


Figure 1

Circular Food-Waste Management Hierarchy

Source: Author's conceptualisation, adapted from Papargyropoulou et al. (2014) and European Commission (2020).

