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ENGINEERING INNOVATION FOR RURAL WASTE MANAGEMENT: DEVELOPMENT OF AN ORGANIC WASTE CHOPPER MACHINE IN JEMBER REGENCY

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Abstract

Abstract. Waste management remains a critical challenge in rural and semi-urban communities in Indonesia, where limited infrastructure and low public awareness often lead to environmental degradation. Jelbuk Village in Jember Regency produces approximately 1,200 kg of household waste per day, most of which is disposed of in rivers or vacant land. This condition has resulted in pollution, health risks, and flooding, while the economic potential of waste recycling remains untapped. To address these issues, the Universitas Jember community service team implemented an integrated waste management program that combines technical innovation with community empowerment. The technical approach involved designing and fabricating a portable organic waste chopper machine with a capacity of 120 kg/hour, enabling the production of compost from organic waste. In parallel, inorganic waste such as plastics and metals was separated for recycling. The non-technical approach included training, awareness campaigns, and mentoring in simple bookkeeping to strengthen community capacity for sustainable waste management. The program successfully reduced waste accumulation, improved sanitation, and created new economic opportunities through compost production and the sale of recyclable materials. Furthermore, the involvement of students in design and implementation enhanced academic outcomes and knowledge transfer. This initiative demonstrates that integrated technical and social approaches can effectively transform waste problems into community-based solutions with long-term sustainability.

Keywords: Integrated Waste Management, Community Empowerment, Composting Technology, University–Community Collaboration

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INTRODUCTION

Waste management has become a major environmental challenge in Indonesia, particularly in areas with high population density and limited infrastructure (Rachman & Matsumoto, 2017). The rapid growth of household waste generation, driven by urbanization and market activities, often leads to serious problems such as air and water pollution, flooding, and the spread of infectious diseases (Amir et al., 2016). Household waste, which consists of both organic and inorganic materials, holds significant potential for recycling and reuse (Lansing et al., 2023). However, inadequate handling practices—such as open dumping and direct disposal into rivers—continue to degrade environmental quality and threaten public health.

Jelbuk Village in Jember Regency exemplifies these challenges. With a population density exceeding 5,000 people per square kilometer (BPD Jelbuk, 2021) and daily waste generation of approximately 1,200 kg, the community faces persistent issues of waste accumulation (Darsin, 2025b). Limited personnel and transportation facilities from the local sanitation department exacerbate the problem, resulting in piles of unmanaged waste around residential areas and the traditional market "Sido Dadi." This condition not only creates unpleasant odors and unsanitary surroundings but also diminishes the economic potential of waste utilization.

Despite these constraints, waste in Jelbuk Village offers opportunities for community-based solutions (Rachman & Matsumoto, 2017). Organic waste can be processed into compost, which is environmentally friendly and beneficial for agriculture, while inorganic waste, such as plastics and metals, can be recycled as raw materials for manufacturing industries. The challenge lies in providing appropriate technology and fostering community awareness to transform waste from a burden into a resource (Hes, 2017; Ohmer et al., 2022).

To address these issues, the Universitas Jember community service team initiated an integrated waste management program in Jelbuk Village. The program combines technical innovation—through the design and fabrication of a portable organic waste chopper machine—and non-technical approaches, including training, awareness campaigns, and mentoring in simple bookkeeping. This initiative aims to reduce waste accumulation, improve sanitation, and empower the community by creating new economic opportunities through compost production and recyclable material sales. The involvement of students in design and implementation further strengthens academic outcomes and knowledge transfer, ensuring sustainability of the program.

IMPLEMENTATION METHOD

The implementation of the integrated waste management program in Jelbuk Village was carried out through a combination of technical and non-technical approaches designed to address both the immediate problem of unmanaged waste and the long-term sustainability of community participation. The technical approach focused on the design and fabrication of waste processing machines (Sucipto et al., 2020). A portable organic waste chopper powered by a 6.5 HP gasoline engine was developed to process organic materials such as leaves, rice straw, banana stems, and livestock manure. With a cutting capacity of 120 kg per hour, the machine produced organic material suitable for composting (Widayanto et al., 2022). In the second phase, a plastic waste crusher was designed to shred plastic into chips, thereby increasing its market value and enabling recycling. The composting process was carried out by fermenting the shredded organic waste for 12–15 days at controlled temperatures between 40–60 °C, after which the compost was dried, sieved, and packaged for sale (Amaral-phillips, 2022; Mariyam et al., 2022). Meanwhile, inorganic waste such as metals and plastics was separated and sold to local recycling traders, creating additional economic opportunities for the community.

Alongside the technical innovations, the program emphasized non-technical strategies to ensure sustainability and community empowerment. Awareness campaigns were conducted through local organizations such as PKK, youth groups, and religious study circles to raise public consciousness about sanitation and environmental cleanliness. Training sessions were organized to transfer knowledge and skills, enabling residents to operate and maintain the machines independently. Furthermore, a local waste management unit was established involving community leaders at the RT and RW levels to coordinate activities and ensure program continuity. To strengthen economic sustainability, simple bookkeeping training was provided to community members, covering income and expense recording, stock management, and financial planning related to compost production and recyclable material sales.

The program also integrated academic outcomes by involving students in the design, manufacturing, and testing of the machines. Undergraduate students contributed through final-year projects, while graduate students assisted in supervision and documentation. This involvement not only enhanced the technical quality of the machines but also ensured knowledge transfer between the university and the community. Overall, the combination of technical innovation, community education, and student participation created a holistic approach to waste management that addressed environmental, economic, and social dimensions simultaneously.

RESULTS AND DISCUSSION

The implementation of the integrated waste management program in Jelbuk Village produced significant technical and social outcomes. The first major achievement was the successful design and fabrication of a portable organic waste chopper machine (Darsin, 2025a). As shown in **Figure 1**, the initial survey documented the condition of unmanaged waste in Jelbuk, which reached approximately 1,200 kg per day. This figure highlights the urgency of providing a technological solution to reduce waste accumulation.

Figure1. Unmanaged waste in Jelbuk village

The chopper machine, powered by a 6.5 HP gasoline engine, was tested on various organic materials, including leaves, livestock manure, and corn cobs. The trials demonstrated that the machine could consistently produce shredded organic material with a size of 2–3 cm, suitable for composting. Although minor adjustments were required during the processing of harder materials such as dried corn cobs, the machine ultimately performed according to specifications. The portability of the machine was particularly appreciated by the community, as it allowed flexible use in different locations without requiring permanent storage facilities (Djumhariyanto et al., 2023). The design of the machine is presented in **Figure 2**, which illustrates the main components, including the hopper, blades, and supporting frame.

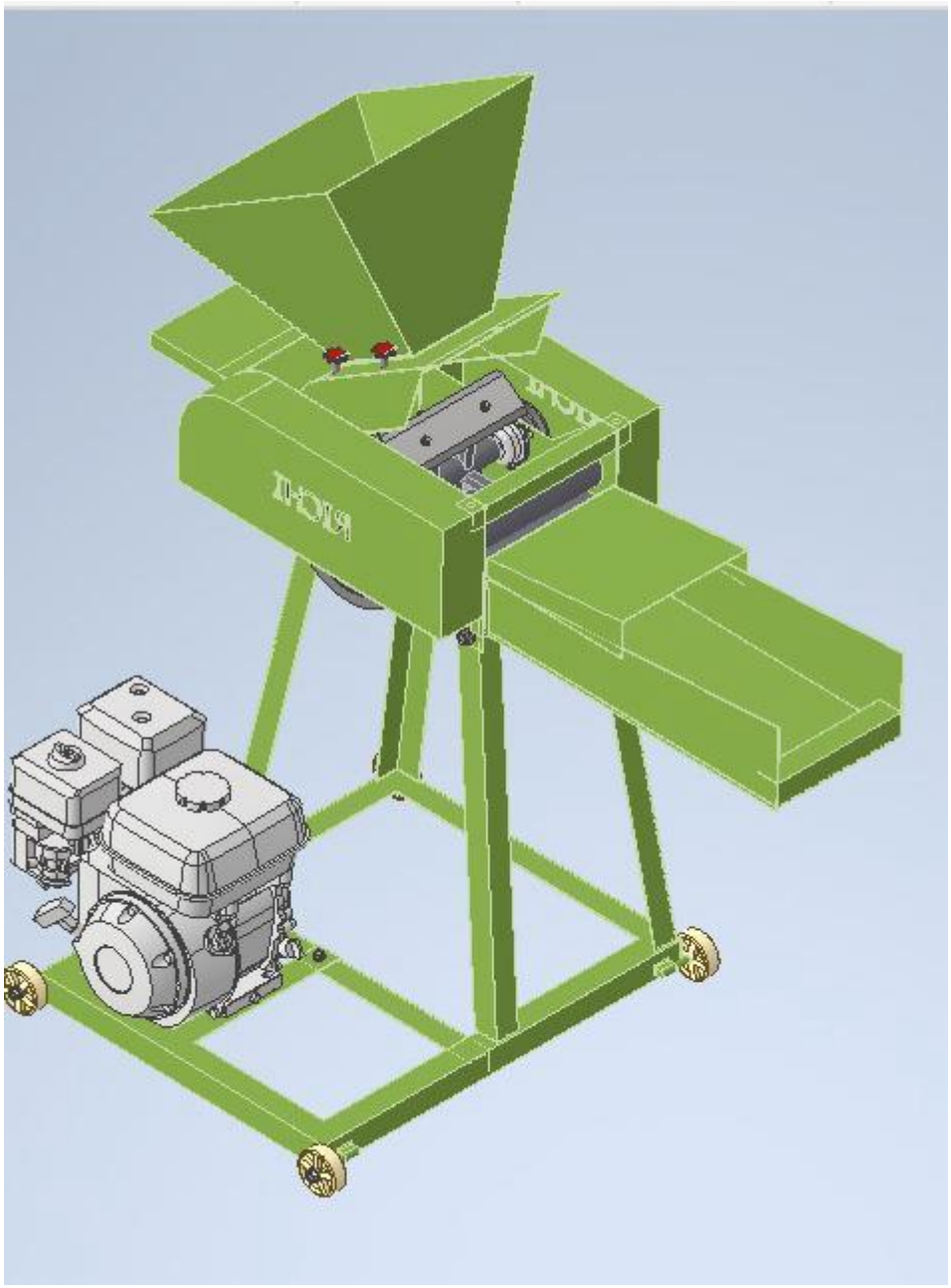

Figure 2. The assembled chopper machine

The composition of waste in Jelbuk Village is summarized in Table 1, which indicates that organic waste is the most prevalent component of daily production, followed by plastics and metals. This finding confirms that composting has the greatest potential for reducing waste volume while generating economic value simultaneously.

Table 1. Waste Composition in Jelbuk Village (Survey Results)

Type of Waste	Daily Volume (kg)	Utilization Potential
Organic (leaves, rice straw, livestock manure)	±800	Compost production
Plastic	±250	Recycling into plastic chips
Metal (iron, aluminum, brass)	±150	Sold to scrap collectors

Beyond the technical achievement, the program also succeeded in empowering the community through training and mentoring. Residents were introduced to composting techniques, including fermentation, temperature control, and packaging methods. This training not only improved technical skills but also raised awareness of the economic potential of waste management. Community members began to recognize that compost production could serve as a new source of income, while recyclable materials such as plastics and metals could be sold to local traders.

The program also emphasized organizational and managerial aspects. As detailed in Tabel 2, several supporting activities were carried out, including the establishment of a local waste management unit, technology transfer, awareness campaigns, and bookkeeping training (Masdani et al., 2023). These activities ensured that the program was not only technically effective but also socially sustainable (Sharma et al., 2024)(Ansar et al., 2025).

Table 2. Supporting Activities of the Community Service Program

Activity	Description	Objective
Organizational development	Establishment of a local waste management unit involving community leaders (RT/RW)	Ensuring structured program implementation
Technology transfer	Training sessions for local residents to operate the machines	Enabling independent operation and maintenance
Awareness campaigns	Socialization through PKK, youth groups, and religious study circles	Raising awareness of sanitation and cleanliness
Management assistance	Training in bookkeeping and marketing	Ensuring sustainability of waste management business

The involvement of students added academic value and strengthened knowledge transfer. Undergraduate students contributed through final-year projects focused on machine design and manufacturing, while graduate students assisted in supervision and documentation. Their participation ensured that the program was not only a community service activity but also an educational platform that integrated research, innovation, and practical application (Sarpong et al., 2025).

Overall, the results demonstrate that an integrated approach combining technical innovation and social empowerment can effectively address waste management challenges in rural communities. The program not only reduced waste accumulation and improved sanitation but also created new economic opportunities and strengthened community capacity.

These outcomes highlight the importance of linking engineering solutions with social interventions to achieve sustainable community development (Yusran et al., 2023).

CONCLUSION

The integrated waste management program in Jelbuk Village has proven that a combination of technical innovation and social empowerment can effectively address complex community challenges. The development of a portable organic waste chopper machine successfully reduced the volume of unmanaged organic waste and enabled the production of compost with economic value. In parallel, the introduction of a plastic waste crusher expanded opportunities for recycling and increased the market value of inorganic materials. These technical solutions directly responded to the community's needs and demonstrated how engineering design can be adapted to local constraints.

Beyond the technical achievements, the program strengthened community capacity through awareness campaigns, organizational development, and bookkeeping training. These non-technical approaches fostered behavioral change, improved sanitation practices, and ensured that residents could independently manage waste and sustain economic activities. The establishment of a local waste management unit further reinforced the program's continuity, while the involvement of students in design and implementation created academic outcomes and facilitated knowledge transfer between the university and society.

Overall, the program reduced waste accumulation, improved environmental quality, and created new economic opportunities for residents of Jelbuk Village. The results highlight that engineering solutions alone are insufficient without accompanying social interventions. By integrating technical and social strategies, the program achieved sustainable community development and provided a replicable model for other rural communities facing similar waste management challenges. Future initiatives should focus on scaling this approach, adapting it to local conditions, and continuously monitoring its long-term impact to ensure both environmental and socio-economic benefits.

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