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Solar-Powered Automatic Water Pump for Energy Independence in Taruna Tani Sukamandiri Farmers' Group

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ABSTRACT

This community service program was conducted in 2025 with the Taruna Tani Sukamandiri Farmers' Group in Ciamis Regency to address water scarcity and high fuel dependency in rainfed farming. An automatic solar-powered water pump system was introduced to strengthen energy independence, reduce irrigation costs, and increase the productivity of chili and cucumber crops. The program was implemented through five stages: coordination, technology installation, training, mentoring and evaluation, and ensuring sustainability. Results showed a significant reduction in diesel pump usage, cutting operational costs by IDR 1–1.5 million per season. Irrigation efficiency improved crop yields during the first two harvests, although the third harvest declined due to excessive rainfall. Farmers actively participated in installation, training, and maintenance, while students gained valuable hands-on learning. Academic outputs include a submitted journal article and a draft technical manual being processed for intellectual property rights, making this program a replicable model of sustainable agriculture.

Keywords*: Community Service, Solar-Powered Water Pump, Energy Independence, Rainfed Agriculture, Appropriate Technology*

1. INTRODUCTION

Rainfed agriculture remains one of the most vulnerable farming systems in Indonesia. Farmers depending on rainfall for irrigation often face unstable yields due to water scarcity during the dry season and excessive water during the rainy season **(Hari, et al 2025; Mariyani, et al, 2019).** These conditions create significant risks for smallholder farmers, who typically operate with limited land, capital, and access to modern technologies. Studies show that water scarcity and unpredictable rainfall patterns are among the most critical constraints to sustaining horticultural crop production in rainfed systems **(Arifin, et al., 2021; Perwitasari, et al., 2018).**

Another challenge is the reliance on conventional energy sources for irrigation. Farmers frequently use diesel pumps to draw water from wells, leading to high operational costs, dependency on fuel availability, and environmental concerns due to emissions. The heavy burden of fuel-based irrigation often undermines farmers' income stability and limits their capacity to expand production **(Ardiansyah & Agustina, 2023).** In the case of the Taruna Tani Sukamandiri Farmers' Group in Ciamis Regency, for example, farmers previously spent between IDR 1–1.5 million per planting season to operate diesel pumps for chili and cucumber fields. This reliance not only increased costs but also restricted irrigation coverage, leaving part of their land underutilized during the dry season.

The adoption of renewable energy technologies in agriculture has been widely promoted as a solution to these challenges. Solar-powered irrigation systems, in particular, are considered an appropriate technology in tropical countries like Indonesia, which receive high solar radiation averaging 4.8–5.5 kWh/m²/day. Solar pumping technology reduces dependency on fossil fuels, lowers irrigation costs, and enhances environmental sustainability **(Escobedo, et al., 2023).** Successful projects in Indonesia demonstrate its potential: in Tanjung Raja Village, solar irrigation pumps allowed farmers to harvest rice twice a year instead of once **(Kementerian ESDM, 2021)**, while in Nanjungan Village, South Sumatra, solar-powered irrigation increased annual harvests from one to up to three times, benefiting more than 150 farmers **(Bukit Asam CSR, 2023).** These outcomes also align with global sustainability targets, particularly the Sustainable Development Goals (SDGs) for zero hunger (SDG 2), affordable and clean energy (SDG 7), and climate action (SDG 13) **(Ahmed, et al., 2024).**

In addition to technical benefits, the role of community empowerment is central to the long-term success of renewable energy adoption in rural areas. Programs that involve farmers in planning, installation, and maintenance foster local ownership, strengthen technical capacity, and ensure sustainability **(Budiman, 2018).** For the Taruna Tani Sukamandiri Farmers' Group, which consists of 30 members primarily cultivating chili and cucumber, the integration of solar-powered irrigation represents not only an innovation in energy use but also a strategic intervention to increase crop productivity and resilience in rainfed conditions. This study documents the implementation of an automatic solar-powered water pump in Ciamis, assessing its impact on energy independence, irrigation management, and agricultural production while highlighting the role of community participation and academic contribution through publications and technical manuals.

2. METHOD

This community service program was implemented in 2025 with the Taruna Tani Sukamandiri Farmers' Group, located in Sukasetia Village, Cihaurbeuti Subdistrict, Ciamis Regency, West Java, Indonesia. The group consists of approximately 30 farmers, primarily cultivating chili and cucumber on small to medium-scale farms in a rainfed agricultural system. The methodology adopted in this program followed a participatory action research (PAR) approach, emphasizing collaboration between university teams and the local farming community to ensure contextual relevance, active involvement, and sustainability of outcomes as seen in Figure 1.

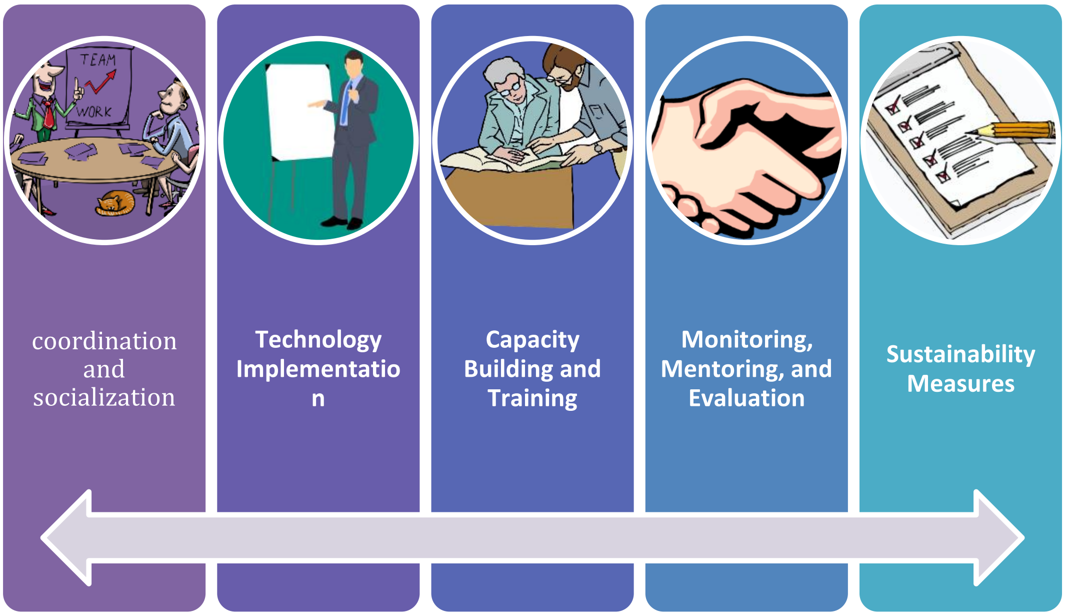

Figure 1. Stages of implementation

2.1 Stages of Implementation

The program was designed and executed in five main stages:

1. **Coordination and Socialization**

   Initial coordination involved formal and informal meetings with the farmers' group to present the objectives, benefits, and relevance of the solar-powered water pump system. During this stage, needs assessment and problem identification were conducted through group discussions and field observations (Figure 2).

Figure 2. Coordination and socialization with local authorities

2. **Technology Implementation**

   The implementation phase began with the repair and preparation of the existing water source (well), followed by the construction of the mounting structure for photovoltaic panels. Subsequently, a solar photovoltaic (PV) system was installed, connected to a submersible pump, and integrated with a distribution pipeline to irrigate the horticultural fields. Farmers actively participated in the installation process to enhance technical understanding and ownership (Figure 3).

Figure 3. implementation of technology

3. **Capacity Building and Training**
   Hands-on training sessions were conducted to equip farmers with operational knowledge and maintenance skills. Training materials included pump operation, panel cleaning, water flow regulation, and troubleshooting for common technical problems. Approximately 25 farmers attended and practiced directly on the installed system (Figure 4).
4. **Monitoring, Mentoring, and Evaluation**
   Continuous mentoring was provided through regular field visits to monitor pump performance and irrigation practices. Evaluation focused on water delivery efficiency, reduction in fuel dependency, and farmer satisfaction. Data were collected through observations, structured interviews, and cost–benefit analysis comparing pre- and post-installation conditions.

Figure 4. Training mentoring and evaluation

5. **Sustainability Measures**
   To ensure long-term sustainability, a farmer-led maintenance team was established. In addition, knowledge transfer was reinforced by developing a technical manual for operation and troubleshooting, currently being processed for intellectual property rights (IPR) registration.

2.2 Data Collection and Analysis

Data were gathered using a mixed-methods approach. Quantitative data included measurements of irrigation coverage area, fuel savings, and crop yield records across three harvest cycles. Qualitative data were obtained from farmer interviews, focus group discussions, and direct observation of field practices. Data triangulation was employed to validate findings, ensuring reliability and comprehensiveness in assessing both technical and social impacts of the program.

3. RESULTS AND DISCUSSION

3.1 Improved Irrigation and Energy Independence

The installation of the solar-powered submersible pump successfully addressed one of the main challenges faced by the Taruna Tani Sukamandiri Farmers' Group: limited access to water in rainfed agricultural systems. Prior to the intervention, irrigation relied heavily on diesel pumps, which imposed high operational costs and were unsustainable in the long term due to fluctuating fuel prices. Following the adoption of the solar water pump, farmers reported a reduction of more than 70% in diesel pump usage, saving approximately IDR 1–1.5 million per season in operational costs. These savings allowed farmers to reallocate resources to other productive activities, demonstrating the immediate economic benefit of renewable energy adoption in smallholder farming.

3.2 Agricultural Production Performance

The availability of stable irrigation improved crop management and directly affected production levels of chili and cucumber. Table 1 summarizes crop yields from the first three harvests after the installation of the solar pump.

Table 1. Yields of chili and cucumber during three harvest cycles

Crop	First Harvest (Kg)	Second Harvest (Kg)	Third Harvest (Kg)	Remarks
Chili	85	120	70	Yields increased in the second harvest due to stable irrigation; declined in the third harvest due to heavy rainfall, flower drop, and pest attacks.
Cucumber	95	160	90	Significant improvement in the second harvest; decline in the third linked to high humidity causing faster fruit decay.

The data show that yields improved significantly in the first and second harvests due to reliable irrigation. However, the third harvest experienced a decline, largely attributable to seasonal factors such as high rainfall and increased disease pressure. This finding underscores that while irrigation technology addresses water scarcity during dry periods, external climatic conditions during the rainy season continue to affect production outcomes (Figure 5).

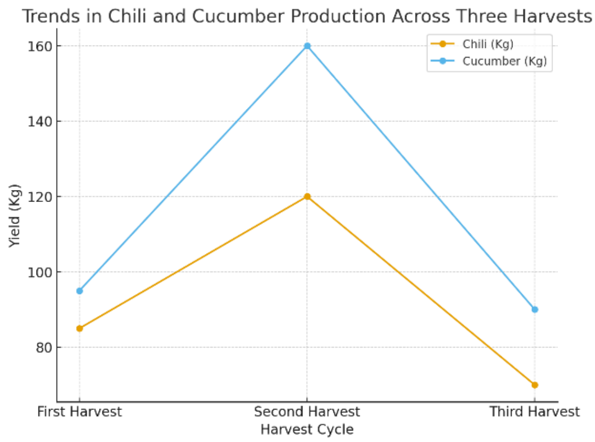

Figure 5. Training mentoring and evaluation

3.3 Effectiveness of Irrigation Management

The introduction of the automatic solar-powered water pump not only reduced dependence on fossil fuels but also increased the effectiveness of irrigation management. Previously, farmers had to dedicate significant time and physical effort to manually operate diesel pumps and monitor water distribution. With the automatic system, irrigation became more efficient, requiring less supervision and labor. Table 2 highlights the differences in irrigation management before and after the system implementation.

Table 2. Effectiveness of irrigation management before and after solar-powered

Parameter	**Before (Diesel Pump/Manual Irrigation)**	**After (Automatic Solar Pump)**	**Improvement**
Daily monitoring time (hours/day)	4–5	1–2	Reduced by 60%
Labor requirement (persons/shift)	2–3	1	Reduced by 50–66%
Irrigation schedule consistency	Irregular, depending on labor & fuel	Regular, automated by system	High consistency
Energy source dependency	High (diesel fuel, PLN)	Minimal (solar energy)	Sustainable, cost-free
Risk of water stress in crops	High during dry season	Significantly reduced	Improved crop health

The data indicate that the automated irrigation system reduced monitoring time by up to 60% and labor needs by more than half. This efficiency not only lowered production costs but also freed up farmers' time for other productive agricultural activities. Furthermore, the consistency provided by the automatic system minimized water stress in crops, which is critical for sustaining horticultural yields in rainfed farming systems.

3.4 Empowerment through Irrigation Management

Beyond yield improvements, the program enhanced farmers' capacity in managing irrigation systems. Farmers who previously relied solely on traditional methods became proficient in operating the solar-powered pump, regulating water distribution, and performing routine maintenance such as cleaning solar panels and checking pipelines. This transformation represents a shift in the community's level of empowerment—from passive technology users to active managers capable of sustaining the system independently. The participatory approach employed throughout the program was crucial in fostering this sense of ownership, ensuring that the technology is not only adopted but also maintained in the long term.

3.5 Academic and Social Contributions

In addition to the technical outcomes, the program produced academic and social contributions. A journal article documenting the intervention has been submitted to a national accredited journal, and a technical manual on system operation and troubleshooting is currently being processed for intellectual property rights (IPR) protection. Socially, the program provided experiential learning opportunities for students from Universitas Siliwangi and Universitas Mayasari Bakti, allowing them to engage directly with community problems and contribute to practical solutions. This dual impact—empowering farmers and enriching student learning—demonstrates the broader significance of university-led community service in advancing both local development and academic goals.

4. CONCLUSIONS

The implementation of an automatic solar-powered water pump with the Taruna Tani Sukamandiri Farmers' Group in Ciamis has demonstrated that renewable energy-based irrigation can effectively address water scarcity, reduce dependence on fossil fuels, and enhance crop productivity in rainfed farming systems. By reducing diesel pump usage by more than 70% and lowering operational costs, the technology provided tangible economic benefits while improving irrigation efficiency for chili and cucumber cultivation. Beyond technical outcomes, the program strengthened farmers' capacity to operate and maintain the system independently, fostered community participation, and contributed to academic outputs including a submitted journal article and a draft technical manual under IPR registration. Overall, the program highlights the dual role of community service in empowering local farmers and supporting sustainable agricultural development that can be replicated in similar rural contexts.

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