



Integrating gold savings-based waste banks and baby diaper waste resin handicraft innovation for sustainable micro, small, and medium enterprise empowerment: An industrial systems perspective

Sri Purwati^{1,*}

¹ Department of Industrial Engineering, Faculty of Engineering, Universitas Islam Batik, Surakarta, Central Java 57147, Indonesia.

*Correspondence: sri.purwati@uibs.ac.id

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ABSTRACT

Background: community-based circular economy initiatives increasingly require the integration of financial mechanisms with waste management and micro, small, and medium enterprises (MSMEs) empowerment. This study examines how the integration of gold savings-based waste banks with resin handicraft production from baby diaper waste can enhance MSMEs capacity, stabilize community participation, and support system sustainability. The research is grounded in institutional and behavioral economic theories, highlighting the role of value-stabilizing incentives in shaping household and MSMEs decision-making. **Methods:** a mixed-methods approach was employed, including participant observation, structured interviews, and quantitative analysis of production, financial, and participation data. The study is grounded in circular economy principles and institutional incentive design theory, emphasizing long-term value mechanisms as drivers of system stability and effectiveness. **Findings:** the integration of gold savings stabilizes community participation, improves the quality and availability of raw materials, enhances MSMEs financial resilience, and reduces environmental impact by diverting baby diaper waste from landfills into productive cycles. Reinforcing feedback loops between economic incentives, social engagement, and environmental outcomes strengthen system durability and scalability. The framework acts as a critical alignment mechanism that coordinates behavioral, operational, and value flows across the community-based industrial system. **Conclusion:** institutionally supported, value-stabilized mechanisms such as gold savings-based waste banks provide a replicable pathway for sustainable community-based circular economy initiatives. The study offers novel insights into the integration of financial innovation, waste utilization, and MSMEs empowerment, providing a practical model for replication in emerging economies. **Novelty/Originality of this article:** this study provides an empirically grounded, replicable, and context-sensitive framework linking financial instruments directly to environmental and social impact while enhancing MSMEs sustainability. Unlike previous research, it demonstrates how institutionally supported long-term value mechanisms can simultaneously stabilize community participation, support inclusive economic empowerment, and promote circular economy practices in emerging economies.

KEYWORDS: baby diaper waste; circular economy; community sustainability; gold savings swaste bank; MSMEs empowerment.

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1. Introduction

Rapid urbanization, demographic growth, and shifts in consumption patterns have significantly increased the generation of municipal solid waste, particularly single-use hygiene products such as baby diapers. Baby diaper waste is classified as complex residual waste due to its multilayer structure composed of plastics, synthetic fibers, and superabsorbent polymers (SAP), which are highly resistant to natural degradation and may persist in the environment for decades (Płotka-Wasyłka et al., 2022; Kordecki et al., 2022). In developing countries, including Indonesia, inadequate waste segregation and limited recycling infrastructure result in the accumulation of baby diaper waste in landfills, exacerbating environmental pollution, greenhouse gas emissions, and public health risks (Iskandar Shah et al., 2025; Schenck et al., 2024).

To address these challenges, the circular economy has emerged as a strategic framework aimed at decoupling economic growth from resource depletion by promoting waste reduction, resource efficiency, and value retention across product life cycles (Subramaniam et al., 2025; Shieh et al., 2025; Ince, 2025). Unlike the linear “take–make–dispose” paradigm, the circular economy emphasizes regenerative systems in which waste materials are reintegrated into production and consumption processes (Scheel & Aguiñaga, 2025). However, empirical evidence suggests that the successful implementation of circular economy principles at the community level depends not only on technological innovation but also on institutional design, incentive mechanisms, and stakeholder coordination (Ceddia et al., 2024; Becchetti et al., 2024).

In Indonesia, one of the most widely adopted community-based waste management instruments is the waste bank system (*bank sampah*). Waste banks function as socio-technical institutions that encourage household-level waste segregation, improve recycling rates, and provide economic incentives through waste-based savings schemes (Tomimi, 2024; Ariescy et al., 2025; Sari et al., 2025). Several studies have demonstrated that waste banks contribute positively to environmental awareness, waste reduction, and supplementary household income, particularly in urban and peri-urban areas (Atmanti & Rejekiingsih, 2024; Wati, Brata, & Ali, 2025; Susilowati & Kasjono, 2025). Nevertheless, conventional waste bank models remain vulnerable to fluctuating recyclable material prices and short-term cash-based incentives, often resulting in inconsistent participation and unstable material supply (Wellang et al., 2025; Sultan et al., 2025).

Recent developments indicate an evolution of waste bank systems through integration with financial inclusion instruments, particularly gold savings schemes facilitated by Pegadaian. Pegadaian, as a state-owned financial institution with extensive national outreach and high public trust, plays a critical role in expanding access to micro-savings and asset-based financial services (Mariyani & Arifin, 2025; Al Faiqoh & Mugiyati, 2025; Faiza et al., 2024). Gold savings are characterized by relative price stability, inflation hedging, and low entry barriers, making them suitable as long-term value storage for low- and middle-income communities (Salam et al., 2025; Badzlina & Arifin, 2025). By converting waste deposits into gold-based savings, waste is reframed from a low-value commodity into a long-term financial asset, strengthening institutional sustainability and community participation.

From an Industrial Engineering perspective, the integration of gold savings-based waste banks represents a community-scale industrial system involving coordinated material flows, value flows, information flows, and multi-actor decision-making. Industrial Engineering emphasizes system optimization through the alignment of resources, processes, incentives, and institutional roles to enhance efficiency, resilience, and sustainability (Pimenta et al., 2025; Somatkar, et al., 2025). Within this framework, waste banks can be conceptualized as value integration hubs that connect households as material suppliers, Pegadaian as a value stabilizer, and productive enterprises as value creators.

A critical opportunity within this integrated system lies in the upcycling of baby diaper waste into resin-based handicraft products. Upcycling focuses on transforming waste materials into products with higher economic value, extended lifespan, and differentiated

market positioning, thereby contributing to both environmental and economic sustainability (Nutrizio et al., 2024). Previous studies have explored the utilization of non-conventional waste streams for creative industries and handicraft production, highlighting their potential to support local economic development and circular business models (Ratalewska, 2024). However, empirical research on baby diaper waste utilization for resin-based handicraft production remains limited, particularly when examined as part of an integrated, community-based industrial system.

Micro, small, and medium enterprises (MSMEs) play a central role in Indonesia's economic structure, contributing significantly to employment generation, income distribution, and regional economic resilience. Despite their strategic importance, MSMEs often face structural constraints related to inconsistent raw material supply, limited access to financial services, and vulnerability to market volatility (Wube & Atwal, 2024). Integrating gold savings-based waste banks with resin handicraft MSMEs offers a systemic solution by stabilizing raw material availability, embedding financial incentives within the production ecosystem, and enhancing MSMEs resilience through community-based resource loops.

Although prior studies have examined waste bank performance, circular economy practices, financial inclusion, and MSMEs empowerment as separate domains (Warsiyah, Mawardi, & Fahrurrozi, 2025; Permatasari, Suparno, & Lutfia, 2024; Irfana, Harjono, & Diana, 2023), empirical research that captures the systemic integration of these elements remains scarce. In particular, there is limited analysis positioning gold savings-based waste banks, facilitated by Pegadaian, as institutional hubs that simultaneously integrate waste management, value stabilization, and value-added MSMEs production within a unified industrial systems framework.

Therefore, this study aims to analyze the integration of Pegadaian's gold savings-based waste banks and baby diaper waste resin handicraft innovation in supporting sustainable micro, small, and medium enterprise empowerment from an industrial systems perspective. This research focuses on practical implementation, institutional roles, and incentive mechanisms. The study is expected to provide empirical contributions to the development of community-based circular economy practices while simultaneously strengthening Pegadaian's role within the national sustainability ecosystem.

2. Methods

2.1 Research design and approach

This study adopts a qualitative descriptive approach using a system-oriented case study design to analyze the integration of Pegadaian gold savings-based waste banks and baby diaper waste resin handicraft innovation in supporting sustainable micro, small, and medium enterprise (MSMEs) empowerment. This approach is selected to enable an in-depth understanding of real-world implementation, institutional roles, incentive mechanisms, and interactions among system components within a community-based circular economy context.

From an Industrial Systems perspective, the study views waste management and MSMEs empowerment as an interconnected socio-technical system consisting of material flows, value flows, information flows, and coordinated actor roles. A qualitative case study is considered appropriate to capture system dynamics, behavioral responses, and institutional interactions that cannot be adequately explained through purely quantitative methods.

2.2 Research location and period

The research was conducted at Bank Sampah Kitiran Emas, a Pegadaian partner waste bank that integrates a gold savings scheme into its waste management system and links

baby diaper waste collection to resin handicraft MSMEs production activities. This location was purposively selected because it represents an operational example of integrated waste management, financial incentive mechanisms, and value-added production at the community level.

The study was carried out during the period August 2024 to December 2025, covering multiple operational cycles of waste collection, gold savings transactions, handicraft production, and MSMEs empowerment programs. This time frame allows for sufficient observation of system stability, participation consistency, and sustainability outcomes.

2.3 Research population, subjects, and sampling technique

The research population includes all actors involved in the integrated system of the gold savings-based waste bank and resin handicraft MSMEs. The research subjects consist of: (1) Waste bank managers and operational staff; (2) MSMEs actors engaged in baby diaper waste resin handicraft production; (3) Pegadaian representatives involved in gold savings facilitation; and (4) Supporting stakeholders, including local government and community leaders. Informants were selected using purposive sampling, based on criteria of direct involvement in system design, operational decision-making, waste management processes, financial incentive implementation, or MSMEs production and marketing activities. Data collection was continued until thematic saturation was achieved to ensure comprehensive representation of system dynamics.

2.4 Research constructs, variables, and analytical framework

The analysis focuses on key constructs derived from an Industrial Engineering and circular economy perspective, including: (1) Gold savings-based waste bank management system, examined as a long-term economic incentive and value stabilization mechanism; (2) Baby diaper waste resin handicraft innovation, analyzed as a value-added material transformation and upcycling process; (3) MSMEs empowerment outcomes, reflected in production continuity, income stability, and business autonomy; and (4) Sustainability performance, encompassing economic, environmental, and social dimensions. These constructs form an integrated analytical framework to examine the relationships between material flows, value flows, institutional roles, and system outcomes. The framework is used to assess whether empirical evidence supports the proposed one-tailed hypotheses, namely that gold savings-based incentives positively influence participation stability, material supply reliability, and sustainable MSMEs empowerment.

2.5 Role of Pegadaian in the system analysis

Within the analytical framework, Pegadaian is positioned as a key institutional actor that provides value stabilization and financial incentive mechanisms through its gold savings scheme. Pegadaian's role is analyzed in terms of its contribution to trust-building, transaction transparency, and long-term value accumulation for waste bank participants and MSMEs.

Methodologically, Pegadaian is examined as a system enabler that aligns environmental objectives with economic incentives, thereby influencing community behavior, participation consistency, and the resilience of MSMEs operations. This positioning directly supports the study's focus on practical implementation and institutional integration.

2.6 Data sources and materials

The study utilizes primary and secondary data sources. Primary data were obtained from in-depth interviews, direct observations, and field notes. Secondary data include waste

bank operational records, gold savings transaction data, MSMEs production and sales reports, and relevant program documentation.

Materials observed in the study include baby diaper waste processing tools, resin materials, simple production equipment, and documentation related to gold savings accounts. These materials support the empirical examination of material transformation and value creation processes within the system.

2.7 Data collection techniques

Data were collected using multiple techniques to ensure data richness and validity: (1) Semi-structured interviews to explore perceptions, experiences, and institutional roles related to waste management, gold savings incentives, and MSMEs activities; (2) Direct observations to map waste collection procedures, pre-treatment stages, resin handicraft production processes, and actor interactions; and (3) Document analysis to examine records of waste deposits, gold savings accumulation, and MSMEs operational performance.

2.8 Data analysis techniques

Data analysis was conducted using a qualitative interactive analysis model, consisting of data condensation, data display, and conclusion drawing. Thematic coding was applied to identify recurring patterns related to incentive mechanisms, system integration, and sustainability impacts. The analysis emphasizes system-level interpretation to assess whether observed empirical patterns support the proposed hypotheses regarding the positive effects of gold savings-based waste bank integration on MSMEs empowerment and sustainability outcomes. Data validity was ensured through source triangulation and method triangulation.

2.9 Data presentation

The research findings are presented in the form of system narratives, flow diagrams, and comparative tables that clearly illustrate relationships among actors, processes, and outcomes. This presentation approach is designed to enhance clarity, demonstrate practical implementation, and facilitate understanding of system integration from an Industrial Systems perspective.

2.10 Ontological and epistemological perspective

Ontologically, this study conceptualizes the integrated waste bank-MSMEs system as a socio-technical industrial system composed of human actors, operational processes, simple technologies, and institutional mechanisms. Epistemologically, the study adopts an interpretive qualitative stance, where knowledge is constructed through empirical interpretation of stakeholder experiences and observed system interactions.

3. Results and Discussion

3.1 System-level overview of the gold savings-based waste bank

At the system level, the findings indicate that the Pegadaian gold savings-based waste bank operates as a central coordination node within an integrated framework that links community-based waste management with sustainable micro, small, and medium enterprise (MSMEs) empowerment. In contrast to conventional waste management approaches that typically position waste as an end-of-pipe environmental problem, this system fundamentally redefines baby diaper waste as an economic input embedded within a structured value creation process.

The integration of waste collection activities, value assessment, and conversion into a gold savings mechanism establishes a stable and trusted value reference within the waste management system. This value stability is shown to be a key factor in shaping community behavioral responses. Interview data consistently reveal that households perceive gold savings as a long-term asset rather than a source of immediate income. This perception encourages more disciplined, sustained, and consistent participation in baby diaper waste sorting and deposition activities.

From an industrial systems perspective, the gold savings mechanism functions as a control variable that regulates both material flows and the intensity of upstream actor participation. The system no longer relies solely on fluctuations in recyclable waste market prices, which in practice often undermine participation consistency. Instead, the value certainty provided by gold savings enables the waste bank to stabilize waste supply for downstream processing activities.

This condition has direct implications for MSMEs engaged in resin handicraft production based on baby diaper waste. A stable inflow of raw materials significantly reduces supply uncertainty, which had previously been a major constraint on production planning and business continuity. Consequently, MSMEs are able to operate within a more predictable production environment, leading to improvements in operational efficiency, cost control, and economic resilience.

Conceptually, the system demonstrates an integrated alignment of material flows (waste), value flows (gold savings), and information flows (recording and coordination), with the waste bank serving as the central control hub. This integrated flow structure forms a reinforcing socio-economic feedback mechanism that strengthens overall system sustainability, as illustrated in Figure 1.

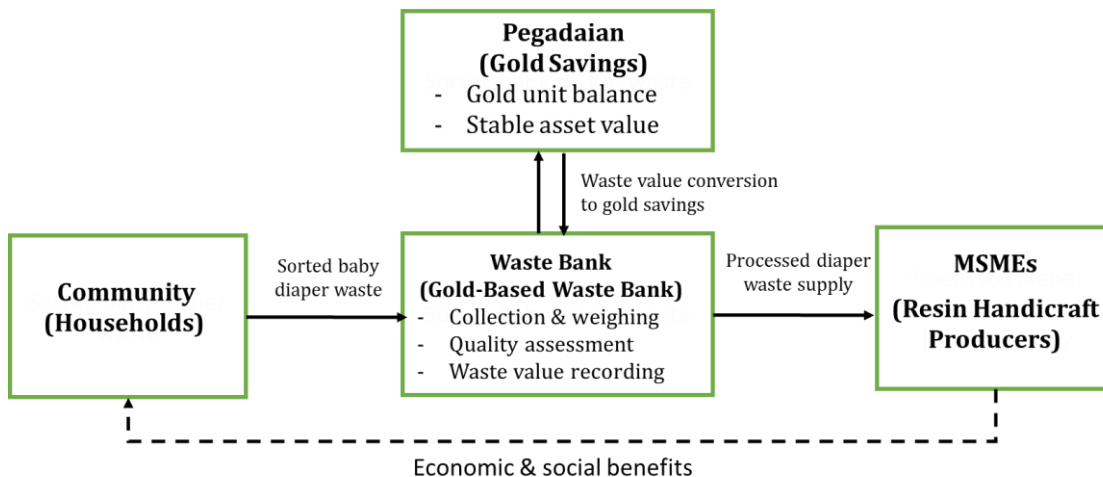


Fig. 1. Flow scheme of the gold savings-based waste bank system

3.2 Actor roles and system interactions

The findings indicate that the performance of the gold savings-based waste bank system is determined not merely by the presence of actors, but more importantly by the patterns of interaction and coordination among them. The system involves several key actors whose interdependencies form an integrated value network.

The community, particularly households, functions as the upstream actor responsible for sorting and depositing baby diaper waste. At this stage, waste is no longer treated as domestic residue, but rather as an economic resource. The level of community participation becomes a primary determinant of system performance, as the quality and consistency of deposited waste directly affect processing efficiency and value creation in subsequent stages. In addition to indirect economic benefits through gold savings, community members

experience increased environmental awareness and enhanced social engagement within a community-based circular economy system.

The gold savings-based waste bank serves as the core system coordinator. Its role extends beyond waste collection and weighing to include recording, valuation, conversion into gold savings, and material quality control. Through these functions, the waste bank aligns material flows with value flows while establishing operational standards that guide all actors. In this capacity, the waste bank acts as a critical link between informal community practices and the formal requirements of financial and production systems.

Pegadaian functions as an institutional value stabilizer that enables the conversion of waste value into gold-based financial assets. Its involvement provides economic legitimacy and value certainty while reducing the risks associated with price volatility commonly observed in conventional waste markets. In this context, Pegadaian operates not only as a financial service provider but also as an institutional actor that strengthens trust and long-term sustainability within the community-based circular economy system.

MSMEs operate as downstream actors that add value through the transformation of baby diaper waste into resin-based handicraft products. By utilizing raw materials that have been standardized through the waste bank, MSMEs are able to improve production efficiency, planning accuracy, and business continuity. Their position within the system enables MSMEs to act as key drivers of economic and social benefits that ultimately flow back to the community.

Interactions among these actors generate a reinforcing socio-economic feedback mechanism. The economic benefits and skill development opportunities created by MSMEs activities increase community motivation to participate consistently in waste sorting and deposition. This reinforcing loop enhances system resilience and distinguishes the model from linear waste management schemes that lack sustainable value feedback mechanisms.

3.3 The gold savings-based waste bank as a system strengthening mechanism

From an industrial systems perspective, the gold savings-based waste bank functions as a system strengthening mechanism that simultaneously controls material and value flows. Observational findings indicate that gold-based incentives significantly improve community discipline in waste pre-treatment stages, including drying, packaging, and separation. As a result, the baby diaper waste received by the waste bank exhibits lower defect rates during subsequent processing stages.

In addition, the waste bank acts as a system interface connecting households as material suppliers, Pegadaian as a financial institution, and MSMEs as value transformation units. This configuration shortens the waste supply chain, reduces potential material losses, and enhances coordination efficiency among actors. Rather than merely facilitating transactions, the waste bank establishes input quality standards that directly influence MSMEs operational performance. The advantages of this system compared to conventional waste banks are clearly observed in terms of incentive stability, supply consistency, transaction transparency, and overall system sustainability. As shown in Table 1, the use of gold savings as a long-term incentive mechanism reduces fluctuations in community participation and improves the reliability of raw material supply for MSMEs.

Overall, the findings confirm that the gold savings-based waste bank functions not only as a waste management unit but as a system-level control architecture that aligns economic, environmental, and social objectives. This mechanism constitutes a critical foundation for the successful integration of MSMEs into a sustainable, community-based circular economy.

Table 1. Comparison between conventional waste banks and gold savings-based waste banks

Aspect	Conventional waste bank	Gold savings-based waste bank
Incentive mechanism	Cash-based or commodity-based, short-term	Gold savings-based, long-term value accumulation
Value stability	Highly dependent on market price	Relatively stable and standardized

Aspect	Conventional waste bank	Gold savings-based waste bank
	fluctuations	
Waste quality	Variable, limited pre-treatment compliance	Higher quality due to standardized pre-treatment
Supply consistency	Irregular and uncertain	More consistent and predictable
Transaction transparency	Limited documentation and tracking	Systematic recording through gold savings accounts
Impact on SMEs	Unstable raw material input	Improved input reliability and production planning
System sustainability	Moderate, participation often fluctuates	High, reinforced by financial and behavioral incentives

3.4 Resin handicraft innovation from baby diaper waste

The resin handicraft innovation constitutes a structured material transformation subsystem within the integrated waste management and MSMEs empowerment model. In this subsystem, baby diaper waste is no longer treated merely as recyclable residue but is repositioned as a semi-processed industrial input that undergoes a series of standardized and controlled processing stages. These stages include separation of superabsorbent polymer and non-woven components, mechanical washing, disinfectant soaking, controlled drying, shredding, coloring, resin molding, and surface finishing. The standardization of these stages is critical to ensuring material consistency, product quality, and production repeatability at the MSMEs level.



Fig. 2. Processing stages of baby diaper waste into resin handicraft products

Empirical observations indicate that the resulting resin-based handicraft products exhibit adequate mechanical strength and satisfactory aesthetic characteristics for non-structural applications such as decorative items, accessories, and souvenirs. The flexibility of resin molding enables variations in form, texture, and color, allowing MSMEs to respond adaptively to diverse market preferences. This design adaptability enhances product differentiation and reduces the risk of market saturation, which is a common limitation in conventional waste-based handicraft products.



Fig. 3. Resin handcraft products made from baby diaper waste

From a systems perspective, this innovation significantly extends the utilization pathway of baby diaper waste beyond conventional end-of-pipe recycling or disposal approaches. By embedding waste transformation within a structured production subsystem, the model creates an intermediate value layer that bridges environmental objectives and market-driven production. This positioning reinforces the role of MSMEs as active value creators rather than passive recipients of waste materials.

Economically, the transformation of baby diaper waste into resin handicrafts yields a substantial increase in value compared to raw waste sales. The margin differential provides MSMEs with higher income potential while simultaneously reducing dependence on conventional raw materials. Over the medium term, the utilization of waste as the primary input contributes to cost efficiency, improved resource productivity, and enhanced economic resilience, particularly for community-based enterprises operating under resource constraints.

3.5 Integration of waste banks and MSMEs in a sustainable value chain

The findings demonstrate that the integration of gold savings-based waste banks and MSMEs forms a closed-loop and sustainable value chain characterized by high coordination and reduced systemic vulnerability. Within this configuration, the waste bank functions as an upstream stabilizer that ensures the availability, standardization, and traceability of raw materials, while MSMEs concentrate on downstream transformation and market-oriented value creation.

This division of roles minimizes dependence on external suppliers and significantly reduces the risks associated with supply disruptions and material quality variability. The standardized preprocessing conducted by the waste bank lowers input uncertainty for MSMEs, enabling more predictable production schedules and reducing inefficiencies caused by rework or material rejection. Consequently, operational performance improves through shorter lead times, lower defect rates, and more efficient resource utilization.

From a managerial standpoint, supply stability allows MSMEs to conduct more accurate capacity planning, inventory control, and pricing strategies. The predictability of inputs also facilitates market expansion by enabling consistent product availability and quality assurance. Strategically, the integrated value chain strengthens the positioning of MSMEs within the local economy by anchoring production activities to community-based resources rather than external market fluctuations.

The value chain integration further reinforces local economic circulation, as material sourcing, value addition, and income generation occur within the same socio-economic ecosystem. This localized configuration enhances system resilience and distinguishes the model from linear waste management schemes that lack long-term value retention and community-based economic integration.

3.6 Impacts on sustainable MSMEs empowerment and system sustainability

The empowerment of MSMEs within this system manifests in multiple interrelated dimensions, encompassing increased production capacity, improved income stability, enhanced business autonomy, and greater resilience to market uncertainties. The availability of a stable and standardized supply of raw materials enables MSMEs to plan production schedules more accurately, optimize inventory management, and anticipate market demand without exposing themselves to excessive operational or financial risk. Such stability allows community-based MSMEs to scale their production incrementally, exploring new product lines or expanding output in response to market signals, while maintaining manageable levels of operational complexity. For instance, resin handicraft enterprises can diversify product offerings, such as decorative items, accessories, and functional goods, with predictable material quality and quantity, thus strengthening their position in competitive local and regional markets. The integration of production planning, quality control, and systematic raw material sourcing contributes directly to the operational sophistication of MSMEs, elevating their capacity to operate efficiently and sustainably over time.

Financially, the gold savings mechanism embedded in the waste bank system provides a critical layer of economic resilience for MSMEs. By functioning as a secure, institution-backed value accumulation instrument, gold savings enable enterprises to manage cash flows more effectively, mitigate short-term liquidity pressures, and strategically allocate resources for reinvestment or business expansion. Unlike volatile cash-based incentives, gold savings offer a relatively stable and trusted reference of value, which enhances financial discipline and reduces household-level vulnerability to income fluctuations. This long-term value accumulation encourages MSMEs owners and participating households to make strategic decisions about production, pricing, and investment, rather than relying solely on short-term gains. Furthermore, the integration of gold savings into the operational core of waste management activities motivates households and entrepreneurs to maintain consistent participation, reinforcing the stability and predictability of the system as a whole.

From an environmental perspective, the system contributes directly to mitigating the burden on landfills and reducing pollution by diverting baby diaper waste into productive cycles. The transformation of previously discarded materials into high-value inputs for MSMEs production not only prevents environmental degradation but also promotes the principles of circular economy by closing material loops at the community level. Quantitative projections suggest that regular diversion of diaper waste could significantly reduce landfill accumulation, while promoting more sustainable consumption and disposal practices within households. Moreover, the system serves an educational function by fostering environmental awareness among participants, encouraging responsible waste sorting, and promoting broader behavioral shifts that extend beyond the immediate operational boundaries of the program.

Socially, the model strengthens community networks, fosters collective ownership, and sustains active participation in waste management and MSMEs activities. The interconnections formed through collaborative sorting, pre-treatment, and packaging activities build trust, enhance social cohesion, and establish a culture of shared responsibility. This social capital contributes to higher levels of compliance with operational standards and creates a platform for knowledge transfer, peer mentoring, and collaborative problem-solving. Community engagement becomes a reinforcing mechanism,

where social interactions promote both behavioral adherence and continued investment in the system, ultimately enhancing overall system durability and resilience.

The reinforcing feedback loops between economic incentives, material quality, community participation, and MSMEs sustainability underscore the integrated nature of the system. Improved adherence to sorting and pre-treatment processes results in higher-quality raw materials for MSMEs, which in turn enhances product value, profitability, and business continuity. The resulting economic benefits motivate further community involvement, creating cyclical reinforcement that stabilizes participation over time. This cyclical mechanism distinguishes the gold savings-based waste bank model from conventional linear waste bank systems that often suffer from sporadic engagement and limited long-term impact.

From a managerial perspective, the predictability and stability of raw material inputs allow MSMEs to conduct more precise capacity planning, implement inventory control measures, and develop informed pricing strategies. Consistent access to high-quality inputs not only facilitates market expansion but also strengthens the position of community-based enterprises within local economies by anchoring production to reliable, community-sourced resources rather than relying on external market fluctuations. Moreover, the integration of financial incentives, production planning, and community engagement provides MSMEs with a systemic advantage, enabling them to respond proactively to changing consumer preferences, regulatory requirements, and environmental conditions.

Overall, the findings confirm that sustainable MSMEs empowerment is driven not merely by product-level innovation but by system-level design, institutional integration, and strategically aligned incentives. The gold savings-based waste bank functions as a critical alignment mechanism, synchronizing economic, environmental, and social objectives within a coherent industrial system. By reinforcing economic stability, enhancing environmental stewardship, and fostering social cohesion, the system demonstrates that long-term, institution-backed value mechanisms are capable of significantly improving the effectiveness, scalability, and resilience of community-based circular economy initiatives. This empirical evidence highlights the potential of integrated incentive structures to catalyze sustainable development outcomes in emerging economies, providing a model that combines financial innovation, environmental management, and community empowerment into a unified, replicable framework.

3.7 Implications for Pegadaian's best practical implementation framework

The findings of this study indicate that the integration of gold savings-based waste banks with resin handicraft innovation from baby diaper waste forms a robust, systematic, and replicable best practical implementation framework for Pegadaian in supporting sustainable, community-based economic systems. Unlike conventional sustainability programs, which are often temporary, rely on short-term incentives, or depend on external interventions, this framework embeds Pegadaian's gold savings mechanism directly into the operational core of community waste management and MSMEs production activities. As a result, Pegadaian's role extends beyond that of a traditional financial service provider to that of a system architect that actively shapes value creation, behavioral incentive mechanisms, and institutional alignment within a circular economy ecosystem. This positioning allows Pegadaian to influence both the micro-level behaviors of households and the meso-level operational structures of MSMEs, creating a synergistic effect that enhances the overall stability and sustainability of community-based economic activities.

From an institutional perspective, Pegadaian functions as a value stabilization authority that redefines how low-value residual materials are perceived and managed at the community level. By enabling the conversion of baby diaper waste into gold-based financial assets, Pegadaian introduces a long-term value horizon that fundamentally alters household decision-making behavior. Waste is no longer considered a short-term source of cash income but is instead recognized as an asset-generating input within a broader

economic system. This shift in perception is particularly critical because it addresses one of the most persistent weaknesses of conventional waste bank models: the volatility of community participation driven by fluctuating cash-based incentives. By offering a stable, trusted form of value, the gold savings system encourages households to consistently engage in proper waste segregation, pre-treatment, and preparation, fostering a culture of discipline and accountability in local environmental management.

Within the industrial systems framework, gold savings operate as a behavioral control mechanism that regulates both material flows and the intensity of actor participation. Unlike cash incentives, which are highly sensitive to short-term market dynamics and price fluctuations, gold savings provide a relatively stable and reliable value reference. This stability reinforces community discipline in sorting, pre-processing, and packaging waste, increases transaction transparency, and enhances compliance with quality standards for raw materials. Consequently, Pegadaian-supported waste banks act as institutional control nodes that integrate material, value, and information flows across the system. This coordination allows for a seamless feedback mechanism between households, waste bank managers, and MSMEs, creating a closed-loop system in which each actor's performance directly affects the quality and quantity of inputs for production and, ultimately, the sustainability of the circular economy initiative.

Beyond behavioral control, the framework demonstrates a clear alignment between economic, social, and environmental objectives. Economically, MSMEs benefit from a consistent, high-quality, and standardized supply of raw materials, enabling more accurate production planning, operational efficiency, and cost management. This predictability in input supply reduces operational uncertainty, allowing MSMEs to strategize production schedules and pricing with confidence, thereby enhancing competitiveness and profitability. Socially, the mechanism fosters sustained community engagement, increases environmental awareness, and strengthens social networks through collaborative activities and participatory decision-making. By actively involving local residents in the collection, segregation, and processing of waste, the framework builds a sense of ownership and shared responsibility for environmental outcomes, which can contribute to more resilient and socially cohesive communities. Environmentally, the diversion of baby diaper waste from landfills into MSMEs production cycles reduces pressure on municipal waste management systems, mitigates pollution, and promotes circular economy practices by converting waste into valuable resources rather than leaving it as an environmental burden.

The concept of best practical implementation emerging from this study differs fundamentally from the notion of best practice commonly found in sustainability literature. Best practices are typically presented as normative benchmarks that assume homogeneous institutional capacity, market conditions, and social behavior. In contrast, the best practical implementation framework is adaptive, context-sensitive, and capable of being tailored to local socio-economic and cultural conditions. It does not impose rigid operational models but instead defines a set of institutional roles, incentive mechanisms, and interaction patterns that can be adjusted according to the specific characteristics of each community. This flexibility enhances the relevance and applicability of the study for real-world implementation, particularly in urban and peri-urban areas characterized by heterogeneous social, economic, and cultural structures. The adaptive nature of this framework allows it to respond dynamically to challenges such as varying levels of community awareness, differing capacities of MSMEs, and localized environmental conditions, making it highly practical for replication in diverse settings.

From a scalability perspective, Pegadaian's extensive national network, standardized gold savings products, and strong public trust provide a solid structural foundation for model replication. The scaling of this implementation does not require large-scale infrastructure investments or sophisticated technological systems; instead, it leverages existing institutional capabilities and community-based organizational structures. This characteristic significantly lowers barriers to adoption and enhances the feasibility of incremental expansion into regions with similar waste generation profiles and MSME ecosystems. Moreover, the replicability of this model allows for knowledge transfer and

capacity building across communities, as successful operational practices and institutional strategies can be shared, adapted, and improved over time.

However, the effectiveness of this implementation framework is contingent upon several boundary conditions. First, sustained community engagement requires ongoing facilitation by waste bank managers capable of translating institutional mechanisms into operational practices that are understandable and actionable by local residents. Second, MSMEs must possess or develop sufficient technical capacity to process waste materials into value-added products that meet market standards and consumer expectations. Third, Pegadaian's institutional commitment must extend beyond pilot programs to include long-term support for system integration, monitoring, evaluation, and organizational learning. In essence, while the framework is replicable and adaptable, its success is not automatic; it depends heavily on the preparedness, coordination, and active participation of all stakeholders. These boundary conditions highlight the need for continuous capacity development, effective communication channels, and institutional support to ensure that the framework achieves its intended objectives.

From a policy and institutional strategy perspective, this model positions Pegadaian as a strategic actor within Indonesia's national sustainability and financial inclusion agenda. The integration of gold savings-based waste banks aligns with broader national objectives related to circular economy development, MSMEs empowerment, and inclusive finance. By embedding financial inclusion instruments into community-based environmental management practices, Pegadaian facilitates the convergence of economic, social, and environmental goals at the grassroots level. This alignment is particularly relevant for state-owned enterprises seeking to demonstrate tangible Environmental, Social, and Governance (ESG) outcomes through operational innovation rather than symbolic compliance. By linking financial incentives with sustainable environmental practices, Pegadaian provides a practical example of how public institutions can play an active role in shaping sustainable development pathways that benefit both communities and the wider economy.

From a research perspective, this study does not aim to develop or validate a formal circular supply chain optimization model, nor does it attempt to quantify environmental impacts through life cycle assessment. Instead, the focus is on empirically analyzing how institutional incentive design and system-level integration can enhance the effectiveness and sustainability of community-based circular economy initiatives. Emphasis is placed on understanding system behavior, actor interactions, and the role of institutions in facilitating operational efficiency, compliance, and value creation. By providing evidence-based insights into practical implementation strategies, this study complements model-driven research and offers a bridge between theoretical frameworks and real-world operationalization.

Furthermore, the framework underscores the importance of reinforcing feedback loops among economic incentives, material quality, community participation, and MSMEs sustainability. For example, improved compliance in household waste segregation produces higher-quality raw materials for MSMEs, which subsequently improves productivity, profit margins, and business continuity. These positive outcomes, in turn, encourage further community participation, creating a self-reinforcing mechanism that strengthens system stability and ensures continuous improvement. This dynamic feedback distinguishes the Pegadaian model from conventional linear waste bank schemes, which lack mechanisms for long-term value creation and cyclical reinforcement.

From a managerial perspective, the stability and predictability of raw material supply allow MSMEs to plan capacity, manage inventory, and implement pricing strategies more effectively. Reliable input availability also facilitates market expansion by ensuring consistent product quality and quantity, thereby enhancing competitiveness. Strategically, this integrated value chain strengthens the position of MSMEs within the local economy by anchoring production to community-based resources rather than relying on external market fluctuations. This approach contributes to resilience, promotes local economic growth, and fosters a more sustainable business ecosystem.

Overall, the findings reinforce Pegadaian's position as a key institutional intermediary capable of bridging financial inclusion, waste management innovation, and MSMEs empowerment through an integrated industrial system. The gold savings-based waste bank model provides strong empirical evidence that long-term, institution-backed value mechanisms effectively stabilize community participation, reduce MSMEs operational uncertainty, and advance sustainable development objectives in practice. This framework represents not only a viable strategy for Pegadaian's implementation but also a transferable institutional approach for strengthening circular economy systems in developing countries, offering a model that can inspire similar initiatives globally.

4. Conclusions

This study demonstrates that the integration of gold savings-based waste banks with resin handicraft innovation from baby diaper waste establishes a replicable and context-sensitive framework for community-based circular economy initiatives. The findings highlight that embedding financial incentives directly into local waste management and MSMEs production processes can effectively stabilize community participation, enhance resource utilization, and promote sustainable economic practices. This approach positions financial institutions, such as Pegadaian, as active system architects rather than merely service providers, expanding the conventional role of finance in supporting socio-environmental objectives.

The framework's adaptability to local socio-economic and cultural contexts underscores its practical relevance for implementation in diverse urban and peri-urban areas. By linking behavioral incentives, institutional roles, and production systems, the model provides a holistic mechanism that aligns economic, social, and environmental goals. The reinforcing feedback loops between community engagement, material quality, and MSMEs sustainability further demonstrate the potential for long-term systemic stability and resilience, distinguishing this approach from conventional, linear waste bank schemes.

From a policy and institutional perspective, the research highlights the strategic role of financial institutions in advancing national objectives for circular economy development, inclusive finance, and environmental stewardship. The framework exemplifies how operational innovation can integrate ESG considerations into practical implementation, providing a model that can inform policy decisions and guide similar programs in developing countries. Its replicability and low infrastructure requirements offer a scalable pathway for expanding community-based circular economy initiatives without imposing excessive resource demands.

Overall, this study contributes empirically grounded insights into the design and operationalization of community-centered circular economy models. It provides evidence that institutionally supported, value-stabilized mechanisms, such as gold savings-based waste banks, can create tangible socio-economic and environmental benefits while enhancing the sustainability of MSME activities. These findings offer both theoretical and practical implications for researchers, policymakers, and practitioners aiming to strengthen circular economy systems in emerging economies.

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Author Contribution

Conceptualization, S.P. and U.N.S.; Methodology, S.M.; Validation, S.P., M.E., and M.F.R.; Formal Analysis, U.N.S.; Investigation, S.M.; Resources, M.E.; Data Curation, M.E.; Writing – Original Draft Preparation, S.P.; Writing – Review & Editing, U.N.S.; Visualization, M.F.R.; Supervision, S.P.; Project Administration, S.P.; Funding Acquisition, S.P.

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Ethical Review Board Statement

The study was conducted in accordance with the ethical guidelines of Universitas Islam Batik Surakarta and approved by the Institutional Review Board of Universitas Islam Batik Surakarta.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study, including community members and MSME participants. Written informed consent for publication was obtained from participants who could be identified.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request. Certain data may be restricted to protect participant privacy.

Conflicts of Interest

The authors declare no conflict of interest. The funder, PT Pegadaian, had no role in the design of the study, in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Declaration of Generative AI Use

During the preparation of this work, the authors used ChatGPT and Mendeley to assist in improving clarity, academic tone, and organization of the manuscript. After using this tool, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

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Biography of Author

Sri Purwati is a lecturer at Universitas Islam Batik, Surakarta, Central Java, Indonesia. She holds a Master's degree in Industrial Engineering and specializes in sustainable manufacturing, circular economy, and community-based waste management. Her research focuses on integrating financial instruments with community empowerment initiatives and the development of innovative waste-to-value solutions.

- Email: sri.purwati@uibs.ac.id
- ORCID: N/A
- Web of Science ResearcherID: GPT-3881-2022
- Scopus Author ID: 57246157100
- Homepage: N/A