

IMPLEMENTATION OF SOLAR-POWERED WATER PUMP AND MONITORING SYSTEM FOR HYDROPONIC URBAN FARMING

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Abstract: Hydroponic farming is gaining popularity in urban areas due to its efficient resource usage and high, clean yields. However, systems like the *Nutrient Film Technique (NFT)* rely on electric pumps for continuous nutrient circulation, making them vulnerable to extended power outages that can disrupt plant nutrition and lead to crop failure. The purpose of this activity is to address the issue of power outages that impacted the hydroponic gardens of the Women Farmers Group (KWT) Sepinggian Raya, Balikpapan, by implementing a solar-powered water pump and a water quality monitoring system. The program consisted of an initial survey, system development and installation, and training sessions on system operation and maintenance. Results indicate that the implementation of the solar pump and monitoring system improves hydroponic productivity while reducing operational costs previously dependent on the national electricity grid. Additionally, the project empowered the local women's group with renewable energy knowledge and modern farming technologies, promoting sustainable urban agriculture practices.

Keywords: application of technologies; hydroponic; renewable energy; urban farming; water quality monitoring

Abstrak: Pertanian hidroponik semakin populer di area perkotaan yang memiliki keterbatasan ruang karena efisiensi sumber daya dan hasil panen yang tinggi. Namun, sistem hidroponik seperti *Nutrient Film Technique (NFT)* sangat bergantung pada pompa listrik untuk sirkulasi air nutrisi secara berkelanjutan. Pemadaman listrik yang berkepanjangan dapat mengganggu suplai nutrisi dan berpotensi menyebabkan kegagalan panen. Kegiatan ini bertujuan untuk mengatasi permasalahan padamnya listrik yang terjadi di kebun hidroponik Kelompok Wanita Tani (KWT) Sepinggian Raya, Balikpapan dengan menerapkan pompa air tenaga surya dan sistem pemantauan kualitas air. Kegiatan meliputi survei awal, pengembangan dan instalasi sistem, serta pelatihan pengoperasian dan pemeliharaan teknologi bagi para petani. Hasil menunjukkan bahwa sistem ini meningkatkan produktivitas kebun hidroponik dan mengurangi ketergantungan terhadap jaringan listrik nasional (PLN). Selain itu, proyek ini memberdayakan kelompok tani dengan pengetahuan tentang energi terbarukan dan teknologi pertanian modern, mendorong praktik pertanian yang berkelanjutan di lingkungan urban.

Kata kunci: energi baru terbarukan; hidroponik; monitoring kualitas air; penerapan teknologi; *urban farming*

INTRODUCTION

Hydroponic farming has been known since the 17th century when Francis Bacon first documented the concept in 1627 (Caputo, 2022). In Indonesia, hydroponics was popularized in the 1980s through Bob Sadino's initiatives (Setyo et al., 2023). Originally adopted as a hobby by plant enthusiasts eager to experiment with soil-less cultivation, hydroponics has since evolved into a significant commercial agricultural practice, especially in urban areas where limited space restricts traditional farming (Monisha et al., 2023; Serio et al., 2022). This transformation demonstrates hydroponics' adaptability and efficiency in densely populated environments (Debangshi, 2021). Furthermore, the COVID-19 pandemic accelerated hydroponic entrepreneurship, emphasizing sustainable income with economic, social, and environmental considerations (Pardede & Pardede, 2022).

In Balikpapan City, the KWT Seraya RT 28 exemplifies urban farming's potential in East Kalimantan (Anggraini, 2022). Their farming system integrates hydroponic methods, especially the *Nutrient Film Technique (NFT)*, and traditional soil-based cultivation. Lettuce is the primary hydroponic crop due to its market demand and economic value (Agrawal et al., 2020). Additional crops include spinach, celery, bok choy, chilli, eggplant, and fruit trees such as Sunkist oranges and Crystal guava (Putri & Matarru, 2023). Despite being in its early stages, the hydroponic initiative has carved a niche market.

Maintaining irrigation for hydroponic plants is crucial to prevent root drying and wilting. For NFT-type hydroponics, the continual operation of the nutrient pumps during the night is essential

to sustain these moisture levels and provide necessary nutrients (Maestre-Valero et al., 2018). Unfortunately, in Sepinggian Raya, the farming community faces significant challenges due to power outages. Frequent power outages interrupt the electric pumps essential for nutrient delivery, risking plant wilting and loss. Furthermore, water quality checks, such as pH measurement using well water, are manually performed, consuming time and reducing precision. This situation highlights the interplay between the physical needs of hydroponic farming and the socio-economic environment (Ragaveena et al., 2021).

Recent advances in renewable energy, electronics, and sensor technologies offer solutions to these issues (Majeed et al., 2023; Ng & Mahkeswaran, 2021). Solar energy addresses power disruptions by ensuring consistent pump operation (Gorjian et al., 2021), while automated sensors can optimize nutrient levels, pH, and moisture, reducing the risks of manual monitoring (Prakash et al., 2023). Without a stable power supply, these systems can automate and optimize nutrient delivery, pH balance, and moisture levels (Saad et al., 2021). The ability to closely monitor and adjust these parameters can mitigate the risks associated with manual checks and the uncertainties of power-reliant systems.

In previous studies, community services have played a crucial role in introducing technologies to society. Training in hydroponics improves yields and empowers local farmers with modern skills (Rozak et al., 2022). Additionally, installing solar-powered public lighting in community areas enhances safety and accessibility while promoting environmental sustainability (Marindra et al., 2022). Furthermore, plant monitoring technology, including sensors and data

analytics tools, allows for precise control over environmental conditions, leading to optimized plant growth and reduced waste (Nasution et al., 2021).

In this activity, we aim to implement two technological innovations in the KWT Seraya hydroponic farm. First, we introduce a solar-powered water pump system to maintain consistent irrigation during power outages. This ensures that the hydroponically grown lettuce and other crops do not suffer from interrupted water supply. Second, we deploy a water quality monitoring system focusing on pH level management, which automates the monitoring process, reduces manual intervention, and maintains optimal nutrient conditions for plant growth. These initiatives address immediate challenges in Sepinggan Raya and contribute to the broader goal of sustainable urban farming.

METHOD

The community service project was conducted through five main stages, as illustrated in Figure 1. The first stage was an initial survey to identify key problems, particularly power outages that affected irrigation continuity and the manual water quality monitoring process. Based on the findings, the second stage involved the development of a solar-powered water pump and a water quality monitoring system. In the third stage, both systems were installed on-site to provide a reliable irrigation source and automate pH and nutrient level monitoring. The fourth stage focused on training and capacity building for the farmers, ensuring they could operate and maintain the new technologies independently. Finally, an evaluation and feedback phase were implemented, involving direct ob-

servation and farmer input to assess the effectiveness of the systems and make necessary adjustments.



Figure 1. Method of community service

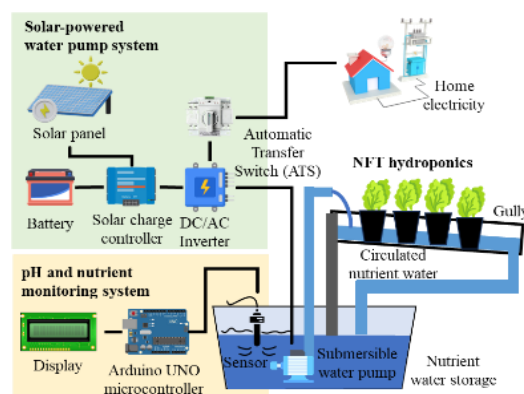


Figure 2. Diagram of the implemented solar-powered pump and pH/nutrient monitoring system

Figure 2 presents a diagram of the solar-powered water pump and pH-nutrient monitoring systems implemented at the hydroponic farm. The pump system harnesses solar energy via photovoltaic panels, with energy stored in batteries and regulated by a solar charge controller. An inverter converts direct current (DC) to alternating current (AC) to operate the water pump, while an *Automatic Transfer Switch (ATS)* enables a transition between solar and grid electricity, ensuring uninterrupted irrigation. The pH and nutrient monitoring system, essential for maintaining optimal plant nutrition, is centered on an Arduino UNO microcon-

troller that receives continuous data from pH and nutrient probes. This data is displayed in real-time, enabling precise adjustments. This integrated system addresses challenges in power reliability and water quality control, setting a model for autonomous, renewable energy-based hydroponic farming.

The success and impact of the community service activity were evaluated through a survey. The survey collected feedback from the farmers on several key aspects: the effectiveness of the solar-powered pump during PLN outages; the ease of hydroponic water management using the monitoring system; the contribution of the technologies to enhancing the appeal of the hydroponic site at Seraya Beach; and the perceived improvement in vegetable quality and productions.

DISCUSSION

The community service project was located at the hydroponic facility in Seraya Beach, Sepinggán, Balikpapan City, East Kalimantan. Figure 3 depicts the map and a picture of the hydroponic and soil-based farm. The location is close to the ITK campus, approximately 24.1 kilometers away, roughly a 31-minute drive via the Balikpapan-Samarinda toll road. This proximity facilitated ease of access for the project team and stakeholders, allowing for efficient coordination and implementation of the community service activities.

The project began with a field study to understand local conditions and farming practices. A survey and observation of the farm were conducted, along with discussions involving the neighborhood unit leader and local farmer, as shown in Figure 4. This initial assess-

ment identified key problems such as irrigation failure due to outages and the inefficiency of manual water quality checks.

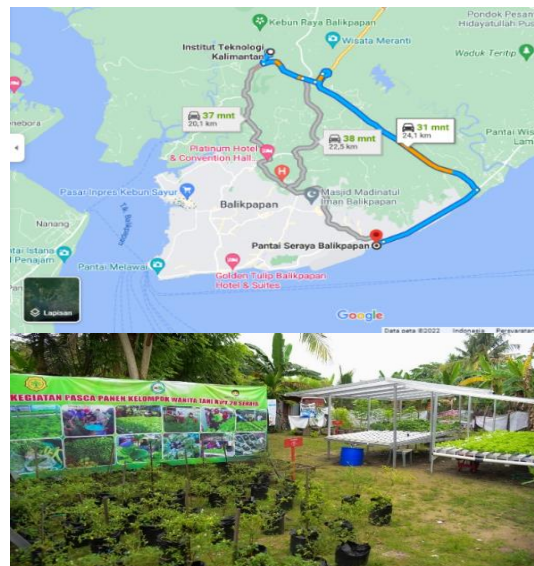


Figure 3. Location of community service



Figure 4. Initial discussion with the local farmers

The realization of these innovations began with determining the type of pump being used, which then informed the specifications for the photovoltaic (PV) modules to be used. Following this, the procurement and assembly of the necessary equipment were undertaken. Installation involved placing 170 Wp solar panels and relevant sensors at the farm. The assembly included components like the *Automatic Transfer Switch* (ATS), a 1000-Watt PSW Inverter, a *Solar Charge Controller* (SCC), terminal blocks, MCB rails, indicator lights, and

the hydroponic monitoring system including an LCD and various supporting components.



Figure 5. System installation and training

Figure 5a illustrates the assembly and development process, showing key equipment testing and integration at the farm. The solar panel was mounted on the rooftop beside the hydroponic area, while the control and monitoring panel was installed at the farm. A two-week testing period confirmed that the PLTS could power the water pump and nutrient-pH monitoring system for over two hours beyond expected durations.

Figure 5b illustrates the training and capacity-building phase, essential to ensure sustainability and effective system use. A hands-on session was conducted for the women farmers to operate the solar-powered pump and the monitoring system independently. During the training sessions, participants were thoroughly guided through the standard operating procedures of the solar-powered system. They were instructed on monitoring battery voltage via the SCC, emphasizing maintaining a minimum of 10 volts for system operation. Procedures for activat-

ing the inverter, handling the Miniature Circuit Breaker (MCB), and manually switching from battery to grid power were explained, including the SCC's automatic disconnection and reset functions. The implementation of this system does not alter the voltage supplied to the equipment, as the inverter ensures a stable output consistent with standard operational levels (220V AC). Moreover, since the energy demand is now supported by solar panels and batteries, reliance on grid electricity is significantly reduced. This leads to a noticeable decrease in monthly electricity bills, particularly during optimal solar exposure throughout the day.

A survey involving 22 hydroponic farmers was conducted to evaluate the project's impact, with results presented in Figure 6. The average score was 3.79 out of 4, indicating that implementing the solar-powered pump and the monitoring system was highly successful and beneficial. Respondents indicated significant improvements in several areas. Notably, 54.55% of farmers strongly agreed, and 45.45% agreed that the pH and water nutrition monitoring system greatly eased their work in managing hydroponic water quality. Hydroponic crops generally thrive at a pH range of 5.5 to 6.5, which ensures optimal nutrient absorption and healthy growth.

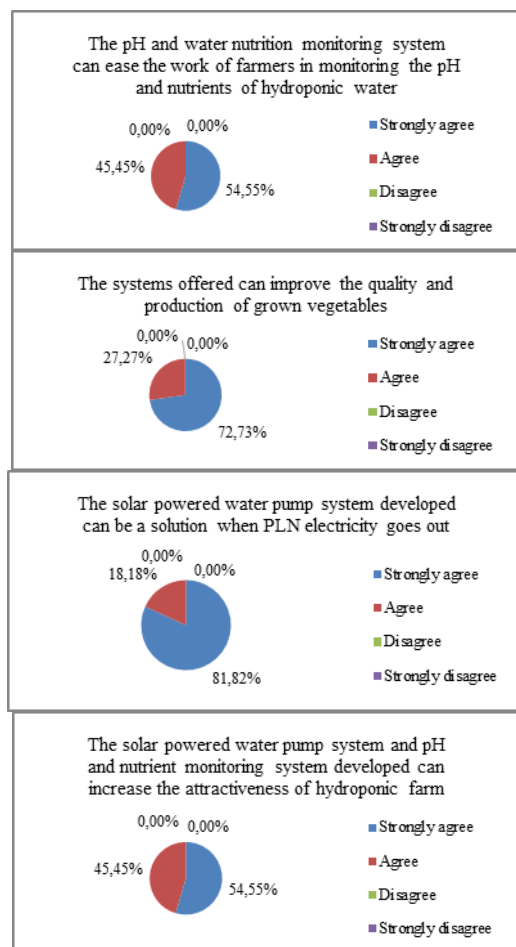


Figure 6. Evaluation results of the community service project

In the feedback, 72.73% of respondents strongly agreed that the systems improved the quality and production of the crops, suggesting the technology positively impacted crop yield. The solar-powered water pump system garnered strong approval, with 81.82% of farmers agreeing that it provided a reliable solution during power outages from the national electricity grid (PLN), ensuring continuous irrigation and preventing crop damage. Finally, the project also improved the overall attractiveness of the hydroponic farm, with 54.55% strongly agreeing and 45.45% agreeing that the new systems contributed to making the site more appealing.

CONCLUSION

The implementation of a solar-powered water pump and monitoring system in Sepinggan Raya's hydroponic urban farming has improved agricultural productivity and sustainability. The solar pump addressed irrigation disruptions caused by electricity outages, while the monitoring system enabled automated control of pH and nutrient levels, maintaining optimal growing conditions. The high survey score reflects the project's success, indicating strong community approval. However, several challenges were encountered, including initial difficulties with system calibration and adapting to new technologies. Despite these challenges, the team provided continuous support through on-site troubleshooting and guidance, ensuring the farmers could effectively use and maintain the systems. The future plan is to offer long-term training programs, focusing on enhancing technical skills and promoting sustainable farming practices.

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