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THE ROLE OF TECHNOLOGY IN ADDRESSING THE WASTE EMERGENCY IN INDONESIA: A SOCIOLOGICAL STUDY OF DIGITAL WASTE BANK INNOVATION IN URBAN AREAS

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Abstract

The waste management crisis in Indonesia, particularly in urban areas, has spurred the emergence of various digital technology-based innovations, including digital waste bank applications such as eRecycle, Octopus, and Rekosistem. This study aims to analyze the role of these technologies in changing community participation patterns and their impact on community social dynamics. The research employed a qualitative approach using in-depth interviews, participant observation, and document study in three major cities : Jakarta, Makassar, and Surabaya. Findings indicate that economic incentives were the initial motivation for app use, but ecological awareness grew with continued participation. Technology also plays a role in shaping new forms of social capital through system transparency, participatory reporting, and strengthening community networks. However, there is a transformation from collective social interaction patterns to more individualistic digital participation. In addition, digital literacy barriers, limited access to technology, and social stigma against waste sorting activities remain serious challenges in creating inclusive engagement. The conclusion of this study confirms that the success of digital waste bank applications is highly dependent on the integration between technological innovation and community-based social approaches. This study recommends the need for strategies to strengthen digital social capital, public education, and policies that guarantee fair access and participation in technology-based waste management.

Keywords : Digital waste bank, Community participation, Social capital, Digital technology, Environmental sociology, Social inclusion

INTRODUCTION

The waste problem in Indonesia has reached a crisis point, especially in urban areas. Every day, Indonesia produces more than 175,000 tons of waste, with the largest contribution coming from households and urban activities (Ministry of Environment and Forestry [KLHK], 2024) (Aprilia, 2021; Dhewanto et al., 2018). Large cities such as Jakarta and Surabaya face systemic challenges in waste management that not only encompass technical aspects such as landfill capacity and waste transportation systems, but also reflect weak public participation and limited community-based approaches. The conventional systems that have been implemented so far have proven to be inadequate in addressing the complexity of the multidimensional nature of waste problems.

In an effort to respond to this crisis, various digital technology-based initiatives have emerged that introduce the concept of *digital waste banks.* This innovation takes the form of applications that allow residents to sort, deposit, and exchange inorganic waste for economic or social rewards. Apps like eRecycle**,** Octopus**,** and Rekosistem offer new ways for communities to engage in waste management directly, at a household level, and connected to an online system. However, the successful implementation of these digital innovations cannot be separated from more fundamental social aspects. The use of technology in the context of waste management is not only related to the efficiency and sophistication of the system, but is also very much determined by the social, cultural, and structural dynamics of the community that uses it.

Based on this context, there are four important aspects that are the focus of the study and also describe the main problems in this research.

First, the motivation for public participation in using digital waste bank applications remains a critical question. Are citizens driven by environmental awareness or solely by economic incentives? To what extent can this motivation persist and develop in the long term? The use of technology in waste management practices is often driven by pragmatic reasons, but sustainable participation requires deeper factors, such as socially formed environmental values and identities.

Second, the role of technology in forming and strengthening social capital in society is also a crucial issue. Technology cannot be separated from social networks, trust between citizens, and collective norms that develop in society. Are digital applications capable of replacing or strengthening traditional forms of social interaction such as mutual cooperation, or are they shifting them into forms of individual participation that are transactional in nature? This research aims to examine the extent to which technology can create new spaces for ecological solidarity at the community level.

Third, there has been a transformation in patterns of social interaction and cultural participation in environmental management along with the development of digital technology. This change includes a shift from manual collective activities to individual-based digital processes, and from a physical meeting-based approach to online reporting and monitoring systems. This transformation is not always positive—in some cases, digitalization has actually led to a weakening of interactions between residents and a decline in local social values such as togetherness and mutual cooperation.

Fourth, there are socio-technical barriers that hinder the creation of inclusive engagement. These barriers include limited access to technology, low digital literacy, and social stigma against waste management activities. Not everyone has a smartphone or the ability to use apps. The elderly, women, and the urban poor often experience digital exclusion, leading to unequal participation.

By considering these four aspects, this study aims to understand in depth how digital technology innovation in waste management interacts with the social realities of Indonesian urban communities. This study not only highlights the technical aspects of digital

applications, but also places technology in a dynamic socio-cultural context. This research is important to ensure that technological innovation does not become an elitist and exclusive solution, but can truly become an instrument of inclusive, equitable, and sustainable social change.

Problem Formulation

Based on the background of the problems outlined above, this research begins with the realization that digital technology, in the form of waste bank applications, cannot be separated from the social, cultural, and community structure of the communities that use them. Therefore, the research problem is formulated as follows:

1. What is the form of community motivation in using digital waste bank applications, and to what extent does this motivation influence the sustainability of their participation in waste management?
2. What is the role of digital technology in shaping, strengthening, or even shifting forms of social capital at the community level in the context of waste management.
3. How does the transformation of social interaction patterns and participatory culture occur as a result of the use of digital waste bank applications?
4. What are the socio-technical barriers that hinder inclusive community involvement in the use of digital waste bank technology, especially for vulnerable groups?

This problem formulation not only reflects a focus on the social impact of technology, but also describes a research approach that places society as the main subject in the process of adopting and developing environmental innovations.

Research Objectives

The aim of this research is to understand and analyze in depth how communities interact with digital technology in the context of waste management, specifically through digital waste bank applications in urban areas in Indonesia. Specifically, this research aims to:

1. Identifying and analyzing various forms of motivation that encourage people to use digital waste bank applications, as well as their relationship to the sustainability of participation.
2. Examining the role of technology in forming or strengthening social capital in society, both in the form of trust, norms, and new social networks formed through digital systems.
3. Explains changes or transformations in social and cultural interaction patterns of community participation in waste management due to the use of digital applications.
4. Uncovering and analyzing social and technological barriers that hinder equitable and inclusive community engagement, particularly for technologically or socially marginalized groups.

With these objectives, this research is expected to contribute to the development of technology-based policies and innovations that are more sensitive to the social context and better ensure participatory justice in environmental management in urban Indonesia.

THEORETICAL BASIS

Technological Determinism Theory

Marshall McLuhan (1964) in his theory of technological determinism stated that media and technology are not only communication tools, but also expand and shape people's ways of thinking and behaving. Digital technology in waste management, such as waste bank applications, is not just a technical instrument, but a medium that changes people's perception of waste as a valuable resource and shapes new behaviors in everyday life (Martin & Badruddin, 2024). In this context, technology has the potential to drive social change, including shifting patterns of participation and ecological values (Lestari & Taufiq, 2025; Mashudi et al., 2023).

Social Capital Theory

Robert Putnam (2000) emphasized that trust, norms, and social networks are key components of social capital that encourage citizen participation in social life. In the context of digital waste bank applications, social capital is formed when citizens trust the system, actively interact with other users, and engage in community-based environmental activities. Technology can strengthen social capital if used as a means of building collaboration and collective trust (Durlauf & Fafchamps, 2005).

Theory of Social Transformation and Participatory Culture

Social transformation refers to changes in the structure and patterns of interaction in society due to external factors, including technology (Giddens, 1990). In the context of digital waste banks, social transformation occurs when traditional forms of collective participation (such as mutual cooperation and community service) shift to individual and online-based patterns (Fatmawati et al., 2022; Tomimi, 2024). This raises sociological questions about whether such changes strengthen or weaken social cohesion and ecological participation of citizens.

Theory of Inequality and Sociotechnical Barriers

Sociotechnical systems theory sees that technology does not stand alone, but interacts with social, political, economic, and cultural elements (Bijker, Hughes, & Pinch, 1987). Within this framework, the use of digital technology is prone to creating inequalities if access, digital literacy, and social norms are not taken into account (Gondwe et al., 2025; Rydzewski, 2025). These barriers can lead to the exclusion of certain groups, such as the elderly, women, and the poor, from digital participation processes.

CONCEPTUAL FRAMEWORK

Based on the four theories above, this study builds a conceptual framework that positions the digital waste bank application as a technology that interacts with the social dimensions of society. This framework is designed to understand the dynamics of its use.

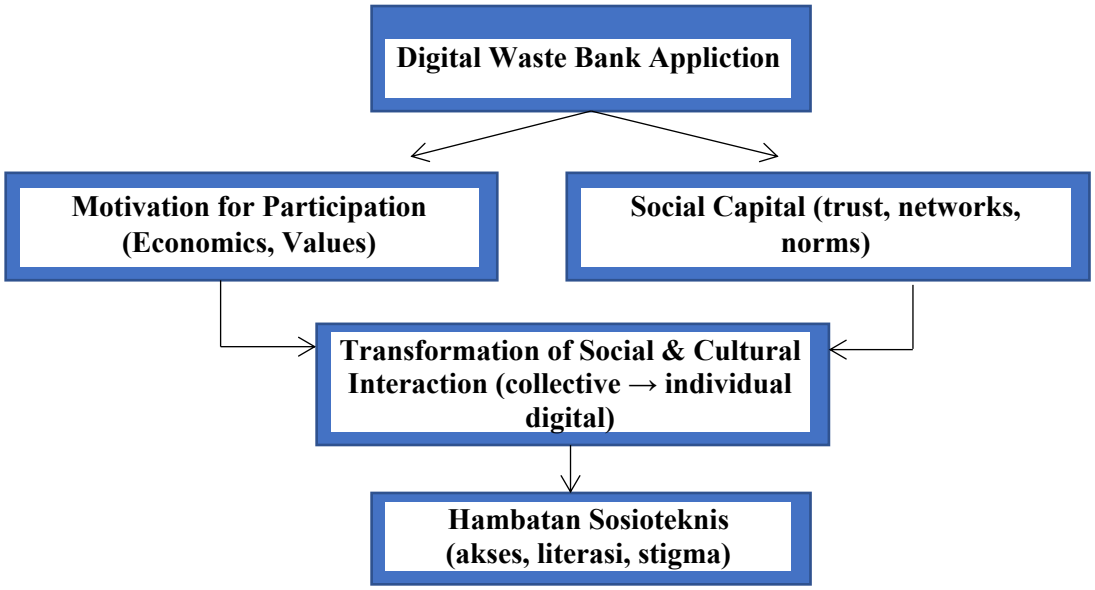

Fig 1. *Conceptual Framework Visualization*

This conceptual framework will serve as the basis for developing interview instruments, observation guides, and data analysis. It emphasizes that technology is only effective when closely connected to the social fabric of society, and that the success of digital innovation is largely determined by social acceptance and adaptation at the community level.

RESEARCH METHODS

Research Approach and Design

This study uses an interpretive qualitative approach with a multi-site case study design (Yin, 2018), which aims to deeply understand the interaction between digital waste bank technology and the social dynamics of urban communities. Researchers did not focus on quantitative measurements of participation, but rather on social meanings, narratives of experiences, and constructions of citizens' realities related to the use of digital applications in waste management.

Three cities were selected as study locations, namely Jakarta, Makassar, and Surabaya, because all three are urban areas with high levels of technology penetration and have become active trial or development locations for various digital waste bank platforms. The location selection was carried out purposively based on the following criteria: (1) active use of digital waste bank applications, (2) the existence of communities or RW/RT structures involved in environmental activities, and (3) the diversity of residents' socio-economic backgrounds.

Data Collection Techniques

Data is collected through three main techniques:

1. In-depth Interview (In-depth Interview)
   Researchers interviewed 20 key informants**,** consisting of:
   a. 9 active users of the application (coming from various age and educational backgrounds)
   b. 3 RT/RW heads who initiated or supported the digital waste bank program
   c. 3 environmental cadres or community facilitators
   d. 2 application managers (from the eRecycle and Rekosistem operational teams)
   e. 3 residents who did not use the app as a comparison

   Interviews were conducted in person and online (via Zoom), depending on location conditions and informant availability. The interview guide was structured around four main themes: motivations for participation, the role of technology in social capital, changing interaction patterns, and barriers to engagement.
2. Participatory Observation

   Researchers were directly involved in several community activities, such as app-based waste sorting training, sorting at residents' homes, and neighborhood association (RW) social activities related to environmental programs. Observations were conducted to understand the context of interactions, social communication, and natural community dynamics. Researchers recorded findings in field journals which were then coded along with interview data.
3. Study of Digital Documents and Archives

   Researchers also reviewed documentation of community activities, app usage reports, feature screenshots, digital educational materials, and online news covering the implementation of digital waste banks. These documents served as secondary data to strengthen field findings and broaden the context of the analysis.

Data Analysis Techniques

The data were analyzed using a thematic analysis approach (Braun & Clarke, 2006) which consists of six stages: (1) data transcription, (2) repeated reading, (3) open coding, (4)

grouping codes into themes, (5) testing the consistency of themes with the data, and (6) writing a narrative of the findings. The coding process was carried out with the help of NVivo 12 software to organize the data systematically.

The four main themes that are the focus of the analysis have been determined theoretically, but the researcher also opens up the possibility of new sub-themes emerging from empirical interactions in the field. Validation was carried out using source triangulation and method triangulation techniques, namely by comparing the results of interviews, observations and documents to ensure the validity of the findings.

Research Ethics

Prior to data collection, all informants were provided with an informed *consent* form explaining the purpose, benefits, and their rights in the study. Anonymity was maintained by changing informants' names and disguising specific locations when necessary. This research has undergone an internal ethical review by the researchers' academic institution.

Researcher Position

The researcher takes the position of a moderately *involved* participant observer, maintaining a balance between active involvement and analytical reflection. This engagement allows for a deeper understanding of residents' values, perceptions, and social logic that are not always explicitly conveyed in interviews.

RESULT AND DISCUSSION

The results of this study are presented based on four main themes that emerged from the analysis of field data, namely: (1) motivation for community participation in using digital waste bank applications, (2) the role of technology in forming and strengthening social capital, (3) transformation of social interaction patterns and participatory culture, and (4) socio-technical barriers that hinder inclusive involvement.

Motivation for Participation: Economic Incentives as a Trigger, Ecological Awareness as a Reinforcer

One of the main findings in this study is that **economic incentives** are the most dominant initial motivation for residents to use digital waste bank applications. As many as 16 out of 20 informants stated that they were motivated to use the application because of the direct financial benefits they felt. For example, the eRecycle application provides digital balance (OVO, GoPay) based on the weight of inorganic waste collected.

> "I saw in the brochure that it said you could make money from trash, so I finally gave it a try. "Not bad, I can use it to buy phone credit," said a housewife in East Jakarta (Interview with SNT, June 12, 2025).

However, participation doesn't stop at material motivation. Several informants, particularly those from younger and more educated age groups, mentioned that they were beginning to understand the environmental value of the activities. A student using Rekosistem in Surabaya stated:

> "Initially, I was invited by a friend and got points. But over time, you get used to it and feel guilty if you litter." (Interview with NR, Surabaya, June 18, 2025).

This finding strengthens the argument that economic incentives can be an initial trigger, but that gradually growing ecological awareness is the determining factor for the sustainability of participatory behavior.

Technology as a Strengthener of Social Capital: Between Trust, Transparency, and Community

Digital waste bank applications have proven instrumental in shaping new forms of digital social capital through system transparency, data reporting, and features that enable community interaction. For example, the transaction history feature in Octopus and the community leaderboard in Rekosistem allow users to compare their results with others.

> "We are holding a competition for the most active citizens in the Rekosistem application. The results are printed every week and displayed on the RW information board. It turns out that it makes people excited." (Interview with ERK, June 20, 2025).

This phenomenon shows that technology is not only a medium for individualization, but also a tool for strengthening social networks and collective trust, especially when combined with local leadership initiatives.

Social Transformation: From Mutual Cooperation to Individual and Digital Participation

Before the use of applications, community participation in waste management was generally carried out through collective activities such as community service, manual collection at waste bank posts, or clean RW programs. However, once the app started to gain widespread use, there was a shift towards individual and digital app-based participation**.**

Respondents stated that they prefer to store waste at home, then call a collection partner via the application, without having to meet in person.

> "We used to work together once a week. Now almost everyone sends trash via the application. "It's more practical, but it lacks a sense of togetherness," said a resident of South Jakarta (ST Interview, June 14, 2025).

This transformation indicates a shift in social interaction patterns, from a collective culture to a more efficient but less cohesive individual digital culture. From a sociological perspective, this creates a dilemma: increased efficiency, but also the potential loss of traditional social values such as mutual cooperation.

Barriers to Participation: Inequality of Access, Digital Literacy, and Social Stigma

Despite the many perceived benefits, there are still **significant barriers** that limit the inclusive adoption of technology. First, **low digital literacy** among the elderly and those with low education is a major obstacle. One elderly resident stated:

> "I can't use the app. I have to ask my grandson to input the trash. If he doesn't come, I can't deposit it." (Interview, SNT, West Jakarta, June 16, 2025)

Second, there is a social stigma against the activity of sorting and collecting waste, which, even though it is done through digital platforms, is still considered a menial job.

> "There are neighbors who say I look like a scavenger even though I use an app. "They don't understand that this can be an environmental savior," said a woman who uses Rekosistem in Makassar (RN Interview, June 21, 2025).

Third, infrastructure limitations such as uneven internet service, *drop point locations* that are far from densely populated areas, and the application not being integrated with the city government's waste management system are also real challenges in implementing this technology.

Key Roles of Social Actors: Local Leadership and Community Facilitators

This study also shows that **local social actors** such as RW heads, youth movement activists, and environmental cadres play an important role in the successful adoption of digital waste bank applications. In areas with strong community structures, app adoption rates are

higher and more sustainable. Conversely, in areas that do not have active facilitators, programs tend to stagnate.

A Rekosistem facilitator said:

> "We don't just teach people how to use the app, we also support them. If they just give them the app, many people won't be interested." (Interview with AS, Surabaya, June 19, 2025)

This reinforces the understanding that digital technology in an environmental context cannot work alone. It must be accompanied by a process of mentoring, education, and community-based social organizing.

Discussion

The results of this study indicate that digital technology in waste management, particularly through digital waste bank platforms such as eRecycle, Octopus, and Rekosistem, is not merely a technical tool, but acts as an agent of social change. McLuhan's (1964) technological determinism approach is relevant in this context, where technology functions as an extension of human social behavior that shapes perspectives and interaction patterns regarding waste. Through features such as point systems, transaction tracking, and participation data collection, these applications have formed a new ecosystem in waste management that is more transparent, personalized, and measurable. However, in practice, the effectiveness of this technology is highly dependent on the social conditions of the community and the support of existing community structures.

The social transformation that occurs through the use of this application is clearly visible in the shift in participation patterns. Before digitalization, waste sorting and management activities were often carried out collectively through *community service* or village activities that were based on mutual cooperation. Today, the process has shifted to a more transactional individual participation. One respondent noted that residents were busier "doing things themselves through apps," and that social interactions among neighbors were decreasing. This suggests that while technology promotes efficiency and convenience, it also carries the risk of weakening social cohesion, previously a key strength in community-based neighborhood management (Putnam, 2000).

On the other hand, technology also opens up new avenues for the formation of ecological identities. Gamification features like badges, leaderboards, and recycling track records not only serve as individual motivational triggers but also create new social symbols. Young respondents in Surabaya expressed pride in being "active users of Rekosistem," which appears on the list of top communities. This demonstrates that technology can create new forms of environmental symbolic capital, where participation in environmentally friendly activities becomes part of a lifestyle and social status (Fuchs, 2014).

However, not all community groups responded equally to this innovation. Findings show that participation is heavily influenced by digital literacy, education level, age, and cultural perceptions of waste. Seniors, for example, face barriers to accessing the app's features and may even have to rely on children or grandchildren to use the service. In addition, there is still a stigma that the activity of sorting and collecting waste, even though it is done through an application, is still associated with "lowly" work. One respondent said his neighbor commented, “like a digital scavenger.” This reflects the need for a cultural approach and public education that accompanies technological innovation, so that there is a change in social perception regarding the role of waste management.

What stands out most from this study is the important role of social actors, such as RW heads, neighborhood cadres, and community volunteers. Their presence is crucial to the success of application adoption, particularly in expanding user reach and providing technical understanding and social motivation. The ecosystem in Surabaya, for example, achieved high

participation rates precisely because of the direct involvement of neighborhood associations (RT/RW) and the integration of digital systems into village activities. This supports the findings of Swyngedouw (2009) and Mulgan et al. (2007), which emphasize the importance of a hybrid model between digital systems and local social systems.

Thus, this discussion confirms that the success of the digital waste bank platform in addressing the waste emergency in Indonesia cannot be separated from the social and cultural dimensions that surround it. Technology is not a single solution, but rather part of a system that must be designed in an inclusive, participatory, and values-based manner. Digitalization will only be effective if supported by social capital, cultural legitimacy, and positive symbolism of environmental action. Therefore, future strategies for developing digital waste banks must integrate technical and sociological approaches.

Key Research Findings

This research yields several important findings that illustrate the complex dynamics between digital technology innovation and social structures in urban waste management. These findings are organized around the following four main research focuses:

1. Motivation for Participation: Economics as a Trigger, Ecological Values as a Reinforcer

   Public participation in using digital waste bank applications was initially driven by direct economic incentives offered by the applications such as e-wallet balances or reward points. However, this motivation has developed over time into a form of ecological awareness, especially among the younger generation and the upper secondary education group. This phenomenon shows a motivational transition from simply "making money from waste" to "social responsibility towards the environment".
2. Digital Technology as a Catalyst for New Social Capital

   Digital waste bank applications have the potential to strengthen digital social capital, namely trust and social networks formed through technological systems. Features such as transaction history, community competitions, and transparency of waste collection logs increase mutual trust among residents and encourage data-driven social cooperation. However, this effectiveness is highly dependent on the involvement of community facilitators and local figures as social bridges between technology and citizens.
3. Transformation of Social Interaction and Participatory Culture

   The use of digital applications has triggered a shift from collective to individual participation, where social activities such as community service, waste bank posts, and community meetings are being replaced by personal practices through applications. This transformation has two sides: on the one hand, it increases efficiency and convenience, but on the other, it risks weakening the social cohesion and culture of mutual cooperation that have long been the strong foundation of community-based environmental management.
4. Sociotechnical Barriers and Inequality of Access

   Despite promising digital inclusion, digital waste bank applications still face various socio-technical barriers, such as:
   a. Low digital literacy among the elderly and low-educated citizens.
   b. Limited access to smartphones and internet connections in densely populated areas.
   c. Social stigma against the activity of sorting and collecting waste is still considered "lowly".

   These barriers demonstrate that technology can create new participation gaps if not accompanied by adequate social support strategies
5. The Role of Local Social Actors as Key Leverage

   The presence and leadership of local actors such as RT/RW heads, youth leaders, and environmental cadres are crucial for the success of the application's implementation. In areas with strong social leadership, app adoption is more widespread and sustainable.

This confirms that technology requires social intermediaries to function effectively in community spaces.

These findings reinforce the position that technology in the context of environmental management is not simply a tool, but a social phenomenon interconnected with structures of values, norms, and social networks**.** Therefore, a technological approach to the waste emergency must be accompanied by a locally based social empowerment strategy oriented toward participatory justice.

CONCLUSIONS

This research shows that digital technology, in the form of waste bank applications, has made a significant contribution to emergency waste management efforts in urban Indonesia. This innovation not only accelerates waste collection and management but also brings about significant changes in the structure of community participation and their perspectives on the environment.

Apps like eRecycle, Octopus*,* and Rekosistem have successfully combined economic incentives, data transparency, and ease of access to encourage citizen participation. However, success is not solely determined by the technology's design. The application's effectiveness is largely determined by the social context in which it is implemented—including social capital, the role of local leadership, cultural norms, and community perceptions of waste management activities.

Technology is not a single actor, but rather part of a broader social system. In some cases, the use of technology has shifted participation patterns from collective (mutual cooperation) to individual and transactional. On the other hand, applications also open up opportunities for the formation of new ecological identities among urban communities, especially young people, through gamification and symbolic rewards. This demonstrates that technology can serve as a catalyst for social change, provided it is accompanied by an educational approach and appropriate policies.

This research also revealed the existence of participation inequality due to digital literacy barriers, limited access to technology, and social stigma towards waste management activities. Therefore, adopting technology without considering sociocultural factors actually risks widening social disparities and weakening collective spirit.

Thus, strengthening the integration between technological innovation and social approaches is key to the long-term success of the digital waste bank program. Technology must be built not only for technical efficiency, but also to support the values of togetherness, community self-reliance, and ecological sustainability.

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