



Optimizing Hydroponic Production through Liquid Organic Fertilizer, Solar Cells, and Digital Financial Management in Gajahan Village

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ABSTRACT

The Gajah Tani Makmur Women Farmers Group (KWT) in Gajahan Village has 62 members with 500 m² of land used for hydroponic cultivation. Partners face a number of obstacles, namely (1) less than optimal production due to expensive nutrients, (2) limited electricity resources for hydroponic irrigation, (3) not yet using modern financial bookkeeping, and (4) no experience in utilizing digital marketing. To address these problems, community service activities were carried out in several stages, namely stage 1 socialization in the form of an introduction to solar cells, the use of liquid fertilizer; stage 2 technical training covering the use of solar cells; stage 3 managerial training in the form of financial management and digital marketing; and stage 4 practical demonstrations on the KWT land. The results of the activities showed an increase in knowledge and skills, including (1) training in financial administration and digital marketing increased the average knowledge of participants from 61.5 to 84.8 with a significant change of 23.3 points; (2) training in making organic liquid fertilizer succeeded in providing practical skills to 30 participants in processing household waste into environmentally friendly fertilizer; (3) training on the use of solar panels increased participants' knowledge from 90.5 to 96.4, a change of 5.8 points; (4) participants' responses to the training method showed that 75 percent agreed; and (5) a survey on understanding solar cell maintenance showed that 81 percent of participants agreed. Thus, this community service activity effectively increased knowledge of production, management, and the use of renewable energy technology to support hydroponic farming.

Keywords: hydroponic farming, solar panels, liquid organic fertilizer

1. Introduction

Colomadu District is an area in Karanganyar Regency, Central Java, separated from the central government, thus holding exclave status. Economic development in Colomadu is supported by trade in goods and services, tourism, and industry. Its geographic proximity to Surakarta City gives this district significant economic potential, as evidenced by its status as the most densely populated area in Karanganyar Regency. Among the villages with horticultural-based economic potential is Gajahan Village, which houses the Gajah Tani Makmur Women's Farmers Group.

The Gajah Tani Makmur Women's Farmers Group (KWT) is located in Kasuran Hamlet, Gajahan Village, and was established in 2019. The organization is led by Dewi Susilowati, S.Sos., and uses a 20 x 25 meter plot of land for hydroponic cultivation. It has approximately 20 active members from Gajahan, Ginung, Kasuran, and Gatak Hamlets, with the majority having a high school education. The main product of hydroponic cultivation is lettuce, accompanied by additional crops such as tomatoes, eggplant, chili peppers, cabbage, ginger, shallots, celery, and aloe vera. These crops are marketed through collaborations with third parties. Furthermore, the group produces food innovations such as instant ginger, processed drinks, aloe vera crackers, and catfish crackers.

The organizational structure of the Gajah Tani Makmur KWT consists of a chairperson, secretary, and treasurer, as well as several sections: cultivation, processing, marketing, and documentation. This management structure supports the effectiveness and efficiency of the group's work. Since its inception, the KWT has actively participated in various competitions and once won second place in the Karanganyar Regency village barn competition.

However, the group faces several challenges, particularly related to plant nutrition, which is a determining factor in

the quantity and quality of the harvest. A lack of nitrogen in lettuce causes yellowing of the leaves and stunted growth, while an excess of nitrogen causes thick leaves but is susceptible to pests (Kumar et al., 2022; Zandvakili et al., 2022). Partners have been using a convenient AB mix solution, which can cause sediment and concentrations that are inappropriate for the plant's growth phase. Lettuce requires different nutrient formulations during the seedling, vegetative, and pre-harvest stages, while partners lack experience in producing cheaper and more efficient alternative fertilizers.

Another issue arises with the electricity sector. Hydroponic lettuce cultivation relies heavily on a stable electricity supply (Figure 1). When a power outage occurs, partners lack backup power, such as a generator. This disrupts circulation, depriving plant roots of oxygen and nutrients, and rendering the system inoperable. This situation risks economic losses due to crop failure. Although the land and installations are adequate, electricity needs are not met, requiring power from private homes (Priyadi et al., 2023; Hendarko et al., 2024). The increase in basic electricity tariffs (TDL) since 2019 has further increased production costs. Therefore, sustainable development of renewable energy is necessary to avoid increasing fixed costs (Marianti et al., 2023; Abidin et al., 2024).



Figure 1. KWT Gajah Tani Makmur hydroponic garden

Despite facing various obstacles, utilizing a plot of approximately 50 square meters of land still generates sufficient profits. In a 35–40-day planting cycle, lettuce yields range from 50–70 kilograms at an average price of Rp 16,000 per kilogram, resulting in monthly income of Rp 800,000–1,120,000. Part of the profit is used

to recoup capital, amounting to Rp 300,000–400,000 per month, plus the costs of fertilizer, nutrients, and agricultural equipment, as well as the fixed cost of electricity of Rp 100,000 per month. Thus, net profit per planting cycle ranges from Rp 620,000–720,000. However, because the harvest is sold through third parties, profits are not maximized.

Furthermore, limited digital marketing innovation is also a barrier (Sari et al., 2023). Lettuce, as a fresh commodity, has a short shelf life and is prone to wilting, making long-distance distribution less suitable. The selling price per unit is relatively low, while packaging and shipping costs often disproportionate to profits. Therefore, a marketing strategy based on engaging visual content, such as high-quality product photos, detailed descriptions, and compelling narratives, is essential for broader market reach.

Another challenge is the manual method of financial record-keeping. Transactions are recorded in notebooks without a standard format, resulting in poorly documented expenditures for nutrients, electricity, seeds, and equipment. This makes it difficult to track and evaluate production costs per planting cycle. Lack of awareness of the importance of monthly or quarterly financial reports makes it difficult for partners to submit business assistance proposals or establish partnerships, as there are no official tools to assess business health (Atarwaman et al., 2026; Gustika et al., 2024).

Table 1. Problems of the Gajah Tani Makmur Women Farmers Group

No	Aspect	Problem
1.	Production	Plant nutrients are expensive and there are no alternatives Inadequate electricity supply for water pump irrigation
2.	Manajement	Lack of modern financial management
3.	Marketing	Lack of use of digital marketing

Given the potential of hydroponic development and processed vegetable

products to boost the economy, it is necessary to conduct development activities including the introduction of renewable energy sources (Hendarko et al., 2024), training in liquid organic fertilizer production, financial and digital marketing training, and to increase capacity and productivity, as well as enhance the knowledge and skills of partners.

2. Method

This community service activity was implemented through community outreach through village deliberation meetings, followed by a series of training sessions and demonstrations. This community service activity adopted a participatory approach with the active involvement of the Gajah Tani Makmur Women's Farmers Group in Gajahan Village. The implementation team acted as facilitators, guiding the target group in designing and implementing activities tailored to local needs, ensuring that the community not only became beneficiaries but also actively participated in the learning process.

The implementation stages include:

- Stage 1: Socialization, including an introduction to the concept of renewable energy through solar cells, the use of liquid fertilizer, and the importance of farm management.
- Stage 2: Technical training, including training on the use of solar cells to support hydroponic systems and training on making liquid fertilizer as an alternative plant nutrient.
- Stage 3: Managerial training, including financial management and digital marketing training to improve partners' knowledge and skills.
- Stage 4: Practical demonstration, conducted on land owned by a farmer group in Gajahan Village so participants could directly practice the skills they learned.

3. Result

This activity was implemented in four stages: the first was socialization; the second was financial management and digital marketing training; the third was organic fertilizer production training; and the fourth was solar panel installation and use training. This activity involved several parties, including the village head, village officials, the Family Welfare Movement (PKK) chair, members of the Gajah Tani Makmur Women Farmers Group, and invitees from the Gajahan Village Women Farmers Group. The socialization took place in October 2025, involving core members of the Gajahan Women Farmers Group (KWT Gajahan) to convey the intent, objectives, and activity plan. Training and equipment introductions were carried out in stages, involving lecturers, students, and alumni from the Nutrition Science Study Program, Faculty of Health Sciences, Development Economics Study Program, Faculty of Economics and Business, and Industrial Engineering Study Program, Faculty of Engineering, Muhammadiyah University of Surakarta.

Based on a survey of women farmers group members in September 2025, members stated during interviews that they had never received training in financial management or digital marketing. On November 6, 2025, training activities were implemented in accordance with community needs. This community service activity was designed to address two key challenges faced by business owners, particularly women farmers: weak financial management and the suboptimal use of digital marketing. In the first session, participants were provided with an understanding of financial management as a crucial foundation for maintaining business sustainability. Financial management is defined as the process of planning, organizing, controlling, and monitoring financial resources (Debataraja, 2024). In practice, many business owners fail to separate personal and business finances, resulting in inaccurate record-keeping and difficult business performance evaluations. The impact of this mix not only obscures profit

and loss statements but also hinders access to external financing due to the lack of valid financial reports (Endaryati, 2023). Therefore, participants were trained to understand the characteristics of a financially healthy business, such as recording daily transactions, budgeting, and regular reporting. The primary purpose of financial recording was explained as a tool to control expenses, increase transparency, and strengthen the business's position in strategic decision-making (Wibowo et al., 2024).

The second session focused on strengthening digital marketing capacity as a cost-effective and impactful promotional strategy. Participants were introduced to the primary goals of digital marketing: expanding market reach, building emotional connections with consumers, and increasing sales through digital platforms. Commonly used platforms such as WhatsApp Business, Instagram, Facebook, and TikTok were explained in a practical manner, including features relevant to micro-businesses (Yaqin, 2025). Branding was a key focus, as participants were encouraged to understand that branding is more than just a logo, but encompasses narrative, communication style, and visual consistency that shape a business's identity. Strong branding can differentiate a product from competitors and increase customer loyalty. Furthermore, the importance of packaging was discussed as the primary visual element influencing consumer perception. Attractive and informative packaging not only strengthens a product's image but also enhances visual appeal in digital marketing. Through this training, participants demonstrated an increased understanding of visual content-based promotional strategies and began to realize that digital marketing and financial record-keeping are two key pillars in building a modern, independent, and competitive business (Sagita, 2025).



Figure 2. Organic Liquid Fertilizer Training at Gajahan Village Hall

The next training activity, which involved making liquid organic fertilizer, was conducted using simple, readily available household ingredients at the village hall. Participants were instructed to prepare 10 liters of water as the primary medium, then add half a kilogram of household waste, such as fruit or vegetable scraps. Next, add one tablespoon of molasses or liquid brown sugar as an energy source for the microorganisms, and one tablespoon of EM4 (Effective Microorganisms 4) to accelerate the fermentation process. All ingredients were mixed in a closed container and then fermented for several weeks, stirring frequently to ensure optimal decomposition (Figures 2 and 3).



Figure 3. Results of Fermentation of Organic Liquid Fertilizer

Through this activity, members of the Women Farmers Group (KWT) gained practical skills in processing household waste into environmentally friendly liquid organic fertilizer. The fermented product can be used as

additional nutrition for plants, either through watering the growing medium or spraying the leaves. This liquid organic fertilizer training not only enhanced participants' technical knowledge but also encouraged the sustainable use of local resources, thus supporting independent and competitive agriculture (Azhimahd, kk, 2025).

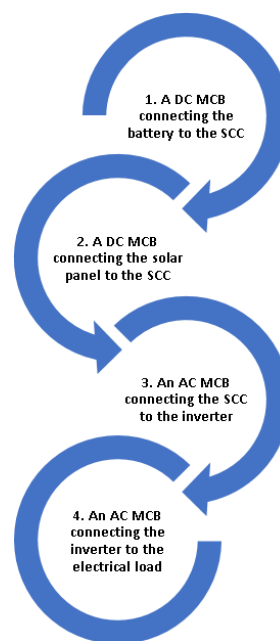


Figure 4. Solar Panel Usage Flow

In the training activity on the use of Solar Cells for members of the Women Farmers Group (KWT), participants were provided with a technical understanding of the procedures for activating and stopping solar energy systems safely and gradually (figure 4). This material aims to enable participants to operate solar panel systems independently to support electricity needs in agricultural activities (Irawati et al., 2023). The process of activating the system begins by turning on the DC MCB (Miniature Circuit Breaker direct current) which connects the power storage battery (accu) to the Solar Charge Controller (SCC), so that the SCC receives a power supply and is ready to work. The next stage is to activate the DC MCB that connects the solar panel (Photovoltaic or PV) to the SCC, so that the solar energy captured by the

panel can be regulated and used to charge the battery. After that, participants turn on the AC MCB (Miniature Circuit Breaker alternating current) which connects the SCC to the inverter, which functions to convert DC voltage to AC. The final stage is to activate the AC MCB between the inverter and the electrical load, so that agricultural equipment begins to receive power from the Solar Cell system.

Table 1. Knowledge before and after financial administration and digital marketing training

	pre	post	delta	P value
mean	61,5	84,8	23,3	0.00
Standar deviation	21,6	12,5		
n	30	30		

The analysis results in Table 1 show a significant increase in knowledge after the financial administration and digital marketing training. The average knowledge of participants before the training was recorded at 61.5, while after the training it increased to 84.8, with a change of 23.3 and a P-value of 0.00, indicating a statistically significant difference. Furthermore, the standard deviation decreased from 21.6 to 12.5, indicating a smaller variation in knowledge among participants and a more equitable learning outcome. The number of respondents involved in this measurement was 30 people, both before and after the

training. These findings indicate that the financial administration and digital marketing training provided was effective in increasing participants' knowledge while strengthening consistency of understanding (Sutarsad et al., 2024).

Table 2. Knowledge before and after Solar Cell and liquid fertilizer training

	pre	post	delta	P value
means	90.5	96.4	5.8	0.001
Deviation standard	8.9	6.1		
n	30	30		

The analysis results in Table 2 show an

increase in participants' knowledge after participating in the Solar Cell and liquid fertilizer training. The average knowledge

before the training was recorded at 90.5, while after the training it increased to 96.4, with a change of 5.8 and a P value of 0.001 indicating that the difference was organically significant. The standard deviation also decreased from 8.9 to 6.1, indicating that the variation in knowledge between participants was getting smaller so that understanding became more uniform. The number of respondents involved in this measurement was 30 people, both before and after the training. These findings indicate that the training provided was effective in strengthening participants' knowledge, while increasing the consistency of understanding related to the use of Solar Cell technology and the manufacture of organic liquid fertilizer.



Figure 5. Participant Responses to the Suitability of Training Methods (%)

Participants' responses to the suitability of the training methods were very positive. According to the survey, 75 percent of participants agreed that the training methods were appropriate for their needs. 19.4 percent strongly agreed, 5.6 percent somewhat disagreed, and no participants disagreed. These results demonstrate that the training approach, which encompasses financial management, digital marketing, liquid fertilizer production, and the use of solar panels in hydroponic farming, was effectively designed and delivered. The high level of agreement indicates that the methods used are relevant to field conditions and significantly support the capacity building of farmer groups.

Figure 6 shows the results of a survey of participants' understanding of solar cell maintenance, indicating that the majority of respondents understood the material presented in the training. Of the 37 participants, 81 percent agreed, indicating they understood how to maintain solar cell equipment. Eleven percent strongly agreed, indicating a high level of confidence in their understanding. Meanwhile, only 8 percent disagreed, indicating a small number of participants still needed further guidance. Overall, these data reflect the success of the training in improving participants' technical understanding. The high level of agreement indicates that the training method used was relevant, easy to understand, and able to meet participants' needs in managing renewable energy technology independently and sustainably.

Participant Responses to Understanding of Equipment Maintenance

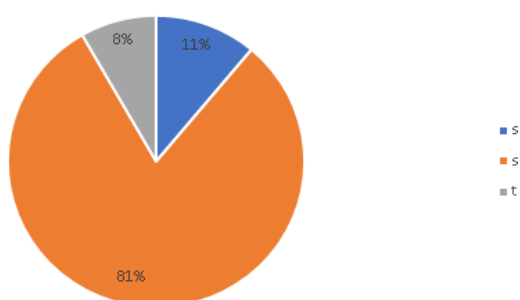


Figure 6. Participant Responses to Understanding of Equipment Maintenance After Training

4. Conclusion

The financial administration and digital marketing training increased the average knowledge of participants from 61.5 to 84.8, a significant change of 23.3 points. The organic liquid fertilizer training successfully provided 30 participants with practical skills in processing household waste into environmentally friendly fertilizer. The solar panel training increased participants' knowledge from 90.5 to 96.4,

a change of 5.8 points and a more uniform understanding. Participants' responses to the training method showed 75 percent agreeing and 19.4 percent strongly agreeing, indicating the method used was relevant to needs. The survey on understanding solar cell equipment maintenance showed 81 percent agreeing and 11 percent strongly agreeing, confirming the training's success in improving technical skills.

AI Disclosure Statement

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