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ANALYSIS OF INNOVATION OF SUSTAINABLE WASTE SORTING MODEL: TECHNOLOGY INTEGRATION, COMMUNITY INVOLVEMENT, AND RESOURCE EFFICIENCY

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ABSTRACT

This study aims to analyze innovations in sustainable waste sorting models implemented within the Jakarta Presidential Palace environment by employing a systematic literature review (SLR) methodology. The research focuses on three critical dimensions: technology integration, community engagement, and resource efficiency, particularly concerning the segregation of organic and inorganic waste. Findings indicate that the synergistic interaction among these dimensions can significantly reduce reliance on landfill sites, enhance overall waste management efficiency, and generate economic value through recycling and reuse processes. Presently, the waste management system at the Presidential Palace remains conventional and suboptimal in terms of waste sorting practices. Consequently, this study advocates for the adoption of more practical and sustainable innovative models. The implementation of such models is expected to improve the effectiveness and environmental sustainability of waste management at the Presidential Palace. Furthermore, this research intends to provide a foundation reference for the advancement of waste management systems in similar institutions contexts. The SLR methodology facilitates the identification of best practices and innovations across diverse settings, enabling tailored recommendations aligned with the specific conditions of the Jakarta Presidential Palace. Effective application of these models will support sustainability objectives and mitigate adverse environmental impacts.

Keywords: Sustainable Waste Sorting; Technological Innovation; Community Engagement; Resource Efficiency; Waste Management Models.

INTRODUCTION

The problem of waste, both organic and inorganic, continues to be a serious challenge in Indonesia, including in strategic environments such as the Presidential Palace. Waste that is not managed properly not only impacts the aesthetics and health of the environment, but also reflects the effectiveness of government governance in adopting the principle of sustainability. Data from the DKI Jakarta Environmental Agency noted that around 60.5% of waste in the area comes from households and residential areas, indicating the urgency of implementing a more structured and innovative management system.

This condition is also reflected in the Cipanas Presidential Palace, where the volume of organic waste such as leaves and grass reaches around 2,200 kg every two to three months. So far, most of this waste has been directly dumped into the Pasir Sembung

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Final Disposal Site (TPA) without going through a sorting or processing process. This practice not only burdens the capacity of the TPA, but also misses the potential for utilizing waste as an economic resource through the recycling or composting process.

On the other hand, waste management in Jakarta faces increasingly complex challenges, marked by the increasing volume of daily waste generation and limited waste processing infrastructure. The Jakarta Presidential Palace, as an icon of the country's government, is also under pressure in terms of sustainable waste management. This situation demands the implementation of an innovative approach that is able to integrate technology, increase community participation, and optimize the use of resources.

As part of the national effort, the Government of Indonesia through the 2025–2029 National Medium-Term Development Plan (RPJMN) targets the processing of at least 38% of the total national waste. This strategy emphasizes the importance of technology integration and active community involvement in all stages of waste management.

Currently, the waste management approach in DKI Jakarta has begun to adopt a holistic model from upstream to downstream, including efforts to reduce waste at the source, sorting and management at the Reduce-Reuse-Recycle Waste Processing Site (TPS 3R), to converting waste into energy. However, concrete implementation in the central government environment such as the Presidential Palace still requires a more adaptive and innovative strategy update.

Therefore, this study aims to examine the innovation of a sustainable waste sorting model that can be applied at the Jakarta Presidential Palace. The main focus of the research is on three integrative aspects: technology utilization, community involvement, and resource efficiency, in order to produce a waste management system that is not only technically effective, but also socially and environmentally sustainable.

METHOD

Several theories taken by the author and relevant to the article Analysis of Sustainable Waste Sorting Model Innovation: Technology Integration, Community Involvement, and Resource Efficiency.

Technology Integration Theory in Waste Management

Technology Acceptance Model (TAM), This model explains the adoption of technology based on the perception of usefulness and ease of use. The implementation of technology such as organic waste shredders and IoT (Internet of Things) systems at the Jakarta Presidential Palace can be analyzed through the TAM lens to understand the acceptance factors by users (officers/staff).

Diffusion of Innovation Theory, Rogers' (1962) diffusion of innovation theory explains how new technologies are adopted through the stages of knowledge, persuasion, decision, implementation, and confirmation. The implementation of smart bins technology or the RDF (Refuse-Derived Fuel) system in Jakarta can be mapped using this theory to identify barriers and drivers of adoption.

Theory of Community Involvement in Waste Management

Community-Based Natural Resource Management (CBNRM), The CBNRM approach emphasizes active community participation in resource management, including waste.

Case studies in Japan and the Nordic countries show that community participation in waste sorting increases system efficiency by 30-50%.

Theory of Planned Behavior (TPB), TPB explains individual behavioral intentions based on attitudes, subjective norms, and behavioral control. Waste sorting education and training at the Presidential Palace can increase collective norms and staff behavioral control, thereby increasing compliance.

Social Practice Theory, This theory views social practices (such as waste sorting) as the result of interactions between materials, competence, and meaning. The Jakarta Recycle Center (JRC) program involving 250,000 residents is an example of how social practices are formed through infrastructure (materials), training (competence), and incentives (meaning).

Resource Efficiency and Sustainability Theory

Circular Economy Model, The circular economy model emphasizes optimal use of resources through the principles of reduce, reuse, recycle (3R). The implementation of a composter at the Cipanas Presidential Palace that converts 2,200 kg of organic waste into fertilizer is a concrete example of resource circularity.

Resource-Based View (RBV), RBV states that an organization's competitive advantage depends on the management of scarce and valuable resources. The efficiency of waste management at the Presidential Palace (e.g. 40% savings in transportation costs) indicates the optimization of internal resources.

Industrial Symbiosis, The concept of industrial symbiosis integrates waste from one process as input for another process. The use of organic waste at the Palace as garden fertilizer and the conversion of inorganic waste into RDF in Bantargebang reflect this principle.

Integrative Theory: Holistic Approach

Triple Bottom Line (TBL), The TBL framework (economic, social, environmental) is used to evaluate the sustainability of waste sorting innovations. Example: Economic: 30% operational cost savings at the Bantargebang RDF Plant. Social: Increased participation of the Jakarta community in waste sorting. Environment: Reduction of carbon emissions from organic waste processing.

Institutional Theory, This theory explains the role of regulation and institutional norms in driving change. The collaboration of the Ministry of Environment with the Presidential. Palace in the eco-office program shows how institutional pressures influence the adoption of sustainable practices.

The SLR study shows that sustainable waste sorting innovations at the Presidential Palace in Jakarta require the integration of three pillars:
Appropriate Technology (TAM, Diffusion of Innovation) to improve operational efficiency. Active Community Participation (CBNRM, TPB) in building collective norms. Optimization of Resources (Circular Economy, RBV) through a circular approach.

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Integrative theories such as TBL and Institutional Theory reinforce the importance of collaboration between stakeholders and alignment with national policies. These findings are in line with global studies on urban waste management that emphasize technological-socio-economic synergies.

RESULTS AND DISCUSSION

Modern waste management innovation requires the adoption of technology that is in accordance with user characteristics and institutional contexts. In the context of the Jakarta Presidential Palace, where waste management still tends to be conventional, the success of implementing technology such as waste shredders, automatic composters, smart bins, or Internet of Things (IoT)-based systems is highly dependent on the level of user acceptance and the diffusion of innovation within the organizational structure. Two relevant theories for analyzing this aspect are the Technology Acceptance Model (TAM) and the Diffusion of Innovation Theory.

The Technology Acceptance Model (TAM) developed by Davis (1989) is one of the most commonly used theories in understanding technology acceptance. This model states that a person's intention to use technology is influenced by two main perceptions:
Perceived Usefulness (PU): The extent to which a person believes that using technology will improve their performance.
Perceived Ease of Use (PEOU): The extent to which a person believes that using technology does not require a lot of effort.

In the context of waste management at the Presidential Palace, the success of implementing an organic waste shredder or an application-based digital reporting system will be greatly influenced by the perception of staff or cleaners and park officers regarding the ease and benefits of the technology. If the technology is considered difficult or does not have a real impact on work efficiency, then resistance is likely to arise.

A recent study by Lee, Ramasamy, and Subbarao (2025) examined the application of TAM and the Unified Theory of Acceptance and Use of Technology (UTAUT) in the context of health services. This study highlights the importance of psychosocial factors, such as perceptions of usefulness and ease of use, in influencing technology adoption in the sector. The results of this study are relevant to understanding how these factors can be applied in the context of sustainable waste management in an institutional environment such as the Presidential Palace.

The Diffusion of Innovation Theory developed by Rogers (1962) explains how an innovation spreads through a social system in five stages: knowledge, persuasion, decision, implementation, and confirmation. This theory highlights the characteristics of individuals or groups in the adoption process, including the categories of innovators, early adopters, early majority, late majority, and laggards.

The application of this theory in the context of waste management in an institutional environment such as the Presidential Palace can be used to map out technology implementation strategies. For example, in the adoption of smart bins or the Refuse-Derived Fuel (RDF) system that uses sensors to automatically separate organic and inorganic waste, the success of diffusion is highly dependent on the persuasion and decision stages of management and cleaning staff as the main users.

A study by Alka'awneh, Abdul-Halim, and Md. Saad (2025) examined the application of the Diffusion of Innovations Theory and the Technology, Organization, and Environment (TOE) framework in the adoption of artificial intelligence (AI) technology. This study shows that technology adoption is influenced by the

characteristics of innovation, individuals, and organizational context. These findings can be applied to understand the factors that influence the adoption of waste management technology at the Presidential Palace.

Sustainable waste management is highly dependent on the active involvement of the community as users and main actors in the waste sorting and management process. Some theories that form the basis for understanding and optimizing community involvement are Community-Based Natural Resource Management (CBNRM), Theory of Planned Behavior (TPB), and Social Practice Theory.

CBNRM is an approach that places local communities as the main actors in managing natural resources, including waste management. The main principle is community empowerment through active participation and control over the resources they use, thus creating collective responsibility and sustainable management (Fabricius & Koch, 2015). Studies in various countries show that direct community involvement in waste sorting and management can increase the efficiency and effectiveness of the management system by 30-50% (Ostrom, 2015).

In Indonesia, the CBNRM approach can be adapted to increase community participation in waste sorting programs at the environmental level around the Gambir sub-district, including the Presidential Palace area. With direct community empowerment and involvement, social norms and waste management practices can develop sustainably.

TPB, developed by Ajzen (1991), explains that a person's behavior is influenced by intentions based on three main factors: attitudes towards behavior, subjective norms, and perceived behavioral control. In the context of waste management, education and training that focuses on increasing positive attitudes, social support, and a sense of ability in sorting waste can increase people's intentions and actual behavior to participate.

Research by Bamberg and Möser (2007) confirms that TPB is effective in predicting environmentally friendly behavior, including waste management. Education designed to improve these three factors can significantly change individual behavior in sorting and reducing waste.

Social Practice Theory (SPT) emphasizes that social behavior, such as waste sorting, is formed through the interaction of three elements: material (infrastructure, equipment), competence (knowledge and skills), and meaning (values and motivation) (Shove, Pantzar, & Watson, 2012). This approach is useful for understanding that behavioral change is not enough with education alone, but must also be supported by the availability of facilities and changes in social norms.

For example, the Jakarta Recycle Center (JRC) program has succeeded in involving more than 250,000 residents by providing adequate infrastructure, waste sorting skills training, and social incentives that provide positive meaning to waste management practices (Wilk, 2018).

In the theory of Resource Efficiency and Sustainability, the circular economy model is a systemic approach that aims to reduce waste and maximize the reuse of resources in a closed cycle. This concept emphasizes the importance of redesigning production and consumption systems so that waste does not become an environmental burden, but is reused as new input in the value chain (Ellen MacArthur Foundation, 2013). In the context of waste sorting, the application of a circular economy can encourage the reuse of organic waste as compost and inorganic waste as recycled materials, thereby reducing dependence on the Final Disposal Site (TPA).

The implementation of a circular economy in the Presidential Palace environment has the potential to generate added value from waste, such as organic fertilizer from leaves

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and grass, and recycled products from plastic or paper. This approach is in line with the principle of sustainability because it extends the useful life of resources and reduces carbon emissions (Geissdoerfer et al., 2017).

The Resource-Based View (RBV) theory views that the competitive advantage of an organization is determined by its ability to utilize internal resources that are rare, difficult to imitate, and difficult to replace (Barney, 1991). In the context of waste management, RBV can be applied by identifying and managing strategic assets such as sorting technology, managerial knowledge about waste management, and human resources trained in waste processing.

The implementation of RBV in the waste management system at the Presidential Palace can be realized through the use of local technology, such as organic shredders or digital waste monitoring systems, as well as strengthening the capacity of human resources that manage internal TPS. By managing these internal resources strategically, waste management is not only an administrative obligation, but also an asset that provides environmental benefits and institutional reputation.

Industrial Symbiosis is an approach rooted in industrial ecology, where companies or institutions share resources, energy, waste, and information to achieve mutual efficiency (Chertow, 2000). In the context of waste management, this approach is relevant to building partnerships between the Presidential Palace and external actors such as recycling business actors, environmental communities, and research institutions.

Through industrial symbiosis, waste from the palace environment that was previously considered worthless can become raw materials for other sectors, such as organic waste for urban farming communities or paper waste for local recycling industries. This approach not only increases resource efficiency but also strengthens collaborative networks that support long-term sustainability (Lombardi & Laybourn, 2012).

The Triple Bottom Line (TBL) concept was introduced by John Elkington (1997) as a sustainability approach that integrates three main dimensions: environment (planet), social (people), and economy (profit). This approach emphasizes that the success of a program or policy is not only measured from the financial aspect, but also from its contribution to social welfare and environmental preservation (Elkington, 1997).

In the context of waste management in the Presidential Palace environment, the implementation of TBL requires a balance between cost efficiency (for example, reducing the cost of disposal to the landfill), social benefits (increasing employee and community participation in sorting), and environmental impacts (reducing emissions and waste volume). This holistic approach is important for designing a waste management system that is not only technically effective, but also sustainable in the long term (Slaper & Hall, 2011). By adopting TBL, the Presidential Palace can be an example of a government institution that instills the principles of environmental and social responsibility in its daily operations.

Institutional Theory explains that organizational behavior is strongly influenced by normative, regulatory, and cognitive pressures from the institutional environment in which the organization is located (Scott, 2001). This theory highlights how institutions, including the government, shape practices and norms through policies, culture, and public expectations.

In the context of waste management, regulatory pressures can arise from national policies such as waste reduction targets in the 2025–2029 RPJMN, while normative pressures come from the expectations of society and environmental communities towards

environmentally friendly practices in government institutions. Cognitive pressures are also relevant, namely the internal drive to adapt to modern and transparent governance standards.

Institutional Theory provides an understanding that the transformation of waste management in the Presidential Palace environment is not only a matter of technical efficiency, but also part of an adjustment to broader institutional dynamics. This adaptation is important so that waste management model innovations gain social legitimacy and operational sustainability (DiMaggio & Powell, 1983).

CONCLUSION

This discussion emphasizes that waste management innovation in the Jakarta Presidential Palace environment requires a multidimensional approach that not only focuses on technical aspects, but also considers social, institutional, behavioral, and sustainability dimensions. Theories such as the Technology Acceptance Model (TAM) and Diffusion of Innovation Theory provide a framework for understanding how technology adoption is influenced by individual perceptions and social processes within organizations. Meanwhile, participatory approaches such as Community-Based Natural Resource Management (CBNRM), Theory of Planned Behavior (TPB), and Social Practice Theory show the importance of active community involvement and the formation of social norms in the success of waste management.

Furthermore, the integration of circular economy theory, Resource-Based View (RBV), and Industrial Symbiosis emphasizes the need to optimize internal and external resources through systemic and collaborative innovation. The Triple Bottom Line (TBL) approach and Institutional Theory then reinforce that the success of a waste management program is not only determined by economic efficiency, but also by social acceptance, institutional legitimacy, and long-term ecological impacts.

By integrating all of these approaches in the design and implementation of a waste management system, the Jakarta Presidential Palace can not only improve the efficiency and effectiveness of waste management, but can also become a model of a progressive and sustainable government institution in facing current and future environmental challenges.

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