



Enhancing Green Economic Circular Ecosystem Growth through AI-Based Waste Management Gamification

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ABSTRACT

The research emphasizes the critical role of technology in advancing the sustainable development of micro, small, and medium enterprises (MSMEs) while highlighting the importance of leadership within green organizations for effective implementation of green economy principles. This study seeks to deepen understanding of how green behaviours contribute to the sustainability of enterprises. Indonesia's National Waste Management Information System highlights the urgency of this research, revealing that the country generates millions of tons of inadequately managed waste, leading to significant environmental challenges. To address this, the study focuses on mapping the needs of MSMEs to foster a green economic circular ecosystem. The researchers conducted in-depth interviews with stakeholders and focus group discussions with MSMEs already involved in waste management. Data were collected through online surveys and interviews, followed by content analysis to understand MSMEs' green behaviors and sentiments. The findings indicate a strong demand for green programs that encourage environmentally friendly behaviors through gamification, such as waste banks that provide economic benefits to MSMEs. This study also contributes to the sustainable development goals by integrating community involvement in value co-creation, raising public awareness, and increasing income through waste management initiatives.

Keywords: Green Behavior, Green Economics Circular, Waste Bank, Waste Management Ecosystem

JFL Classifications: Q56, Q55, Q50

1. INTRODUCTION

Waste management has long been a persistent challenge in Indonesia. According to the National Waste Management Information System of the Ministry of Environment and Forestry, Indonesia generated 69.9 million tons of waste in 2023. The majority of waste is composed of food residues (41.60%) and plastic (18.71%) (Pandu, 2024). The primary sources of waste include households (39.1%), traditional markets (20.4%), and commercial centers (17.8%) (Ahdiat, 2024).

One of the primary contributors to food waste is households and the food service industry. This research focuses on waste control in the food service industry, such as cafeteria or canteen businesses. The role of leadership plays a major role in overcoming a major problem like this waste (Simbolon et al., 2024; Helmefalk et al.,

2023) because each individual has a different level of awareness and attention to waste management efforts (Kusumo et al., 2024; Joseh, 2006). This is where the role of leadership is important to encourage the growth of individual motivation, either through socialization, learning, mentoring, or the establishment of binding regulations. Canteen/cafeteria managers typically hold the authority to establish regulations that encourage tenants to implement systematic waste management. Regulations play a critical role in shaping individual behavior to achieve specific objectives. Even within the confines of institutional areas, strong waste management regulations can bind individuals through the establishment of reward and punishment systems. On the other hand, an incentive program can serve as a form of gamification, motivating individuals to reach specific targets (Rasendriya et al., 2024; Wibowo & fauzi, 2019). For instance, when a cafeteria tenant successfully complies with waste management standards, they are

entitled to receive incentives through a waste bank program, which may be rewarded in the form of points or monetary compensation. The National Strategic Policy through the “Indonesia Clean from Waste” program targets 100% waste management by 2025, with a goal of 30% waste reduction and 70% waste handling. However, current efforts have only achieved a 15.36% reduction in waste and 51.76% waste handling (Pandu, 2024). This shortfall is attributed to the weak collaboration between the government and the public. Effective waste management must begin at the household level, involving the collection and sorting of waste through local waste banks, where it can be processed according to the waste categories.

The waste issue is not only about the increasing volume each year but also the suboptimal handling, leading to environmental pollution. Factors such as population growth, higher consumption rates, and industrial activities significantly contribute to the rising waste generation. Currently, the public predominantly follows a “collect-transport-dispose” system rather than optimizing 3R (Reduce, Reuse, Recycle) waste management facilities and waste banks (Sholihah and Hariyanto, 2020). The Waste Management Law of 2008 by the Ministry of Environment and Forestry mandates the separation of waste and its processing into energy or raw materials, rather than resorting to open dumping. The success of waste management programs hinges on public support and active participation. A public opinion survey revealed that 61.6% of respondents wish to separate their waste but are hindered by inadequate facilities, 47% lack the time to sort waste, and 6.8% do not view waste sorting as their responsibility (Rainer, 2023).

Based on the situation analysis, three primary issues hinder effective waste management. First, public awareness of waste separation remains low, coupled with limited knowledge of waste types, making sorting difficult. Second, there is a lack of facilities to assist in waste sorting and to estimate the rewards from waste collection. Third, a sustainable waste management ecosystem has yet to be established. In response to these challenges, this study aims to identify the roles and contributions of stakeholders in waste management.

2. LITERATURE REVIEW

2.1. Concept of Circular Economy

Organizational sustainability has increasingly attracted attention to several emerging and complex concepts, including the circular economy (CE). The concept of the circular economy (CE) is an economic model designed to minimize waste and make the most efficient use of resources by adopting closed-loop systems (Kara et al., 2022). Unlike the traditional linear economy, which follows a “take-make-dispose” model of production and consumption, the circular economy emphasizes recycling, reusing, refurbishing, and regenerating materials and products (Kirchherr et al., 2023). The key principles of the circular economy:

- 1) Designing out waste, includes reducing waste and innovate waste to be valuable recycled product or new product.
- 2) Keeping product and material in use by maintaining, repairing, reusing to extending the lifecycle.
- 3) Regenerating natural system, restoring ecosystem dan

returning valuable nutrient to the environment.

This approach aims to keep resources in use for as long as possible, extracting maximum value before recovering and regenerating products and materials at the end of their life cycle. Another statement said that CE is a production and consumption model that focuses on maximizing resource efficiency and minimizing waste through closed-loop, regenerative, and collaborative approaches (Khalili-Fard et al., 2024). Fatimah et al. (2020) mentioned that the implementation of CE has an objective to reduce costs; and extract the maximum value from resources. The Ellen MacArthur Foundation introduced the ReSOLVE framework, which outlines several CE-based business models (Gonçalves and Maximo, 2023). The successful implementation of CE business models requires an analysis of market conditions, legal frameworks, and stakeholder expectations, as these factors can either enable or hinder the adoption of CE initiatives (Gonçalves and Maximo, 2023; Salvioni et al., 2022).

2.2. Value Co-creation

Service-dominant logic is a perspective in marketing theory that emphasises the superiority of service provision and exchange that focuses on creating shared value. (Vargo and Lusch, 2017). Tregua et al. (2015) stated that engagement plays a role in growing value co-creation. In practice, in the socialization of solid waste management, Frempong et al. (2019) stated that operant resources significantly contribute to increasing tenants’ knowledge, skills, and willingness to waste management. Even value co-creation has a crucial mediation role in disseminating information about the importance of waste management in creating a clean and healthy environment, which indirectly also improves community welfare. Apostolidis et al. (2021) and Vo-Thanh et al. (2021) also explain the importance of collaborative involvement between parties in creating value in the food industry, using the example of the Reduce Food Waste - Zero Waste campaign, which is a specific description of the campaign. In the context of “Green HRM,” Darvishmotevali and Altinay, (2022) dan Parimita (2023) stated that increasing awareness of maintaining the company’s environment requires the role of the synergy of company management, individual awareness, and leadership style that supports the achievement of proactive pro-environmental behavior.

2.3. Personal Innovativeness

(Agarwal and Prasad, 1998) conceptualized innovativeness as a cognitive style that involved individual’s intellectual, perceptual, and attitudinal characteristics that influence how an individual reacts to new products, sensations, and experiences and communication about them. They conceptualize personal innovativeness in the domain of information technology as an individual’s willingness to experiment with new information. Several authors have validated the positive effects of personal innovativeness on behavioral intention. Handarkho and Harjoseputro, (2020) found that consumer innovativeness is the predictor of intention to adopt mobile payment. Then, Lyu et al. (2023) stated that personal Innovativeness refers to an individual’s willingness to adopt new ideas, technologies, or systems earlier than others in their social system. In the context of technology adoption, personal innovativeness plays a significant role in

influencing how people engage with and accept new technologies, such as AI-based systems (Sestino et al., 2023). It is particularly relevant in the context of technology-driven practices like waste management using AI.

The dimensions of personal innovativeness on information technology (Agarwal and Prasad, 1998; van Raaij and Schepers, 2008), includes: a) openness to new experiences – individuals with higher personal innovativeness are more open to experimenting with unfamiliar technologies and ideas, b) risk-taking attitude - individuals willingness to take the risks associated with adopting novel technologies, even when uncertainties exist, c) curiosity and adaptability – a natural curiosity about new advancements and possess the adaptability to embrace changes, and d) proactive behavior – people high in innovativeness often take proactive steps toward learning and integrating new tools, including AI-based technologies.

Personal innovativeness plays a crucial role in influencing the intention to adopt AI-based waste management systems (Na et al., 2023). This influence can be explained through several key factors (Herath and Mittal, 2022). Firstly, individuals with high personal innovativeness tend to exhibit positive attitudes toward technology. They are more likely to view AI as a beneficial tool that offers superior solutions compared to traditional waste management methods. This positive outlook translates into a greater willingness to engage with AI-based systems, enhancing their behavioral intention to adopt such technologies. Additionally, innovators often serve as early adopters and opinion leaders within their communities or organizations. Their early adoption of AI-based waste management systems can inspire others to follow suit, particularly in contexts where communal or organizational participation is essential.

Moreover, environmental awareness is often more pronounced among individuals with high personal innovativeness (Lyu et al., 2023). These individuals may recognize AI-based waste management as a modern and effective approach to addressing environmental challenges. As a result, they are more inclined to engage with such systems, seeing them as aligned with their values of sustainability and environmental responsibility. Finally, trust in technology is a significant factor in the adoption of AI-based waste management (Aoki, 2020). Innovators tend to exhibit higher levels of trust in emerging technologies, including AI. They are more likely to believe in the system's capacity to make accurate decisions, such as waste classification or predicting recycling patterns. This trust increases their willingness to implement AI-based solutions in waste management.

2.4. Personal Green Mindset

Personal Green Mindset refers to an individual's attitude, values, and beliefs that prioritize environmental sustainability and ecological responsibility (Tawde et al., 2023). People with a personal green mindset are deeply aware of environmental issues and are committed to behaviors that minimize their ecological footprint. This mindset is shaped by factors such as environmental knowledge, eco-conscious values, and a commitment to protecting the environment for future generations.

Rimanoczy and Klingenberg (2021) and Tawde et al. (2023) mentioned characteristics of a Personal Green Mindset:

1. Environmental awareness: Individuals with a green mindset are highly informed about environmental challenges like pollution, climate change, and resource depletion.
2. Sustainability-oriented values: They prioritize sustainable living, aiming to reduce waste, conserve resources, and promote eco-friendly practices in their daily lives.
3. Proactive environmental behavior: A green mindset is not just about awareness but also involves taking action—such as recycling, reducing consumption, and adopting sustainable technologies.
4. Long-term thinking: These individuals focus on the long-term consequences of their actions and aim to create a positive environmental legacy.

Tawde et al. (2023) highlight the importance of a personal green mindset in enhancing the intention to engage in waste management. Individuals with this mindset tend to align their actions with their values, perceiving practices such as recycling, composting, and waste reduction as integral to their environmental responsibility. This intrinsic motivation is often accompanied by a moral obligation to protect the Earth (Wang et al., 2021), pushing individuals to adopt behaviors aimed at minimizing waste and ensuring proper disposal.

Moreover, people with a green mindset are generally more open to innovative solutions, such as AI-based waste management systems and smart recycling technologies (Neofotistos et al., 2023). Their commitment to sustainability makes them receptive to advancements that improve waste reduction and recycling efficiency, such as AI systems that optimize sorting and track waste patterns. Behaviourally, individuals with a green mindset strive for consistency between beliefs and actions, viewing engagement in waste management as a practical expression of their sustainability values. Additionally, their dedication can influence community norms, inspiring others to partake in waste management initiatives and fostering a culture of environmental responsibility. This collective effort often aligns with the principles of the circular economy, as those with a green mindset actively support systems that promote reuse and recycling, further contributing to effective waste management.

3. METHOD

This research uses a qualitative method with an exploratory case study approach. The exploratory approach was chosen because it can understand in depth the complex real-life phenomena of the research target, namely the role of stakeholders and gamification strategies in artificial intelligence (AI)-based waste management, as well as how the green economy is applied in the context of micro, small, and medium enterprises (MSMEs) in the food sector operating in canteens. This approach is particularly valuable in areas such as health research, policy analysis, and social science, where it can help develop theories, evaluate programmes, and design interventions (Baxter and Jack, 2015; Miller et al., 2023). Thus, the use of exploratory methods allows researchers to collect qualitative data, which is then used to develop an AI-based green

economy circular ecosystem model in waste management. The interview process is carried out with MSMEs that have waste management problems. To select MSMEs that are in accordance with the research objectives, researchers have criteria for selecting respondents. First, the interview target must be an MSME. Second, the MSME has a rental place in a certain area such as a school or university canteen. Third, MSMEs have waste management problems. After the selection process, there are 5 MSMEs that are targeted by researchers, which are detailed in Table 1.

The researcher used an interactive model approach to collect data in the field starting from data collection in the field, data evaluation and verification, and conclusions (Miles et al., 2013). The author uses data analysis with a thematic analysis approach where the interview results are carried out with iterative techniques to obtain responses from respondents (Musyaffi et al., 2022; Ose, 2016) (Table 2). Then the interview data was analysed with the help of Microsoft word and excel which is more effective for coding unstructured data systematically (Ose, 2016). Then each interview was transcribed into word format, then transferred to excel and inductively coded by several researchers separately (Ose, 2016). The results were then compared and discussed with the researchers.

4. RESULTS AND DISCUSSION

Based on the results of the research above, the summary of each question item is summarised in the Table 3.

Personal innovativeness refers to the extent to which individuals are open to new technologies and how quickly they adopt innovations in their daily lives or business practices (Musyaffi et al., 2024). This concept is crucial in determining how quickly new technologies are accepted and integrated in small

businesses. Previous research shows that higher levels of innovativeness usually correlate with a more proactive approach in trying and implementing new technologies (Mamun, 2018). In this study, we explored the personal innovativeness of small business owners regarding their curiosity and readiness to adopt new technologies.

The results revealed several items of concern. Firstly, in relation to curiosity towards new technology (PI1), respondents showed interest in using technology as a way to keep up with the latest trends (CA2, CA3) and improve business operations (CA1, CA5). This is in line with previous research which shows that business owners with high levels of personal innovativeness tend to actively seek technology to improve efficiency and competitiveness (Mamun, 2018). However, despite their curiosity, respondents expressed the need for further support and education to fully understand the potential benefits of new technologies.

For the courage to try new technology (PI2), most respondents (CA3, CA4, CA5) showed a willingness to experiment with technology, but they often needed guidance. This finding supports the study of Musyaffi et al. (2024) which showed that although SME owners are open to new technologies, the lack of adequate support and training can hinder full adoption. The respondents expressed the need for tutorials or support systems that can bridge the gap between technology introduction and implementation.

In terms of confidence to learn new technologies (PI3), some respondents emphasised the importance of guidance (CA1, CA4), while others preferred self-exploration (CA2, CA3). This suggests that while some individuals are confident in their ability to learn on their own, others still require structured support. This finding is in line with Rogers' (2003) research on the diffusion of innovations, which emphasises the importance of adequate support during the learning process.

Which emphasises the importance of adequate support during the learning phase to ensure technology adoption. Regarding the handling of risks associated with new technology (PI4), respondents took basic steps such as the use of passwords (CA2, CA3), but they expressed the need for a deeper understanding of

Table 1: Respondent description

No	Code name	Age	Gender	Education
1	CA1	Under 30 years old	Male	Graduate
2	CA2	40-49 years	Female	Senior high school
3	CA3	Under 30 years old	Male	Senior high school
4	CA4	Above 49 years old	Male	Senior high school
5	CA5	Above 49 years old	Male	Senior high school

Table 2: Questionnaire

Scope	Code	Research Instrument	Reference
Personal green mindset	GM1	Support waste reduction	(Darvishmotevali and Altinay, 2022)
	GM2	Saving energy	
	GM3	Using recycled materials	
	GM4	Supporting environmental maintenance regulations	
	GM5	Inviting others to protect the environment	
Personal innovativeness	PI1	High curiosity towards technological novelty.	(Al-jundi et al., 2019)
	PI2	Courage to try new technology.	
	PI3	Confidence in being able to learn new technology	
	PI4	Confidence in accepting the consequences of technological novelty	
	PI5	Confidence to like the challenge of technological novelty	
Government and business support	BS1	Policies that encourage the use of technology.	(Pal et al., 2021)
	BS2	Socialisation of the programme.	
	BS3	Training in the use of technology.	
	BS4	Technology facility support.	

Table 3: Item of concern

Scope	Code	Research concern	Item of concern
Personal green mindset	GM1	Support waste reduction	Separating waste for better management (CA1, CA2, CA4, CA5) Providing waste bins to discipline disposal (CA3)
	GM2	Saving energy	Switching off lights during the day (CA1, CA3) Saving water and electricity (CA2, CA5) Using energy efficient electrical appliances (CA3) Using electricity sparingly (CA4)
	GM3	Using recycled materials	Recycling in daily activities (CA1, CA5) Support recycling, but do not fully utilise it (CA2) Collects bottles for resale (CA3) Reusing used cardboard for storage (CA4)
	GM4	Supporting environmental maintenance regulations	Reduce waste according to regulations (CA1, CA2, CA5) Paying fees and collecting waste according to regulations (CA2, CA5) Complying with regulations and raising public awareness (CA3, CA4)
	GM5	Inviting others to protect the environment	Reminding and inviting others to manage waste properly (CA1, CA2, CA4, CA5) Printing stickers/banners for environmental awareness (CA3, CA5)
Personal innovativeness	PI1	High curiosity towards technological novelty.	Technology to keep up with the times (CA3, CA2) Technology to increase business benefits (CA5) Technology to support operations (CA1)
	PI2	Courage to try new technology.	Willingness to try new technology with guidance (CA3, CA4, CA5)
	PI3	Confidence in being able to learn new technology	Need guidance to learn new technology (CA1, CA4) Utilise independent exploration to understand technology (CA2, CA3)
	PI4	Confidence in accepting the consequences of technological novelty	Risk protection with basic security measures (CA2, CA3) The need for a deeper understanding of risk (CA1, CA4, CA5)
	PI5	Confidence to like the challenge of technological novelty	Technology for efficient waste management (CA2, CA4) Technology to convert waste into economic value (CA3) Technology to facilitate waste management (CA5)
Government and business support	BS1	Policies that encourage the use of technology.	Knowing waste management policies or procedures from various sources (campus, friends, internet, TV) (CA2, CA3, CA4, CA5) Not aware of specific policies (CA1)
	BS2	Socialisation of the programme.	Only a few trainings attended and no clear instructions (CA2) Never attended waste management training (CA1, CA3, CA4, CA5)
	BS3	Training in the use of technology.	Only a few trainings attended and no clear instructions (CA2) Never attended waste management training (CA1, CA3, CA4, CA5)
	BS4	Technology facility support.	Not aware of or using waste management applications (CA1, CA2, CA3, CA4, CA5)

risk management (CA1, CA4, CA5). These findings suggest that while SME owners are mindful of security risks, their limited knowledge of comprehensive risk management may be a barrier to full adoption. This highlights the need for targeted training on cybersecurity risks as part of a technology adoption strategy.

Personal green mindset refers to individual attitudes, behaviours and practices that are aligned with environmental sustainability (Rahnama Haratbar et al., 2024). This dimension reflects a commitment to waste reduction, energy saving, and contribution to ecological well-being. In the context of small businesses, especially in the food industry, green mindset plays an important role in shaping sustainable operational strategies (Maniu et al., 2021). In this study, we explored the waste management and energy saving efforts undertaken by the respondents to understand how their green mindset affects business operations. In waste reduction (GM1), most respondents (CA1, CA2, CA4, CA5) actively separate waste for better management, while one respondent (CA3) provides special bins to ensure customers dispose of waste in an orderly manner. This finding is in line with Maniu et al. (2021), which showed that small business owners with a green mindset are more likely to adopt environmentally friendly waste management practices. However, the effectiveness of these efforts could be

improved with local government support, such as the provision of better waste segregation facilities.

Regarding energy saving (GM2), respondents (CA1, CA3) focused on switching off lights during the day, while others (CA2, CA5) endeavoured to save on water and electricity usage. One respondent (CA4) highlighted using electricity only as needed. This is consistent with Rahnama Haratbar et al. (2024), who noted that individuals with a strong green mindset often take proactive measures to reduce energy consumption. This finding reflects a good awareness of energy saving, although further education on more advanced energy-saving technologies could help improve this practice. In the recycling practice (GM3), respondents varied in their implementation. Some (CA1, CA5) are actively involved in recycling, while others (CA2, CA3) support recycling but have not fully integrated it into their daily activities. Others collect used materials, such as bottles or cardboard, for resale or reuse (CA3, CA4). This partial adoption of recycling is in line with previous research, which suggests that while small businesses recognise the importance of recycling, implementation can be inconsistent (Maniu et al., 2021).

Regarding support for environmental regulations (GM4),

most respondents (CA1, CA2, CA5) support environmental policies by following local waste management rules, while others (CA3, CA4) take additional steps to raise awareness among the community. This supports the findings of Freeman and Louca (2001), who note that regulatory support plays an important role in encouraging environmentally friendly business behaviour. Finally, regarding encouraging others to protect the environment (GM5), some respondents (CA1, CA2, CA4, CA5) made efforts to remind others to manage waste responsibly. In addition, some respondents (CA3, CA5) took more proactive steps, such as printing stickers or banners to raise environmental awareness. This reinforces the finding that individuals with a green mindset not only practice sustainable behaviour themselves, but also encourage their communities to do the same (Maniu et al., 2021).

Support from government and businesses plays an important role in helping small businesses adopt new technologies and practice sustainability, including waste management and energy saving. Previous research shows that collaboration between the public and private sectors accelerates the adoption of sustainable practices in SMEs (Hossain et al., 2023; Zhong and Chen, 2023). In this study, we explore how support from government and business influences respondents' actions regarding waste management and technology adoption.

In terms of policy support (BS1), respondents (CA2, CA3, CA4, CA5) were aware of waste management policies, usually through campus regulations, friends, or the media. However, one respondent (CA1) was not aware of this policy, indicating a gap in awareness. This is in line with the findings of Pal et al. (2021), which showed that while some SMEs have information about environmental policies, others lack access or resources to effectively implement such policies.

Regarding programme socialisation (BS2), respondents indicated a lack of training in waste management (CA1, CA3, CA4, CA5). Only one respondent (CA2) had attended a training programme, but noted a lack of clear instructions. This finding is consistent with Hossain et al. (2023), who found that while the government and business sector may offer training programmes, their effectiveness is often limited by unclear communication and insufficient practical guidance.

Regarding training (BS3), all respondents agreed that waste management training is important, especially to prevent waste accumulation and reduce negative environmental impacts (CA2, CA3, CA4, CA5). This finding supports the research of Zhong and Chen (2023), who emphasised the importance of structured and continuous training programmes to ensure SMEs adopt sustainable practices effectively. Regarding technological support (BS4), none of the respondents were aware of waste management applications that could provide economic benefits. This suggests a gap in the availability and promotion of digital solutions for waste management. Previous research has shown that technology, including mobile applications, can play an important role in improving waste management practices

in SMEs (Pal et al., 2021). The lack of awareness among respondents highlights the need for better promotion and support for such technologies.

5. CONCLUSION

This research explores three key dimensions of Personal Innovativeness, Personal Green Mindset, and Government and Business Support to understand how small business owners approach the adoption of sustainable technologies and practices. While respondents showed curiosity and openness towards new technologies and green behaviours, there were clear gaps in support and training that hindered full implementation. The findings suggest that while small business owners are willing to adopt new technologies and engage in sustainable behaviours, they need more structured support from the public and private sectors to do so effectively. Thus users need more accessible training, better enforcement of regulations, and promotion of digital tools to help SMEs achieve sustainability and operational efficiency.

Based on these findings, there are several important recommendations that can be made to encourage the adoption of sustainability technologies and practices among SMEs. First, increased training and education is needed. The government and private sector need to provide more structured training on the use of new technologies and waste management, with a focus on practical steps relevant to SMEs, including technology risk management and utilisation of digital tools. In addition, the promotion of digital waste management technologies needs to be enhanced. The introduction of apps that offer economic benefits can help SMEs manage waste more efficiently and sustainably, and this can be realised through government cooperation with app developers. Secondly, socialisation of environmental policies should also be done more effectively to reach all levels of SMEs, through media such as television, the internet, and local communities. Finally, it is important to raise the awareness of small business owners on technology risk management, especially regarding cybersecurity. The government and private sector need to develop specialised training modules that address how to better manage technology risks so that SMEs can adopt new technologies safely and efficiently.

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