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Socialization of Local Waste-Based Organic Fertilizer and Ultrasonic Solar-Powered Water Monitoring Sensors to Improve Food Security in Menganti Village

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ABSTRACT

This community service activity was carried out in Menganti Village, Glagah District, Lamongan Regency, with the aim of increasing community knowledge and skills in the application of environmentally friendly agricultural technology as a strategy to strengthen food security. A total of 35 participants, consisting of members of farmer groups, housewives, and village youth, participated in this activity. The implementation method included socialization, training in making organic fertilizer from goat manure, ash, and rice husks, and a demonstration of an automatic water level measuring device based on a solar-powered ultrasonic sensor. Evaluation was carried out through pre-tests and post-tests of knowledge and practical observations. The results of the analysis showed a significant increase in participant knowledge, from an average of 25.54 in the pre-test to 87.51 in the post-test ($\Delta = 61.97$ points; $t(34) = 37.06$; $p < 0.001$; Cohen's $d = 6.27$). Participants also demonstrated skills in the practice of making organic fertilizer and a high interest in adopting water sensor technology. This activity has had a positive impact in raising public awareness about sustainable agriculture, reducing dependence on chemical fertilizers, and opening up opportunities to utilize renewable energy technologies for efficient water management. Therefore, this outreach can serve as a model for strengthening food security based on sustainable local innovation.

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INTRODUCTION

Agriculture is an important sector in supporting food security in Indonesia, especially in rural areas where most of the population depends on local natural resources. (Aqilla et al., 2024). However, conventional agricultural practices that still rely excessively on chemical fertilizers have caused various environmental problems, such as decreased soil fertility, water pollution, and decreased land health quality in the long term. (Priono & Sujono Putro, 2024). Therefore, an environmentally friendly and sustainable alternative solution is needed to support agricultural productivity while maintaining ecosystem balance. (Muttaqin et al., 2023).

One strategic effort that can be made is the use of organic waste as a raw material for natural fertilizer. (Purwadinata et al., 2023). Animal waste, ash, and rice husks are abundant sources of organic material in rural areas and can be processed into organic fertilizer that can improve soil structure, increase nutrient content, and reduce agricultural production costs. (Ekawandani & Alvianingsih, 2018). Gadjah Mada University has developed a rapid fermentation technology that utilizes goat manure to produce high-quality, environmentally friendly organic fertilizer. (Ginting et al., 2022). Likewise, community service research in Jombang proved that training in making solid and liquid organic fertilizers was able to improve farmers' skills in managing livestock waste and provide added value to agricultural products. (Novia et al., 2022). The results of other studies show that the combination of rice husk charcoal and organic goat manure fertilizer has a positive effect on the growth of corn plants. (Nugroho et al., 2022), Biochar from livestock waste has been proven to increase red chili productivity by improving the chemical and physical properties of the soil (Anand et al., 2020).

Besides organic fertilizer, water management is also a key factor in the success of sustainable agriculture. (Widya Kayohana et al., 2024). In many villages, limited access to electricity and delays in monitoring water availability are often obstacles to optimizing irrigation. (Christie et al., 2024). Solar panel-based ultrasonic sensor technology is present as an innovative solution for measuring water levels in real-time, energy-efficient, and environmentally friendly. (Nurcahyanie et al., 2024) (FAO, 2022). An Internet of Things (IoT) based monitoring system using ultrasonic sensors and solar energy has proven effective in monitoring water levels in Situ Rawa Besar. (Eka Febri Anggara et al., 2024). Another study developed a flood detection prototype using the HC-SR04 sensor and LoRa transmission, which is capable of providing early warnings to the public regarding flood risks. (Missa et al., 2018).

Integrating the use of organic fertilizer and renewable energy-based water sensor technology can be a holistic approach to promoting village food security. (Lubis et al., 2022). Organic fertilizers help improve soil fertility without polluting the environment, while sensor-based water monitoring systems provide support in efficient water use for agriculture. (Siregar, 2023). Thus, there is a mutually supportive relationship: organic fertilizer improves soil quality, water sensors help manage irrigation efficiently, and both together strengthen village food security (Kragt et al., 2023).

This community service activity was specifically carried out in Menganti Village, Glagah District, Lamongan Regency. This village was chosen because its residents still rely on chemical fertilizers and lack adequate access to renewable energy-based agricultural technology. This situation makes Menganti Village a suitable location for implementing a program to promote environmentally friendly agricultural technology.

Based on this background, this community service activity is designed to disseminate environmentally friendly agricultural technology through training in the production of organic fertilizer based on local waste and the use of solar-powered ultrasonic sensors for water level monitoring. It is hoped that this activity will increase the awareness, skills, and motivation of village communities in

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implementing sustainable agricultural practices as a strategy to improve food security.

Based on the description above, this community service is designed to:

- Provide training and demonstrations on making organic fertilizer from goat manure, ash, and rice husks as an alternative to chemical fertilizers.
- Introduce and install an automatic water level measuring system based on ultrasonic sensors and solar panels as a tool for agricultural water management.

This approach is expected to foster awareness and concrete skills in village communities to implement environmentally friendly agricultural innovations, while simultaneously supporting food security and long-term well-being.

METHOD

Location, Time, Activity, and Participants

This community service activity was carried out in Menganti Galagah Village, Lamongan Regency, East Java, on August 7, 2025. The location was chosen because the majority of the village community works as farmers and has great potential in utilizing organic waste, and the need for simple technology to support sustainable agriculture.

The activity involved 35 participants, consisting of members of farmer groups, housewives, and village youth. This sample size was determined by considering:

- Population accessibility – the number of residents active in farmer group activities is approximately 40, so 35 participants represent >80% of the target population.
- Statistical considerations – a minimum sample size of 30 participants is considered to meet the assumptions of the central limit theorem for parametric analysis (Creswell & Creswell, 2018).

All participants participated voluntarily after being informed of the objectives, benefits, and procedures. Consent for participation was obtained through verbal informed consent facilitated by village officials. This activity poses no medical risks, is educational in nature, and has received approval from the Institute for Research and Community Service (LPPM) of Lamongan Islamic University.

Activity Participants

The activity participants consisted of farmer groups, housewives, and village youth, totaling ± 30. The participant criteria were people who were active in agricultural activities and had an interest in developing environmentally friendly technology.

Activity Stages

The activity implementation method consists of several stages as follows:

- Preparation
- Coordination with village officials and farmer groups.
- Preparation of outreach modules, presentation materials, and preparation of tools and materials.

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- Initial survey to determine the level of community knowledge regarding organic fertilizers and water management technology.
- Outreach and Education
- Presentation of material on the importance of environmentally friendly agriculture, the negative impacts of chemical fertilizer use, and the benefits of organic fertilizers.
- Introduction of solar panel-based ultrasonic sensor technology as a solution for water level monitoring.
- Training and Demonstration
- Training on making organic fertilizer using goat manure, ash, and rice husks. Participants were directly involved in the mixing, fermentation, and introduction of additional materials (EM4, molasses, etc.).
- Demonstration of an automatic water level measuring device based on ultrasonic sensors and solar panels. Participants were shown how the device works, the function of its components, and its benefits for efficient water use.
- Mentoring and Discussion
- Participants were assisted in repeating the practice in groups.
- Discussion and Q&A sessions were held to identify obstacles and potential applications of the technology in their respective fields.
- Activity Evaluation
- Evaluation was conducted through pre- and post-tests to assess participants' understanding of organic fertilizer and water sensor technology.
- Short interviews were conducted to determine community perceptions, interest, and readiness to adopt the introduced technology.

Tools And Materials

- Organic fertilizer: goat manure, ash, rice husks, EM4, molasses, rice washing water.
- Water sensor technology: HC-SR04 ultrasonic sensor, Arduino, mini solar panel, lithium battery, indicator light, and supporting circuitry.

Data Analysis

Quantitative data (pre-test and post-test): analyzed using a paired t-test to determine significant differences before and after the activity (Wahyuni et al., 2021). The Shapiro–Wilk normality test was performed first. The effect size was calculated using Cohen's d. Skill observation data and questionnaire responses: analyzed descriptively and quantitatively (percentage, mean, standard deviation). Instrument validity and reliability: tested using content validity (expert judgment) and internal reliability (Cronbach's Alpha) (Belete, 2022).

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RESULT AND DISCUSSION

Implementation of Activities

The outreach program was held on August 7, 2025, in Menganti Galagah Village, Lamongan Regency, East Java. Approximately 30 participants attended, consisting of members of farmer groups, housewives, and village youth. The program began with a pre-test on organic waste utilization and renewable energy-based agricultural technology. The initial survey results indicated that 75% of participants had never made organic fertilizer themselves, and 85% were unfamiliar with solar-powered ultrasonic sensors for water level monitoring.

The program consisted of three main stages: outreach, training and demonstration, and evaluation. During the outreach phase, participants learned about the long-term impacts of chemical fertilizer use, environmentally friendly agricultural concepts, and the benefits of renewable energy-based technology. The next stage involved hands-on experience in making organic fertilizer from goat manure, ash, and rice husks. Participants were involved in every step of the process, from mixing the ingredients and adjusting the humidity to storing the fertilizer during fermentation. Additional ingredients such as EM4, molasses, and rice washing water were also introduced to speed up the fermentation process. In the technology demonstration session, participants were introduced to an automatic water level gauge based on the HC-SR04 ultrasonic sensor powered by solar panels. This device is simply installed in a water reservoir. Participants were shown how the sensor reads the water level, how the Arduino processes the data, and how the indicator light displays the water level status (low, medium, full).

FIGURE 1. Implementation of Activities

Participant Knowledge Enhancement

The pre-test and post-test results showed a significant increase in participants' understanding.

TABLE 1. Comparison of Pre-test and Post-test Results

Rated aspect	Pre-test (%)	Post-test (%)	Improvement (%)	Sig. (p)
Organic fertilizer knowledge	20	92	+72	0,000*
Understanding of water sensor technology	15	85	+70	0,000*

Source: SPSS 2025 analysis results

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*$p < 0.05$ indicates a significant difference based on a paired t-test.

In addition to test scores, observations showed that more than 80% of participants were able to independently practice making fertilizer with minimal guidance.

Results of Making Organic Fertilizer

The results of the organic fertilizer-making workshop demonstrated the participants' high level of enthusiasm. After the initial fermentation process (3–5 days), the fertilizer darkened in color and began to develop a crumbly texture. Participants were given guidance on continuing the fermentation process for 4–8 weeks to allow the fertilizer to fully mature.

Significant improvements were seen in understanding:

- Before the training, only 20% of participants knew that livestock waste could be processed into organic fertilizer.
- After the training, 92% of participants understood the steps for making organic fertilizer, the characteristics of mature fertilizer, and its benefits for the soil.

In addition, several participants stated that they would try making organic fertilizer at home, especially because the raw materials are easy to obtain and the process is relatively simple.

FIGURE 2. Organic goat manure fertilizer

Water Sensor Technology Demonstration Results

The introduction of solar-powered ultrasonic sensor technology received a positive response from the community. Participants stated that this technology was very helpful in monitoring water availability, especially for irrigating rice fields and fish ponds (Tawalbeh et al., 2023). Discussions revealed that 65% of participants expressed interest in adopting similar tools, particularly for farmer groups that frequently face water shortages or excesses.

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Evaluation results showed that participants' understanding of water monitoring technology increased from 15% before the outreach to 85% after the outreach. This demonstrates that a hands-on demonstration approach is more effective than simply delivering theoretical material.

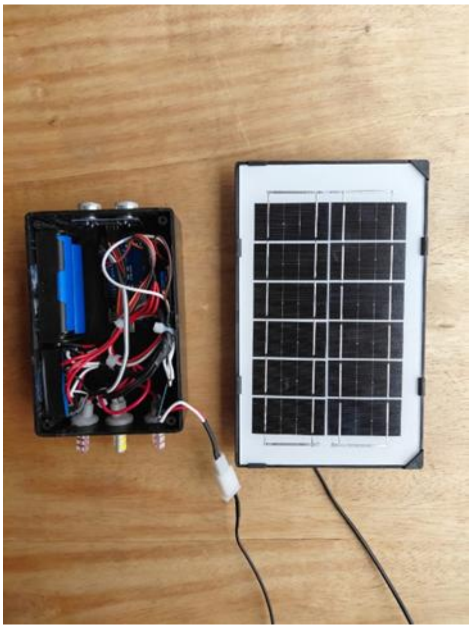

FIGURE 3. Water level detection tool

Social and Economic Impacts

This outreach activity had a direct impact on increasing the knowledge, skills, and motivation of the village community. Some of the identified impacts include:

- Economic: reducing dependence on expensive chemical fertilizers and utilizing local waste as a source of organic fertilizer.
- Environmental: reducing livestock and agricultural waste that previously polluted the environment.
- Technological: the community is becoming familiar with affordable and applicable renewable energy-based technologies.
- Social: a small study group has formed that plans to continue making organic fertilizer regularly.

Cost-Benefit and Scalability Analysis

A simple analysis shows that the production cost of organic fertilizer ±Rp250/kg) is much cheaper than chemical fertilizer (Rp5,000–7,000/kg). Ultrasonic sensor technology can be made at a cost of Rp350,000–500,000, affordable if borne collectively by farmer groups. The potential for scalability is quite high because raw materials and devices are widely available and can be replicated in other villages with similar conditions.

Limitations and Challenges

- There was no control group, so the results showed only internal differences.

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- Limited fermentation time means that fertilizers have not been fully tested on the field.
- The initial cost of installing sensors is still an obstacle for some participants.
- Potential social bias can arise because participants tend to give positive responses in front of facilitators.

Sustainability Prospects

This activity has sustainable prospects because:

- Local farmer groups plan to continue the production of organic fertilizers together.
- Lamongan Islamic University students and village officials are ready to provide periodic assistance.
- The water monitoring system will be further tested in the next planting season.
- Follow-up in the form of a post-activity survey (6 months later) will be carried out to assess the adoption of technology and the sustainability of the program.

Discussion of Results with Previous Research

The results of this service are consistent with the findings of Gadjah Mada University. (Ginting et al., 2022) which shows that organic fertilizer from goat manure can significantly increase soil fertility. This finding also supports research (Muttaqin et al., 2023), which states that biochar and compost from livestock waste can increase horticultural crop productivity. From a technological perspective, the results of this activity align with research at Situ Rawa Besar. (Anand et al., 2020) which proves the effectiveness of solar-powered ultrasonic sensors for real-time water monitoring.

Thus, this socialization activity not only succeeded in increasing community knowledge but also demonstrated that the application of a combination of local organic fertilizer and simple water monitoring technology can be a real strategy to strengthen village food security.

CONCLUSION

Training in making organic fertilizers from goat manure, ash, and rice husks has proven to be effective in introducing alternatives to chemical fertilizers that are cheaper, environmentally friendly, and able to improve soil fertility. Meanwhile, a demonstration of an ultrasonic sensor-based water level measuring device with solar panel energy sources broadens the public's insight into the importance of water management efficiency in supporting agricultural productivity.

However, this activity has some limitations:

- The absence of a control group limited the comparison of outcomes with the non-intervention group.
- The fermentation of organic fertilizers is still in the early stages so it has not been fully tested on agricultural land.
- The initial cost of installing water sensors is a challenge for some participants.

For further research, it is recommended:

- Directly test the effectiveness of organic fertilizers on various types of plants.

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- Development of a prototype of a water sensor that is cheaper and integrated with IoT-based applications.
- Longitudinal (long-term) studies to assess the sustainability of the use of this technology at the level of households and farmer groups.
- In terms of scalability, this approach can be replicated in other villages with similar conditions because:
- Organic fertilizer raw materials (goat dung, ash, husks) are widely available in rural areas.
- Solar ultrasonic sensor technology is relatively inexpensive, simple, and easy to install.

Participatory training models that engage communities have been shown to increase enthusiasm and motivation for technology adoption.

Overall, this activity has a positive impact on increasing community motivation in making optimal use of local resources, reducing environmental pollution, and strengthening village food security strategies. The integration of local waste-based organic fertilizers with simple water monitoring technology based on renewable energy is a practical and sustainable strategy to realize village independence.

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We hope that this synergy between universities, village governments, and the community can continue to encourage the birth of environmentally friendly agricultural innovations that are effective and sustainable.

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