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Management Circular Economy-Based Waste Management to Create Resilient and Sustainable Cities

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Abstract

Densely populated coastal settlements face dual vulnerabilities in the form of the threat of hydrometeorological disasters and limited capacity for managing household waste, especially organic waste which dominates the generation. This community service activity aims to strengthen the capacity of human resources (HR) and community institutions in Tambakrejo Village, Gayamsari District, Semarang City, in implementing circular economy-based waste management and producing value-added products. Program partners include the Berkah Jaya 07 Waste Bank (RW 7), the waste management group and the Climate Village Program (ProKlim) of RW 5, and the Lestari Jaya Farmers Group. The program will be implemented throughout 2026 through five stages, namely socialization and coordination, technical training, technology transfer and facility facilitation, pilot studies, and mentoring and evaluation. The intervention is supported by the provision of 4 composter units, 5 *planter bags*, 2 cage packages and 20 laying hens, 200 sorting bags made from used sacks, and 1 product *showcase unit*. The implementation results show the formation of a partial organic material reuse chain from the source through processing into compost, *eco-enzymes*, alternative feed, and craft products made from used materials. The integration of waste management, food production, and value-added product development contributes to strengthening institutional capacity, environmental resilience, food security, and economic opportunities for coastal communities. This program supports the achievement of SDGs 2, 11, 12, 13, and 17 through a collaborative approach and a community-based circular economy.

Keywords: *organic waste management; resilient city; tambakrejo subdistrict; waste bank*

INTRODUCTION

Growth embossed global waste is taking place faster than rate urbanization and growth population. The World Bank projects embossed rubbish congested urban increase from 2.01 billion tonnes in 2016 to 3.40 billion tonnes in 2050, with increase the biggest occurs in high-income countries lower-middle class (Kaza et al., 2018). Report latest United Nations Environment Programme, (2024) confirm that “*business as usual*” scenario will multiply cost external management garbage, while scenario economy circular potential produce profit global cleanup. Circular economy understood as the system that replaces draft end-of-life product with a reduction strategy, using return, recycle, and recover material along the chain production-consumption (Kirchherr et al., 2017). Formulation latest draft the put dimensions social and justice as part No inseparable, so that transition circular No can reduced become problem technology only, but demand change institutions and

behavior actors at the level smallest, including House ladder (Kirchherr et al., 2023). In Indonesia, households is contributor embossed rubbish the largest, namely around 46% of the total generation national, whereas food waste dominates the composition rubbish with proportion approaching 40% (Kementerian Lingkungan Hidup, 2025). The national policy framework has actually mandated a paradigm shift from collect-transport-dispose towards waste reduction and management from the source, as arranged in Constitution Law No. 18 of 2008 concerning Waste Management and Presidential Regulation No. 97 of 2017 concerning the National Policy and Strategy for Household Waste Management. However, their implementation is still lagging. Studies in major Indonesian cities show that household participation in waste reduction is significantly influenced by knowledge, availability of facilities, and institutional support. local, not solely by willingness individual (Dhokhikah et al., 2015). Findings the in line with cross-country evidence of a gap between intentions and actions in household waste sorting, which can only be narrowed if interventions provide means of sorting while strengthening social norms at the household level. community (Cheng et al., 2024)

The city of Semarang faces this problem in a unique way. rubbish city recorded at 1,189.71 tons per day with an average of 0.70 kg per person per day, while only around 0.12% of the total waste generated is handled through waste bank units and initiatives inhabitant (Rancangan Peraturan Daerah Tentang Rencana Pembangunan Jangka Menengah Daerah (RPJMD) Kota Semarang Tahun 2025-2029, 2025) This burden is compounded by the physical vulnerability of coastal areas. Tambakrejo Subdistrict, Gayamsari, inhabited by 10,370 people in 3,481 families spread across 9 RW and 54 RT, with land elevation of only 1.5–2.8 meters above sea level, making it prone to tidal flooding and land degradation. environment (Ramadhan et al., 2024) In low-elevation, high-density areas like this, unmanaged waste accumulation not only creates aesthetic and health issues but also exacerbates drainage channel blockages, which are a contributing factor to flooding.

In this context, the activity partners demonstrate an unequal capacity profile. The Berkah Jaya 07 Waste Bank in RW 7 has been operating with 31 administrators and throughout 2024 successfully sorted 3,761.5 kg of inorganic waste, or an average of 372 kg per month. mark Sales of Rp646,150. This group is also active in sorting education and Climate Village Program (Proklm) activities. In contrast, in RW 5, there is no integrated waste management; waste is disposed of without further processing. In both areas, handling the organic fraction is the weakest link. Identified barriers are multi-layered: concerns about odor and the presence of flies, limited technical knowledge of processing, and the lack of facilities and infrastructure for organic waste processing.

Whereas rubbish organic precisely keeps potential valorization largest. Composting decentralized at a community scale has proven to be capable divert rubbish *biodegradable* from place processing end at a time produce ameliorant land, with competitive operational costs per ton compared to centralized city transportation small and medium (Donthi & Ramannagari, 2025; Oviedo et al., 2025) Fermentation of fruit and vegetable waste become ecoenzyme produce fluid multipurpose which can be used as organic fertilizer liquid and cleaner friendly environment (Rukmini & Herawati, 2023), and its application to plants horticulture show response positive growth (Novianto, 2022). Bioconversion Using *Black Soldier Fly* (BSF) larvae reduces the mass of organic waste quickly and produces two valuable outputs, namely high protein larval biomass for feed as well as kasgot as improver land (Amrul et al., 2022; Siddiqui et al., 2022). In addition, kitchen waste can be converted directly into alternative livestock feed, a strategy that is explicitly positioned as track circular For pressing cost feed at a time reduce embossed rubbish (Chisoro et al., 2023; Jayathilake et al., 2022) On the inorganic side, community-based waste banks act as nodes for collection and creation of economic value which, when integrated with municipal waste policies, are capable of increase achievements recycling repeat in a way measurable (Kubota et al., 2020; Raharjo et al., 2017).

However, most similar community service programs in Indonesia still tend to focus on a single node in the resource management chain. Interventions generally take the form of partial training, such as manufacturing *Eco-enzymes*, maggot cultivation, or waste bank strengthening have not yet systematically integrated these various activities into a single, interconnected and supportive material flow system. Furthermore, institutional strengthening and self-management mechanisms are often not an integral part of the interventions, so the sustainability of activities still depends on external assistance and has not fully built the capacity of groups to manage, develop, and maintain their resources. system in a way independent after the program ends (Mujahiddin et al., 2021; Nurhayati et al., 2022; Pranata et al., 2021). Studies on waste bank participation also show that sustainability is more determined by the internal governance and financial transparency of the group. rather than by ability technical solely (Rachman et al., 2021) This gap in practice is the entry point for this activity:

the lack of an intervention model that simultaneously addresses organic and inorganic fractions, connects them in a single local value chain, and includes institutional strengthening as an equivalent component to technical training.

This community service activity is designed to address this gap through an integrated intervention package in the sub-district. Tambakrejo. The intervention includes training and technology transfer for processing organic waste into compost and ecoenzyme, conversion waste kitchen waste into feed for community laying hen farming, expanding organic valorization insights through BSF cultivation model studies, strengthening group institutions and bookkeeping, and facilitating sorting facilities at source and diversifying plastic waste products. The program's novelty lies in combining these two material streams in a single, densely populated coastal area, with community poultry as the node that converts kitchen waste into food products, and the waste bank as the node that converts inorganic waste into group income. Based on the description, the objectives of this community service activity are: (1) to increase the capacity of human resources of partners in processing household waste, especially organic fractions, through the development of sustainable businesses. based economy circular; and (2) increasing public knowledge regarding household waste management and skills in utilizing organic waste into value-added products. This article reports on the implementation, measurable achievements, and academic interpretation of these two objectives.

METHOD

Activity devotion implemented throughout 2026 in the Village Tambakrejo, District Gayamsari, Semarang City, with waste bank performance data 2024 used as a baseline. Activity partners arranged in three entities with distribution different roles, as presented in Table 1.

Table 1. Structure of community service activity partners in Tambakrejo Village, 2026

Partners	Region	Role in the program	Focus intervention
Waste Bank 07 (31 administrators)	RW 7	Knot management rubbish inorganic which has walk	Strengthening institutional, bookkeeping, diversification product plastic, showcase facilities and bags sort
Group manager waste and Proklam RW 5 (elements RW, PKK, Proklam administrators)	RW 5	Pilot area without management rubbish integrated	Training compost and ecoenzyme, facilitation composter and planter bag, reinforcement group, facilitation bag sort
Group (KT)	RW 5	Cultivation unit manager chicken egg layers community	Training conversion waste kitchen become feed, facilities pens and livestock
Tambakrejo Farmers Group (KT)	Ward Tambakrejo	Participant expansion outlook valorization organic	mock study BSF cultivation

Stages Implementation

Activity implemented through five sequential stages.

Stage 1 — Initial socialization and coordination. Meetings with neighborhood association (RW) administrators, waste bank groups, and farmer groups were held to outline the activity plan, map the partners' actual needs, and agree on a schedule and implementation mechanism. This stage resulted in an agreement on the division of intervention focuses, as shown in Table 1.

Stage 2 — Technical training. The training is conducted using interactive lectures, demonstrations, and hands-on practice (*learning by doing*). The material covers processing organic waste into eco-enzymes and compost, raising laying hens and introducing feed types based on quality and quantity, processing kitchen waste into fermented feed, and organizational governance and group bookkeeping.

Stage 3 — Technology transfer and facility facilitation. Each training material is followed up with the handover of facilities so that knowledge can be directly put into practice: 4 units of composter barrels and 5 planter bags along with activator materials (EM4 and molasses) for RW 5; 2 cage installation packages and 20 laying hens for KT Lestari Jaya; 200 sorting bags made from used sacks measuring 30 × 50 cm for households in the partner area; and 1 showcase unit to display the diversified plastic waste products of Bank Sampah Berkah Jaya 07.

Stage 4 — Field trip. Representatives from KT Tambakrejo, Bank Sampah Berkah Jaya 07, and the RW 5 waste management group conducted a study visit to the BSF maggot cultivation unit at Ecofarm UNNES, managed by the waste-conscious community "Komunal," to directly observe the bioconversion process, from receiving domestic waste to harvesting larvae and maggots.

Stage 5 — Mentoring and evaluation. Mentoring is carried out through regular monitoring, gathering input, and resolving technical issues that arise during and after the training.

Instruments Evaluation

Indicators of program success are determined based on: (a) *output*, in the form of training conducted, the number of trained participants, and the number of installed facilities; and (b) *medium-term outcomes*, in the form of sustainable unit operations, orderly group bookkeeping, and expansion of sorting practices at the household level.

RESULTS AND DISCUSSION

Processing Rubbish Organic become Compost and Ecoenzyme

RW 5 is environment on the population without management rubbish integrated, so that all over rubbish organic House ladder go out from the region as residue. Training processing rubbish organic becomes ecoenzyme and compost followed by 22 representatives RW, PKK, and Proklim administrators. Participants chosen from elements that have range social wide so that it can play a role as distributor knowledge (*cascade training*) in the environment. As action continue, partner accept 4 units composter barrel, 5 planter bags, and EM4 and molasses ingredients.

Compost and ecoenzyme were chosen as entry points because they are low-tech, require minimal investment, and produce outputs that are readily usable in partner communities. Decentralized composting at a community scale has proven technically and economically feasible for densely populated areas, reducing transportation costs while producing a soil amendment (Oviedo et al., 2025). Ecoenzyme, a product of the anaerobic fermentation of fruit and vegetable waste, produces a multipurpose liquid that can be used as a liquid organic fertilizer (Rukmini & Herawati, 2023) with documented plant growth responses (Novianto, 2022). In coastal areas with relatively high soil salinity and limited open space, the combination of compost and planter bags makes sense because it allows for the growing medium to be completely controlled outside the original soil.

This facilitation program is a pilot project, not a comprehensive solution. Four composters won't absorb all the organic waste from a densely populated neighborhood. Its value lies in its demonstration function, providing tangible evidence in the community that organic waste can be processed without producing odor, thus neutralizing the perception barriers most often cited by residents. Similar programs in other locations have reported similar patterns: increased knowledge immediately after training, but sustainability depends on the availability of follow-up support (Nuryati et al., 2024; Pranata et al., 2021).



Figure 1 Eco enzyme and compost training for residents of RW 5, Tambakrejo Subdistrict

Conversion Waste Kitchen as Feed in Laying Hen Farming Community

Waste kitchen House stairs in RW 5 no own track utilization, while group farmer local No have a production unit food in operation. KT Lestari Jaya received 2 (two) packages installation pen chicken along with 20 laying hens. Training and mentoring included understanding the characteristics and techniques of laying hen farming, as well as an introduction to feed types based on quality and quantity, followed by training. processing waste kitchen becomes feed fermentation.

This unit is not the key that differentiates this program from conventional waste interventions. Poultry farming functioning as converter A biological process that converts waste streams with no market value into high-protein food products, while simultaneously reducing the largest cost component in livestock farming, namely feed. The use of food waste as animal feed is positioned in literature economy circular as a high value- added strategy, because it maintains materials at the highest utilization level in the food hierarchy before fall to compost or energy (Jayathilake et al., 2022) This strategy has also proven relevant for small-scale farmers in developing countries who face volatility price feed commercial (Chisoro et al., 2023). Conceptually, this unit close previous material coil open: trash the original kitchen become residue now enter return to system as production input food, while dirt cattle potential directed to track composting that has been built on intervention previously.



Figure 2 Socialization and cultivation chicken KT. Lestari Jaya egg layer

Expansion Chain Valorization through Cultivation Copy Study *Black Soldier Fly* (BSF)

Partners get to know the term maggot, but Not yet Once witness system BSF production in operation, so that perception to technology This Still colored doubt about smell and complexity management. Representatives of KT Tambakrejo, Bank Sampah Berkah Jaya 07, and the RW 5 waste management group conducted a pilot study of the BSF maggot cultivation unit at Ecofarm UNNES managed by the “Komunal” community, which utilizes domestic waste and waste from shops around the campus.

BSF was chosen as the next development horizon because of its reduction capacity. Far beyond composting conventional and produces two valuable outputs at once, namely high protein larval biomass as raw material feed and kasgot as improver land (Siddiqui et al., 2022). A systematic review reported that BSF is able to reduce the mass of organic waste substantially more efficient compared to composting, with Larval biomass contains around 40% protein and 30% fat so it is suitable to replace some of the feed commercial (Amrul et al., 2022). The replicate study method was chosen because of the main obstacles adoption nature perceptual and observational Directly to the running unit is more effective in changing perceptions than delivering material. class (Asrowi & Farida, 2024).

Output stage This is the increase in partners' insight regarding series of BSF bioconversion processes as basis for the development plan for a similar unit in Tambakrejo. It should be stated frankly that during this reporting period the pilot study has not yet produced an operational BSF unit in the partner area. This activity is therefore positioned as *outcome* between, not production achievement. When the BSF unit is built, the feed supply for the laying hen unit will be strengthened by self-produced protein sources, so that chain circular become more meeting.



Figure 3Simulation study of maggot cultivation as part of organic waste processing

Strengthening Institutional and Group Governance Capacity

Group partners own skills technical sorting, but governance organization and record keeping finance Not yet orderly. Condition This limit ability group account for funds and access support party outside. Two activities done in a way parallel. First, counseling and strengthening group integrated in management rubbish for 20 administrators and members group manager RW 5 waste, includes function organization, division roles and systems management rubbish sustainable. Second, training bookkeeping for Berkah Jaya 07 Waste Bank, includes compilation Cash In Book, Cash Out Book, and Cash Book Inventory.

This component is placed on par with technical training because evidence suggests that the sustainability of a waste bank is determined more by the quality of governance than the technical skills of its members. Orderly bookkeeping creates transparency, serves as evidence of accountability, and strengthens the trust of external parties who will provide support (Bayu & Wijaya, 2023). Studies of waste banks in several Indonesian cities found that a decline in member participation often occurs, triggered by uncertainty recording savings trash, not by loss of consciousness environment (Rachman et al., 2021; Raharjo et al., 2017). The integration of institutional strengthening into the waste program is what differentiates this approach from most similar community service programs, which generally stop at skills training, production (Mujahiddin et al., 2021).



Figure 4Training bookkeeping For Berkah Jaya Waste Bank 07

Sorting at Source and Diversification Product Rubbish Inorganic

Sorting waste at the level House ladder Not yet become routine practice, while rubbish plastic worth sells low still end as residue although already collected in waste banks. As continuation of the 2025 program, in 2026 200 bags were handed over sort made from bag used measuring 30×50 cm to House stairs in the partner areas of RW 5 and RW 7, as receptacle special plastic results sorting. Simultaneously with that, Berkah Jaya 07 Waste Bank developed processing waste plastic colored become craft products in the form of decoration plants and flowers, which are facilitated with 1 showcase unit for display product.

Providing sorting facilities is a structural intervention, not merely an educational one. Empirical evidence shows that the gap between sorting intentions and sorting actions narrows significantly when facilities are available at the point of collection, arising, because cost behavior for households decreases

(Cheng et al., 2024; Dhokhikah et al., 2015). At the systems level, sorting bags serve as a tool that transforms households from endpointsof consumption to starting points of material supply for waste banks. Without this tool, increased knowledge risks not being converted into changes in practice that, diversification Craft products address the specific problem of low-value plastics that collectors do not accept; transforming them into aesthetically valuable products moves materials from the residue category to the raw material category. (Fitri et al., 2025).



Figure 5Provision of waste sorting bags for community servicepartners (RW 5 and 7)



Figure 6Diversification of plastic waste into ornamental plant craft products

Circular Economy Framework, Urban Resilience, and Contribution towards SDGs

Before the program, the flow rubbish House stairs in partner areas follow *take–make–dispose* linear pattern: materials are consumed, discarded without sorting, and ending as burdensome residue environment and drainage. This program organizes repeat flow the become series circular *reduce–reuse–recover–recycle–regenerate*, as in presented in Figure 7.

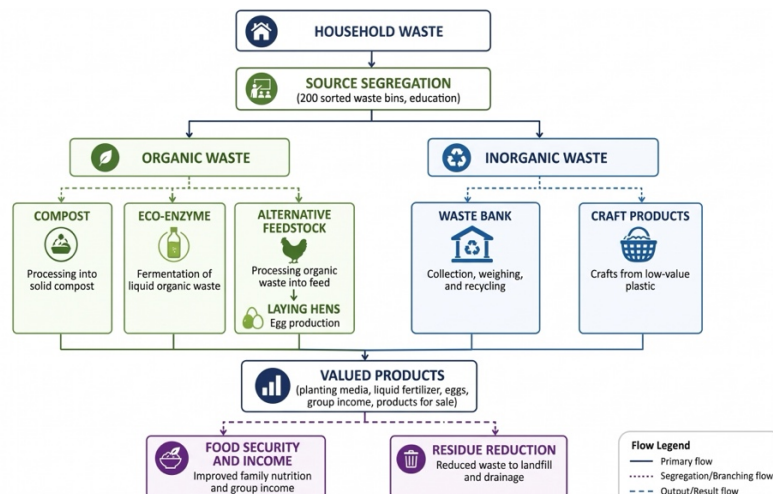


Figure 7Framework waste material flow House ladder results intervention

Shift this not only nature technical. Formulation latest economy circular emphasize that circularity demand arrangement repeats relation actors and institutions, not just addition technology processing (Kirchherr et al., 2023). In this program, the arrangement the come true through distribution clear roles inter-partner: home ladder as sorter, waste bank as aggregator inorganic, group farmer as converter organic, and bookkeeping group as instruments that maintain flow mark still tracked, Need to noted that circularity achieved Still partial: part material flow is already closed on a scale pilot project, while part large volume of regional waste still follow linear path,

Resilience city is capacity system urban along with network socio-ecological and socio-technical for maintain function, recover from disturbances, and adapt to change (Meerow et al., 2016). The program's contribution is realized through five mechanisms : 1) resilience environment, through processing rubbish organic become compost and *eco-enzyme*; 2) toughness food, through cultivation chicken egg layers and *urban farming* input- based results processing rubbish (Abdillah et al., 2023; Abdurrohman et al., 2021); 3) toughness economy, through diversification income from sale trash, crafts, and eggs; 4) toughness community, through strengthening institutions and bookkeeping group (Rachman et al., 2021); and 5) toughness climate, through subtraction rubbish potential organic produce methane (United Nations Environment Programme, 2024). Magnitude reduction emission No measured so that no claimed in a way quantitative. The program's contribution to the SDGs (United Nations, 2015) is stated in a way proportional in accordance proof activities, as presented in Table 2.

Table 2. Linkage of activities to the Sustainable Development Goals

SDGs Goals	Form relatedness concrete	Contribution level
SDG 2 – Without Hunger	20- head cultivation unit chicken egg layers and utilization compost as well as ecoenzyme on 5 planter bags build capacity production food scale House ladder	Start-up; not yet scale resilience regional food
SDG 11 – Cities and Human Settlements Sustainable	Sorting at source in 200 homes ladder and strengthening of waste banks reduce burden residue as well as risk blockage drainage in the area prone to tidal flooding	Direct and measurable at the RW level
SDG 12 – Consumption and Production Responsible	Valorization rubbish organic become compost, ecoenzyme, and feed, as well as conversion plastic worth low become craft products	Direct; core of the program
SDG 13 – Addressing Climate Change	Diversion rubbish organic from track disposal pressing potential emission methane; synergy with group Proklam	Indirect; magnitude reduction Not yet measured
SDG 17 – Partnership For Achieving goals	Collaboration college high (UNNES and Wahid Hasyim University), group society and community Communal through studies imitate	Directly; realized in structure implementation

CONCLUSION

Activity service in the sub-district Tambakrejo, Semarang City, produces findings main that intervention that pairs training technical with facilitation facilities and reinforcement institutional capable increase capacity partners in management rubbish House ladder-based economy circular. Against management waste, the program produces basic infrastructure in the form of 4 units composter, 5 planter bags, 2 cage installation packages with 20 laying hens, 200 household sorting bags, and 1 product showcase unit, which together open track processing for rubbish organic previously completely neglected. Contribution to economy circular lies in the closure of part of the material chain at the community level: organic waste which was originally residue now has three paths utilization (compost, ecoenzyme, and feed) livestock, while low-value plastics that were previously not absorbed by the market are diverted become valuable craft products sell. For village resilience, the mechanism contribution ongoing through decrease residual load on drainage channels in areas prone to tidal flooding, the formation of household-scale food production capacity, increasing group income

sources, and strengthening the capacity of organizations to act collectively. The sustainability of the program is supported by institutions partners who have strengthened, incentives economics attached to output activities and plans development of BSF bioconversion units as continuation studies imitation. Development next need directed at expansion scale facilitation and addition outcome indicators in the form of measurement of the volume of diverted waste.

DECLARATION OF GENERATIVE AI

The authors declare that no generative AI or AI-assisted technologies were used in the writing process of this manuscript.

CONFLICTING INTEREST STATEMENT

The authors states that there is no conflict of interest in the publication of this article.

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