



Modernization of hydroponic farming using rice husk for community food security in Karang Langit, Lamongan

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Abstract

Rice husk waste is an abundant agricultural byproduct in Karang Langit Village, Lamongan, but its utilization is still limited, posing a potential environmental problem. This community service program aims to modernize agricultural practices by utilizing rice husk as a hydroponic growing medium to support food security and promote a circular economy. The methods applied include community coordination, carbonization of rice husks, preparation of the hydroponic system, and both theoretical and practical hands-on training. Evaluation results show a significant increase in participants' knowledge by 32%. A total of 85% of participants successfully prepared a viable rice-husk-based growing medium, and 75% were able to cultivate and harvest leafy vegetables in the trial phase. Additionally, a farmer group was formed and is committed to independently continuing hydroponic practices after the program's conclusion. These results confirm that utilizing rice husk as a hydroponic medium not only enhances community skills and self-sufficiency but also opens new economic opportunities. This model is recommended for replication in other agricultural areas to support local food security and environmental sustainability.

Keywords: Circular economy; Hydroponics; Food security; Rice husk

Modernisasi pertanian hidroponik menggunakan sekam padi untuk ketahanan pangan masyarakat di Desa Karang Langit, Lamongan

Abstrak

Limbah sekam padi merupakan hasil samping pertanian yang melimpah di Desa Karang Langit, Lamongan, namun pemanfaatannya masih terbatas sehingga berpotensi menimbulkan masalah lingkungan. Program pengabdian kepada masyarakat ini bertujuan untuk memodernisasi praktik pertanian dengan memanfaatkan sekam padi sebagai media tanam hidroponik guna mendukung ketahanan pangan sekaligus mendorong ekonomi sirkular. Metode yang diterapkan mencakup koordinasi dengan masyarakat, proses karbonisasi sekam padi, persiapan sistem hidroponik, serta pelatihan berbasis teori dan praktik langsung. Hasil evaluasi menunjukkan adanya peningkatan pengetahuan peserta sebesar 32%. Sebanyak 85% peserta berhasil menyiapkan media tanam berbasis sekam padi yang layak digunakan, dan 75% mampu membudidayakan serta memanen sayuran daun pada tahap uji coba. Selain itu, terbentuk satu kelompok tani yang berkomitmen melanjutkan praktik hidroponik secara mandiri setelah program berakhir. Hasil ini menegaskan bahwa pemanfaatan sekam padi sebagai media hidroponik tidak hanya meningkatkan keterampilan dan kemandirian masyarakat, tetapi juga membuka peluang ekonomi baru. Model ini direkomendasikan untuk direplika di wilayah pertanian lain guna mendukung ketahanan pangan lokal dan keberlanjutan lingkungan.

Kata Kunci: Ekonomi sirkular; Hidroponik; Ketahanan pangan; Sekam padi

Contributions to
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1. Introduction

The intersection of sustainability, resource efficiency, and food security is becoming increasingly relevant in modern agriculture, even in rural areas where traditional farming remains dominant (Salé et al., 2021). As a key agricultural byproduct, rice husk presents a dual challenge: it's a waste product that burdens the environment and a potential resource for innovative farming solutions (Júnior et al., 2022). Its carbonization not only mitigates waste but also creates a hydroponic medium with high porosity and excellent nutrient retention (Pinheiro et al., 2022). Studies have demonstrated that this medium significantly improves crop growth, particularly for high-value crops such as strawberries, kale, and basil, by enhancing aeration and drainage, which are critical for healthy root development in soilless systems (Nafiah et al., 2023).

The use of rice husk in hydroponics offers significant environmental and economic advantages. Combining it with other materials like cocopeat has been shown to improve plant growth and water quality in aquaponic systems (Alam et al., 2020), supporting a circular economy and zero-waste production model. Furthermore, rice husk biochar positively affects soil microorganisms and nutrient availability, making it a valuable soil amendment. For hydroponic systems, its low bulk density and high porosity make it lightweight and easy to transport (Castoldi et al., 2014), and it can perform as effectively as traditional peat substrates. The economic benefits are particularly notable in rice-producing regions like Indonesia, where rice husk is abundant and inexpensive, reducing reliance on non-renewable resources and promoting ecosystem conservation (Huang et al., 2019; Morano et al., 2017). Recent innovations, like hydrogel-biochar formulations, have shown promising results in vertical farming, and integrating technologies such as IoT can further enhance productivity and resilience (Thapa et al., 2024).

Despite this clear potential, the adoption of modern farming techniques like hydroponics remains limited in many rural areas due to a lack of access to information and technology (Carnevali et al., 2010). This gap highlights the need for community education and capacity-building frameworks to help scale these innovations. Such programs can empower local farmers, stimulate sustainable agricultural development, and build community resilience by optimizing the use of local resources (Sufi et al., 2022; Wulandari et al., 2022). This approach aligns with broader empowerment strategies that use digital frameworks to accelerate the adoption of new practices in rural communities (Wahab et al., 2025).

This project focuses on Karang Langit Village in Lamongan, East Java, a community that primarily relies on rice cultivation but lacks crop diversification and modern farming techniques. Our initiative aims to transform a local waste product – rice husks – into a renewable and economically viable hydroponic growth medium. Through a mentor-centric model, the project seeks to equip villagers with the practical skills and knowledge needed to construct and maintain these systems independently, thus fostering food security and economic resilience. The originality of this program lies in its unified approach: it integrates waste management, sustainable farming, and economic self-sufficiency into a single, comprehensive solution. By doing so, it goes beyond mere food production to cultivate the principles of a circular economy and agricultural modernization.

This initiative is directly aligned with several Sustainable Development Goals (SDGs), such as SDG 2 (Zero Hunger), by improving access to nutritionally rich food and SDG 12 (Responsible Consumption and Production), by promoting resource-efficient agricultural practices (Chatterjee et al., 2025). By evaluating community participation, knowledge acquisition, and the practicality of using local materials, this paper contributes to the growing body of literature on rural agricultural innovation. It offers a replicable model for other resource-constrained communities and provides insights into effective strategies for combining waste utilization, technological innovation, and community empowerment. Ultimately, this project demonstrates that even in low-resource settings, agricultural modernization is achievable through targeted, community-based interventions that are grounded in both scientific principles and local wisdom (Rosli et al., 2023).

2. Method

This community service program was conducted in Karang Langit Village, Lamongan, from June to August 2025. A total of 27 community participants, consisting of farmer group members and household representatives, attended. The program employed a descriptive qualitative approach through a series of hands-on training and mentoring sessions. The implementation was divided into three distinct phases: preparation, training and implementation, and evaluation.

The preparation phase focused on initial coordination and resource readiness. We collaborated with village leaders to identify key community priorities and select the participants. We also gathered the necessary materials, which included rice husks, simple drum kilns, hydroponic kits, and various vegetable seeds. The program team prepared the venue, training tools, and demonstration equipment to ensure a smooth and efficient learning environment.

The training and implementation phase began with a socialization session that introduced participants to the value and potential of rice husk waste as a productive resource. Participants then engaged in two primary activities. First, they learned to produce biochar by slowly burning dry rice husks in open-top drums, with a strong emphasis on safety and the simplicity of the process for easy replication. Second, participants were guided through the creation of a hydroponic wick system. Using simple household materials like plastic bottles, cloth wicks, and net pots, they prepared the setups and filled them with the newly produced biochar media. Finally, they planted vegetable seedlings and received practical instruction on providing nutrients, managing water, and monitoring plant growth.

Following the training, a mentoring phase was initiated through regular field visits by our program team. During these visits, the team provided personalized guidance, addressed participants' technical questions, and helped them troubleshoot any problems encountered with their hydroponic systems. This consistent support was crucial for building participants' confidence and fostering independence in maintaining their new cultivation practices.

The evaluation was designed to measure the program's overall impact. We administered a pre-test and a post-test to quantify the improvement in participants' knowledge. We also conducted direct observation of their practical skills and the growth of their plants.

Brief interviews were carried out to capture participants' perceptions of the program and their interest in continuing the practice.

3. Results and Discussion

This community service program successfully demonstrated the effectiveness of a low-cost, community-based approach to modernizing agriculture for food security. By leveraging local resources and a structured training model, the project significantly enhanced the technical skills and confidence of participants in Karang Langit Village.

3.1. Community participation and skill enhancement

The program effectively engaged 27 participants, including a diverse group of youth, women, and smallholder farmers. An initial baseline assessment revealed a significant knowledge gap, with only 11% of participants having basic hydroponic knowledge. This finding underscored the need for targeted and practical training.

The training sessions were highly successful, combining theoretical instruction with hands-on practice. Participants were guided through the entire process, from preparing carbonized rice husks as a growing medium to assembling simple wick-based systems. As a result, the training outcomes were remarkable: 85% of participants independently prepared the substrate, while 82% successfully assembled and managed their hydroponic systems. This rapid acquisition of skills, as shown in [Table 1](#), validates the program's practical and participatory learning approach, a strategy recognized for accelerating the adoption of sustainable agricultural techniques in rural settings (Wulandari et al., 2022).

Table 1. Summary of knowledge and skills improvement

Indicator	Baseline (Pre-test)	Post-training	Improvement
Knowledge of hydroponics (%)	11%	85%	+74%
Skill in substrate preparation (%)	–	85%	–
Skill in system assembly (%)	–	82%	–
Confidence in applying hydroponics (%)	Low (qualitative)	High (qualitative)	↑

To reinforce the skills gained during training, the program team conducted continuous mentoring through regular field visits. These sessions provided opportunities to troubleshoot technical problems, refine practices, and foster independence in maintaining hydroponic systems. As a result, participants developed proficiency in carbonizing rice husks, regulating the pH of the growing medium, and cultivating leafy vegetables until harvest. Beyond technical competence, mentoring also nurtured participants' confidence and motivation to sustain hydroponic practices. Feedback collected through structured interviews indicated that participants were satisfied with the content and delivery of the training and strongly identified with the skills acquired. Several participants expressed intentions to apply the practices in their home gardens and even disseminate the methods to neighboring communities, suggesting potential for organic expansion. This indicates that the mentoring stage not only ensured knowledge retention but also strengthened community capacity for independent agricultural innovation.

Overall, the sequential process beginning with baseline knowledge assessment, followed by intensive training and continuous mentoring, proved highly effective in improving both the knowledge base and technical skills of the participants. The integration of quantitative data with qualitative insights underscores the program's success in enhancing community competence, confidence, and readiness for sustainable hydroponic farming.

Furthermore, [Figures 1](#) and [Figure 2](#) illustrate the mentoring and practical training sessions, showcasing participants actively engaging in the conversion of rice husks into charcoal and the setup of hydroponic systems. These quantitative improvements were complemented by further observations. Compared to other rural-focused capacity-building efforts, seemed to be much quicker. The rapid shift toward technical self-reliance among the participants was made possible due to the modular structured learning approach which was more relevant to the participants' context. The facilitation strategies which included the use of local vernaculars, farming analogies, and hands-on illustrative teaching made the learning less daunting and more approachable for novices.



Figure 2. Demonstration session showing participants the process of making rice husk charcoal



Figure 3. Participants engaging in practical training and discussion on hydroponic systems

The quantitative data was complemented by qualitative data collected from structured interviews, which offered valuable insights regarding the participants' engagement.

Such feedback indicated participants were pleased regarding the training's content, organization, and delivery. A number of participants reported they strongly identified with the skills learned and were keen to implement them in their home gardens or in small-scale farming enterprises. More importantly, a few participants expressed a desire to implement the approach within neighboring communities, which suggests prospects for organic dissemination and expansion. The findings highlight the need to address training program design with local and socio-cultural contexts while adapting them to modernization strategies for agriculture in the rural areas with limited resources.

3.2. Impact of hydroponic implementation on food security

The program delivered tangible benefits across multiple domains, including food supply, economic viability, and environmental sustainability (Table 2). First, household food supply, within four weeks of implementation, 85.2% of participants (23 out of 27 households) were managing their systems independently. The average germination success rate was an impressive 93%, leading to a steady weekly production of leafy greens. On average, each household produced 2.1 kg of vegetables per week, directly enhancing household food security and dietary diversity. These results highlight the efficacy of carbonized rice husks as a low-cost, effective growing medium.

Second, economic impact, beyond self-consumption, the initiative created new economic opportunities. 41% of participating households sold surplus produce, generating an additional weekly income of IDR 75,000 to 100,000. This income diversification demonstrates the potential of small-scale hydroponics to strengthen household resilience, a finding consistent with studies on biochar-based hydroponic systems (Rosli et al., 2023). Lastly, environmental impact, the program also contributed to environmental sustainability by repurposing approximately 48 kg of rice husks per month. This practice reduced open-field burning and its associated carbon emissions, showcasing the dual role of this technology in both food production and waste management (Adekiya et al., 2022).

Table 2. Household-level impact of hydroponic adoption

Indicator	Result
Independent adoption rate	85.2% (23/27 households)
Average germination success rate	93%
Average vegetable yield per household	2.1 kg/week
Households selling surplus produce	41%
Additional income earned	IDR 75,000–100,000/week
Rice husk repurposed	~48 kg/month

3.3. Comparative discussion

The rapid adoption and independence achieved by the participants demonstrate the effectiveness of a modular, context-specific training model. This approach, which utilized local vernacular and hands-on demonstrations, made learning accessible and reduced the apprehension often associated with new technologies. These findings are consistent with research emphasizing localized training as a key driver of food security resilience (Sufi et al., 2022) and support the argument for decentralized, low-cost hydroponic systems as a sustainable solution for resource-limited rural areas.

In conclusion, this community service project successfully empowered the people of Karang Langit with a simple yet impactful agricultural innovation. The use of rice husk-

based hydroponics improved food security, created new income streams, and promoted sustainable waste management. The project's tangible benefits not only validate academic findings (Rosli et al., 2023) but also reinforce insights from national empowerment initiatives (Sufi et al., 2022; Wulandari et al., 2022). Looking ahead, sustained success will require further support focused on value chain integration and the introduction of basic digital monitoring tools.

4. Conclusion

This community service project effectively empowered the people of Karang Langit with a simple but powerful agricultural innovation. The use of hydroponic systems with rice husk as a growing medium not only facilitated better management of farm waste but also improved nutrition and created new income avenues. These tangible benefits illustrate the impact of community empowerment and demonstrate that local, context-specific solutions can contribute significantly to food security.

Ultimately, this initiative showed that modern agriculture doesn't always require expensive equipment. The project leveraged local knowledge, adaptability, and strong community support to create a sustainable solution. This success lays the groundwork for future self-initiated technological use, entrepreneurial innovations, and a collective responsibility toward environmental conservation. While these initial results are promising, continued support is recommended to ensure long-term sustainability, focusing on value chain integration and the introduction of basic digital monitoring tools.

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Author Contribution

Activity implementation: CP, RSCM, AAZR, MGC; Documentation: AR, SA; Article preparation: AR, SA, ANAF; Analysis of service impact: AAZR, RSCM; Presentation of service result: MGC; Article revision: ANAF.

Conflict of Interest

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

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