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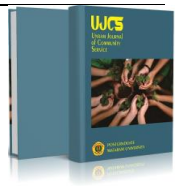

# Increasing Paddy and Tuber Crop Production Through Environmentally Friendly Straw Biodecomposer Technology Innovation in Wara Village, Jayawijaya

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**Abstract:** Rice straw management remains a major challenge in Wara Village, Jayawijaya Regency, where farmers commonly burn straw after harvest and lack the technical capacity to process agricultural waste. This community service program aimed to strengthen farmers' and women's family welfare development (FWD) technical and managerial skills by introducing biodecomposer technology based on locally available resources. The program involved socialization, technical training on compost production, simple farm bookkeeping instruction, field practice using molasses and EM4, and intensive mentoring. The results indicated substantial improvements in participants' knowledge and skills, including the ability to process 20–30 kg of rice straw per fermentation cycle and the establishment of a pilot farmer group capable of independently applying the technology. The family welfare development also gained competencies as household-level environmental stewards. The intervention contributed to reducing straw burning, improving soil quality through organic matter reintegration, and strengthening local socio-economic institutions. Overall, this program supports the development of autonomous, environmentally friendly, and sustainable agricultural practices in Wara Village.

**Keywords:** Biodecomposer, Community Empowerment, Compost, Jayawijaya, Rice Straw.

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## Introduction

Wara Village in Pisugi District, Jayawijaya Regency, is one of the highland areas in Papua Pegunungan that is currently developing paddy cultivation as part of a local food security strategy. The development of the wet rice system in this area continues to increase with the expansion of land and support from the local government. However, the growth of the rice cultivation sector has resulted in consequences, namely an increase in the volume of rice straw waste that has not been optimally utilized by local farmers.

Most farmers in Kampung Wara still burn the straw after the harvest season. This practice is common in traditional farming systems and is generally associated with limited information and access to agricultural waste processing technology. Various studies show that burning straw leads to the loss of essential nutrients, reduces soil quality, and releases carbon emissions and harmful particulate matter into the atmosphere (Arunrat et al., 2023; Kaur et al., 2022). Additionally, biomass burning increases the release of black carbon and $PM_{2.5}$ which has negative impacts on human health and the environment (Gili et al., 2025; Zhu et al., 2024). This condition also hinders the development of sustainable agricultural systems, as waste that should be returned to the soil is instead discarded.

In fact, rice straw has a rich lignocellulose composition, with high levels of crude fiber, organic carbon, and extractives that are important for improving soil fertility. The pressure to adopt more environmentally friendly waste management practices is becoming increasingly relevant, considering that straw can be processed into nutrient-rich compost with the help of decomposer microorganisms (W. Liu et al., 2023; Yumnam et al., 2023). Returning organic matter to the soil through composting has been proven to improve soil structure, cation exchange capacity, and soil microbial activity (Zhou et al., 2024). Besides technical aspects, the institutional capacity of farmer groups in Kampung Wara is also still weak.

Based on the results of the initial condition identification, all farmers (100%) do not yet have an adequate farm business record-keeping system, whether in terms of production, input use, or operational costs. The lack of record-keeping makes it difficult for farmers to evaluate production efficiency or make data-driven decisions. Similar findings were also reported by (Duden et al., 2023; Svenson et al., 2024), who stated that traditional farmers generally rely on intuition and memory in business decision-making, making them susceptible to inefficiency and economic vulnerability.

The conditions of the PKK group in Kampung Wara also face similar challenges. The minimal involvement of women in agricultural waste management indicates a gap in technical knowledge and social capacity. However, empowering women in household and agricultural waste management has been proven to improve the sustainability of environmental practices and strengthen family economies (Arya & Shukla, 2025; Fertő & Bojnec, 2024).

Against this backdrop, the application of biocomposter technology based on local microorganisms becomes a cost-effective solution for processing rice straw into solid or liquid organic fertilizer. This technology has been proven to accelerate the straw decomposition process and improve compost quality through efficient fermentation (Elsayed et al., 2024; Li et al., 2025). Additionally, using local materials like sugarcane molasses, which are abundant in Jayawijaya, makes this technology more adaptable and sustainable.

This program is also in line with the regional development agenda, particularly in strengthening the organic farming system, green economy, and food self-sufficiency as outlined in the Jayawijaya Regency Regional Medium-Term Development Plan (RPJMD). Furthermore, this activity supports the achievement of the SDGs, particularly goals 2 (Zero Hunger), 12 (Responsible Consumption and Production), and 13 (Climate Action), and also supports Asta Cita in realizing sustainable villages, healthy villages, and environmentally independent villages. With abundant local resources, rice straw can be a strategic resource to promote sustainable organic farming while empowering communities through improved technical and managerial capacity. Therefore, this service program is designed to improve community knowledge, technical skills, and institutions in managing straw waste through an appropriate and participatory biocomposer technology approach.

## Method

The implementation method for this service activity is designed using a participatory approach (participatory rural approach) that involves the Wara Rice Farmer Group and the PKK mothers' group as the main actors in each stage of the activity. This approach was chosen because it can increase the sense of ownership, strengthen the community's technical capacity, and ensure the sustainability of the straw management practices implemented in Wara Village. Broadly speaking, the program implementation consists of five stages: socialization, training, technology application, mentoring and evaluation, and program sustainability planning.

*Program Socialization*

The initial stage began with socialization activities for farmer groups and PKK groups, who are the main target partners. Socialization was conducted through focused group discussions aimed at introducing the program background, the urgency of straw waste management, the benefits of biocomposter technology, and the implementation mechanisms of activities during the program. At this stage, the implementing team directly gathered the aspirations, problems, and local potential of the Kampung Wara community. The socialization activities also resulted in a mapping of basic problems, including farmers' low knowledge of composting and the absence of a farm business recording system at the group level. This stage is an important foundation for building shared commitment among partners and ensuring the involvement of all parties in the subsequent process.

**Figure 1.** Socialization of Straw as Compost and Sugarcane as Molasses

*Technical, Managerial, and Marketing Training*

The training activities were designed with two main focuses: technical training on processing straw into organic fertilizer and managerial training related to farm business record-keeping. Technical training included explanations of the basic concepts of biodecomposers, the characteristics of straw as an organic material, required ingredients (straw, local sugarcane molasses, and EM4), straw chopping techniques, material mixing, and fermentation procedures in closed barrels. The material was delivered through a combination of interactive lectures, live demonstrations, and field simulations to ensure participants understood the step-by-step composting process.

Meanwhile, managerial training focused on farmers' ability to record production flows, categorize costs, and evaluate the development of their farming businesses. This activity emerged as a response to the initial conditions of the partners, where all farmers (100%) did not yet have adequate production and cost recording systems. The training is provided using a simple workbook that is easy to implement for diverse levels of formal education.

As an effort to strengthen the marketing aspect, this program also includes training on creating product packaging labels. During the training, participants were equipped with an understanding of the basic principles of brand identity, the mandatory information components to be included on labels (such as composition, instructions for use, production date, and the identity of the farmer group), and effective design rules to improve readability and visual appeal. The label design process was carried out through hands-on practice using the digital design platform Canva, which was chosen for its accessibility and ease of use by participants with varying levels of digital literacy.

Through this approach, farmers are expected to be able to produce more professional, consistent, and representative label designs, thereby increasing the selling value of organic fertilizer and expanding market access potential.

**Figure 2.** Training on Making Rice Straw Compost

**Figure 3.** Bookkeeping Training


**Figure 4.** Organic Fertilizer Label

*Application of Biocomposter Technology*

After training, participants began to apply the technology directly in the field. This application is done through the practice of making organic fertilizer from straw, using 20–30 kg per production session. The

process begins with chopping the straw, mixing it with EM4 solution and local sugarcane molasses, filling the material into the composting barrels, and fermenting it for several weeks. A team of faculty and students accompanied the entire process to ensure procedures ran according to technical standards and to provide corrections if any technical errors were found in the field. At this stage, model farmer groups were also formed, which are groups that successfully demonstrated the technical ability to independently produce and replicate the making of biodecomposers. This group will then serve as a reference and learning center for other residents who wish to adopt similar technologies.

**Figure 5.** Compost Bins Used

*Mentoring*

Mentoring was conducted intensively over a two-month period to ensure that the technology implementation process could run optimally at the field level. The mentoring activities include comprehensive monitoring of the straw fermentation stages, from measuring the moisture and temperature of the materials and evaluating the development and maturity level of the compost to identifying and addressing various technical obstacles faced by farmers during the production process.

Besides technical aspects, the mentoring also focuses on strengthening the farmers' managerial capacity. This activity is aimed at encouraging farmers to start getting used to regularly recording their farming operations, including recording production costs, the use of production inputs, and the yields obtained. Furthermore, the assistance also includes guidance in developing product branding, both for the organic fertilizer produced and other agricultural commodities, so that farming businesses can have added value and better competitiveness in the market.

*Program Sustainability*

The final stage is ensuring the program's sustainability after the intervention ends. At this stage, the team trained several members of the farmer groups and PKK to act as local technology cadres or peer mentors. This cadre is responsible for continuing internal training, guiding other group members, and ensuring the sustainability of biodecomposer production in Kampung Wara. In addition, the team provided biodecomposer starter, supporting materials, fermentation tanks, and training modules as tools that partners can use repeatedly. This sustainability approach is designed to ensure that the introduced technology doesn't just stop at training activities but becomes a routine practice internalized within the local community's agricultural system and social life.

## Result and Discussion

1. *Increasing Farmers' Knowledge in Utilizing Rice Straw*

Initial conditions showed that farmers' knowledge level regarding straw utilization was still very low. Based on observations and interviews with 20 members of the farmer group, only 1 person (5%) knew that straw could be processed into compost, while the other 19 people (95%) considered straw to be waste that should be burned after harvest. This condition aligns with the research findings of (Cuong et al., 2025; Q. Wang et al., 2025), who observed that straw burning is still commonly practiced by small-scale farmers due to limited literacy in composting technology. This practice not only eliminates the potential for straw utilization but also worsens soil and air quality.

Through socialization activities, farmers are introduced to the concept of straw as a high-value organic material. This explanation covers the chemical content of straw, such as lignocellulose and cellulose, which makes it ideal as a raw material for organic fertilizer if processed through fermentation. This evidence-based scientific literacy is important because research shows that rice straw has great potential as a source of organic matter to improve soil fertility when returned in the form of compost (Kuchi et al., 2024; H. Liu et al., 2024). This increase in theoretical knowledge became the foundation for changing farmers' behavior in Kampung Wara.

Furthermore, during the training, the farmers' understanding deepened as they saw firsthand that the composting process could utilize decomposer microorganisms such as EM4, which accelerates straw degradation. This practice-based training is an effective approach to enhancing the technical capacity of the community. The presence of effective microorganisms is an important factor that accelerates the decomposition time of straw and improves the quality of the resulting compost (Zhao et al., 2024). By seeing the real process, farmers realized that straw is not useless waste but rather a source of fertilizer that can increase land productivity.

At the end of the activity, the farmers' increased knowledge was evident in their ability to re-explain the

composting process, understand the ecological value of returning straw to the soil, and begin to abandon the practice of burning straw. This result demonstrates the successful transformation of knowledge while also supporting more environmentally friendly behavioral changes. This change aligns with climate change mitigation efforts because it reduces the burning of biomass, which is known to release significant amounts of $CO_2$ emissions and $PM_{25}$ particles (Zauli-Sajani et al., 2024).

2. *Improving Technical Skills in Organic Fertilizer Production*

After basic knowledge was reinforced through socialization, farmers entered the technical training phase for making compost. In the initial stages, most farmers had not been involved in the process of technology-based agricultural waste treatment. This is evident from the initial condition of the farmer group, which showed that none of the members had ever produced solid organic fertilizer, resulting in an initial compost production of 0 kg before the program intervention. This condition highlights the need for systematic and practical technology transfer to enable farmers to improve their management capacity. After the training was conducted, a significant improvement in the farmers' technical skills was evident. They began to be able to count straw, mix ingredients with local sugarcane molasses as a simple carbon source, and add EM4 as a fermentation starter.

The use of molasses as an additional energy source for microorganisms can increase decomposition activity, thereby accelerating the straw fermentation process (Antonius et al., 2025; Zhang et al., 2024). This fact aligns with the process also observed during service activities, where fermentation proceeded faster and more stably when local molasses was added in the correct dosage. During field practice, farmers learned to use closed compost bins to maintain moisture and fermentation temperature. They also periodically stir the material to ensure oxygenation and prevent unwanted spoilage. This skill is important because the success of composting heavily relies on managing environmental conditions during fermentation. Controlled fermentation methods using biodecomposers can produce high-quality compost with more stable nutrient content compared to conventional composting methods (Said et al., 2020).

The success of this technical skills improvement is reflected in the farmers' ability to produce organic fertilizer independently. By utilizing 20–30 kg of straw per fermentation cycle, the farmer group successfully produced increasing amounts of compost with each period of assistance. The formation of model farmer groups as learning centers strengthens the impact of activities, as these groups can serve as a local reference for other farmers in sustainably applying biocomposter technology.

3. *Managerial Transformation: Enhancing Farm Business Recording Capacity*

The service activity not only focused on technical aspects but also on improving farmers' managerial capacity. Based on the initial report, all farmers (100%) did not keep records of harvest yields, input costs, or operational evaluations, so all farm business decisions were based solely on habit and memory. This condition is a common characteristic of subsistence farming, as explained by (Vijayakumar et al., 2025), which indicates that the lack of data makes it difficult for farmers to plan long-term, efficiency-oriented farming operations. After the business management training was conducted, there was a significant change in the farmers' mindset and behavior. They are beginning to recognize the importance of farm record-keeping as a core part of the production planning and evaluation process. The training activities include the preparation of a simple workbook containing cost records, the volume of compost produced, material requirements, and an organic fertilizer distribution plan. This simple approach is crucial for facilitating the adoption of managerial technologies at the farmer level with diverse educational backgrounds.

Furthermore, improving farm record-keeping skills allows farmers to assess the efficiency of input management, including whether the use of compost impacts land productivity and reduces the cost of purchasing chemical fertilizers. According to (Wulandari et al., 2023), simple business record-keeping can increase the efficiency of input use by 20–40%, as it helps farmers understand their cost structure and determine savings strategies. By starting to implement regular record-keeping, the farmer group in Kampung Wara has taken an important step toward more professional farm business management.

This managerial transformation also strengthens the overall institutionalization of farmer groups. With a shared recording system, discussions and decision-making become more structured and data-driven. This ultimately increases trust between group managers and members and serves as an important social capital for long-term sustainable agricultural development.

4. *Empowerment of PKK Groups as Environmental and Household Economic Agents*

PKK groups are important actors in environmental behavior change in Kampung Wara, even though they were not involved in agricultural waste management before the program. Limited technical knowledge, the absence of a strong organizational structure, and minimal access to

technology have resulted in PKK groups being less active in sustainable agricultural activities. This condition aligns with the findings of (Rahmania et al., 2025), which indicate that women's involvement in environmental activities is significantly influenced by access to continuous training and mentoring.

After completing the biocomposter training, all PKK members (100%) were able to understand the fermentation process, material mixing techniques, and the steps for packaging organic fertilizer. Additionally, hands-on training helps boost women's confidence in managing straw waste to create organic fertilizer that can be used for family gardens. Involving women in organic waste management has been proven to enhance community adaptation to environmental issues, as reported by (Enciso-Alfaro & García-Sánchez, 2024; Palm et al., 2024), who stated that women play a crucial role in strengthening household-based circular economies.

In addition to improving technical skills, organizational strengthening activities were also carried out to form an environmentally based PKK management structure. The formation of this structure allows the PKK to carry out coordination functions, plan activities, and ensure the sustainability of compost processing at the community level. The involvement of the PKK in waste management also opens up opportunities for household businesses based on organic compost, thus providing additional economic value for families.

Ultimately, empowering PKK groups strengthens the social aspect of the service program. Women are no longer just passive recipients of benefits but also active agents of change who are driving the adoption of environmentally friendly practices at the household level. The success of the PKK in managing household compost also created a model of social innovation that can be replicated in other villages in the Pisugi and Jayawijaya Districts.

5. *Environmental Impact: Reduced Burning and Improved Soil Quality*

The ecological impact of the program is evident in the reduction of rice straw burning practices by the community. Before the intervention, most farmers burned straw to quickly clear the land. This practice not only removes essential nutrients but also produces carbon emissions, harmful particulates, and residues that are detrimental to human health. Burning straw can release high levels of $PM_{2,5}$ and greenhouse gasses, contributing to decreased air quality and worsening the effects of climate change (Kirasamutranon et al., 2025). After the program was underway, farmers began diverting straw for the fermentation process to become organic fertilizer. Returning straw as compost to agricultural land helps improve soil structure, increase cation exchange capacity, and enrich soil microorganism activity. Returning organic matter to the soil through compost improves long-term soil health and contributes to increased crop production ((Ho et al., 2022; Oueld Lhaj et al., 2024).

On the other hand, the use of this fermented organic fertilizer also supports the local ecological balance. With the increasing amount of compost used on agricultural land, the risk of soil degradation is reduced. Straw-based compost applications can improve soil's water retention capacity and reduce the excessive use of chemical fertilizers (Ninkuu et al., 2025; Y. Wang et al., 2023). This aligns with the Jayawijaya government's appeal to reduce reliance on chemical fertilizers to prevent long-term soil quality decline.

Overall, the environmental impact of this program demonstrates a real contribution to the development of environmentally friendly agriculture. The minimal burning of straw and the increased use of compost are early indicators of the success of ecological transformation in Kampung Wara. These results strengthen the achievement of sustainable development goals, particularly SDGs 12 and 13, which relate to sustainable production and climate action.

6. *Socio-Economic Impact: Institutional Strengthening and Local Independence*

In addition to ecological benefits, this program has a significant social impact on the community of Kampung Wara. The formation of model farmer groups and environmentally based PKK groups marks the strengthening of local institutions that were initially weak and unstructured. With a stronger organizational structure, knowledge sharing and decision-making processes can be carried out more systematically. This aligns with the concept of community-driven development, which places the community as the main driver of development based on local potential. The improvement of the community's technical and managerial capacity also has an impact on economic aspects. By being able to produce organic fertilizer independently, communities can reduce the cost of purchasing chemical fertilizers, which has been a significant economic burden. According to research by (Mubambwe et al., 2025), the use of compost can increase the cost efficiency of agricultural production while also improving crop yields in the long run. This opens up opportunities for communities to increase their income while achieving sustainable agriculture.

At the social level, this program strengthens intergroup collaboration through training activities, field practice, and intensive mentoring. Strong collaboration is an essential foundation for building social and environmental resilience at the village level. Additionally, the presence of local technology cadres as

mentors within the community has the potential to strengthen the sustainability of biocomposter technology without excessive reliance on external parties.

This program also contributes to achieving the SDGs, particularly goals 2 (Zero Hunger), 12 (Responsible Consumption and Production), and 13 (Climate Action). Using compost independently not only increases food productivity but also maintains environmental balance and reduces the carbon footprint. Thus, strengthening the socio-economic conditions of the Kampung Wara community not only impacts food security but also environmental sustainability and the overall well-being of the community.

## Conclusion

This service activity successfully increased the technical and managerial capacity of the Wara Village community in managing rice straw waste through the application of biocomposter technology. Farmers' previously very low knowledge significantly increased after attending socialization, training, and mentoring sessions. Farmers are able to practice making solid organic fertilizer independently and form model farmer groups as technology adoption centers.

Additionally, the ability to record farm business activities, which was never done before, is now being implemented through simple workbooks, making production management more measurable. The PKK group also demonstrated an increased role as environmental agents, able to process straw at the household level and contributing to the reduction of waste burning.

Overall, this program has an ecological impact by reducing straw burning and improving soil health, as well as a socio-economic impact by strengthening local institutions and increasing community self-reliance in sustainable agricultural practices.

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