



## Site Visit and Needs Analysis for IoT and Solar Energy Integration in Greenhouse and Aquaponics Systems in Bojong Renged Village, Tangerang Regency

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### ABSTRACT

*This community service project aims to monitor the progress of implementing Internet of Things (IoT) and solar-powered agricultural systems in Bojong Renged Village, Tangerang Regency. A field visit was conducted on October 21, 2025, by a collaborative team from Universitas Multimedia Nusantara and Universitas Siber Indonesia following an initial Focus Group Discussion (FGD). The methods applied include field observations of greenhouse and aquaponics construction, interviews with farmer and fisheries groups, and environmental measurements such as temperature, humidity, water quality, and site conditions. The visit confirmed the installation of lightweight steel structures for the greenhouse and preliminary frameworks for aquaponics above fish ponds. Partners expressed the need for IoT-based temperature, pH, soil moisture, and water quality monitoring systems powered by solar energy. These findings provide practical implications for system design, including sensor selection, energy capacity planning, and community training modules. The results serve as a foundation for the next implementation phase toward a sustainable smart farming and aquaculture model.*

**Keywords:** IoT; Greenhouse; Aquaponics; Sensor; Smart farming

### ABSTRAK

Kegiatan pengabdian kepada masyarakat ini bertujuan untuk melakukan kunjungan lapangan dan memantau progres implementasi teknologi Internet of Things (IoT) serta energi surya pada sistem greenhouse dan akuaponik di Desa Bojong Renged, Kabupaten Tangerang. Kegiatan yang dilaksanakan pada 21 Oktober 2025 ini melibatkan dosen dan mahasiswa dari Universitas Multimedia Nusantara bekerja sama dengan Universitas Siber Indonesia, sebagai tindak lanjut dari kegiatan Focus Group Discussion (FGD) yang telah dilakukan sebelumnya pada awal Oktober. Hasil observasi menunjukkan bahwa proses pembangunan kerangka greenhouse berbahan baja ringan telah dimulai, bersamaan dengan pemasangan struktur akuaponik di atas kolam ikan. Melalui sesi diskusi bersama Kelompok Tani dan Kelompok Perikanan Waru Brilliant, teridentifikasi kebutuhan teknologi berbasis IoT seperti sensor suhu, pH, dan kelembapan tanah, serta sistem alarm otomatis untuk pemantauan kualitas air. Temuan ini menjadi dasar perancangan sistem pertanian cerdas yang efisien, adaptif, dan berkelanjutan berbasis energi terbarukan.

**Kata kunci:** IoT; Greenhouse; Akuaponik; Sensor; Pertanian cerdas



## INTRODUCTION

Agriculture and aquaculture is important in supporting Indonesia's economy and food security, contributing significantly to rural livelihoods and employment (Wasik et al., 2025; Wijaya & Phalepi, n.d.). However, many farming and fishery practices in rural areas still rely on conventional and manual methods, which limit productivity, efficiency, and sustainability. Farmers and fish cultivators often face challenges such as inefficient resource management, unstable yields, dependency on seasonal weather, and high operational costs due to limited technological adoption. The lack of automation and data-driven decision-making tools has also hindered the optimization of agricultural and aquaculture operations.

In recent years, the integration of Internet of Things (IoT) and renewable energy technologies has offered innovative solutions to these challenges. IoT allows real-time monitoring of environmental parameters (Nugrahni Halawa, 2024; Saputri et al., 2025), enabling more precise control of temperature, humidity, pH, and water quality. Meanwhile, the use of solar energy provides an environmentally friendly and cost-effective alternative to conventional electricity, supporting the transition toward sustainable and energy-independent rural systems (Handayani et al., 2019; Shafie et al., 2022).

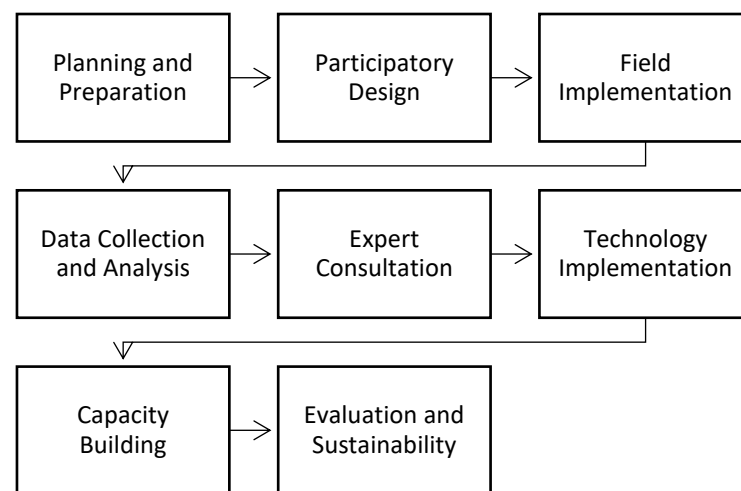
Bojong Renged Village in Tangerang Regency represents one of the rural communities with strong potential in both horticultural and freshwater aquaculture sectors (Pura et al., 2025; Redaksi, 2022). Managed by the Waru Brilliant Farmer and Fisheries Groups, the village has begun to develop greenhouse-based vegetable cultivation and fish farming systems. Despite these promising efforts, most operational activities remain manual, such as watering, feeding, and monitoring water quality leading to inefficiencies in labour, energy use, and production control. Although the physical cultivation systems already exist, there is currently no automated environmental monitoring, no digital cultivation data logging, no integrated aquaponic control system, and no independent renewable energy support. As a result, production decisions rely on estimation rather than empirical data, limiting yield optimization, increasing vulnerability to environmental fluctuations, and reducing scalability. Therefore, a technological intervention is required to transition from manual and reactive management toward data-driven and energy-efficient smart farming systems.

To address these issues, a site visit and progress monitoring activity was conducted as part of the Community Service and Village Empowerment Program by Universitas Multimedia Nusantara in collaboration with Universitas Siber Indonesia. The visit aimed to observe the ongoing construction of the greenhouse and aquaponics systems, collect environmental measurements, and discuss technological needs with local partners. This activity serves as an essential step toward implementing IoT- and solar-based smart farming systems that promote efficiency, sustainability, and community self-reliance. The findings from this field activity will serve as a foundation

for system integration and community training programs in the next phase of implementation.

## METHODS

The overall stages of this community service program are illustrated in Figure 1. The methodological framework adopts a participatory and action-oriented approach that integrates academic research, community engagement, and technology implementation (Feekery, 2024; Vaughn & Jacquez, 2020). It consists of eight main phases: (1) Planning and Preparation, (2) Participatory Design, (3) Field Implementation, (4) Data Collection and Analysis, (5) Expert Consultation, (6) Technology Implementation, (7) Capacity Building, and (8) Evaluation and Sustainability.



**Figure 1.** Flowchart of Community Service Methodology.

Each phase is interconnected, forming a continuous cycle from initial assessment to post-implementation evaluation. This approach ensures that every stage, starting from problem identification and field validation to system installation and community training contributes directly to the goal of sustainable smart farming and aquaponics development in Bojong Renged Village.

### 1. Planning and Preparation Phase

The initial stage involved a preliminary study and coordination meetings with community partners and local authorities to review existing profiles, identify key challenges, and establish project objectives. This was followed by a literature review and problem identification process to analyze previous studies related to Internet of Things (IoT) and solar energy applications in agriculture and aquaculture. The outcome of this stage provided a foundational understanding of both the technical and socio-economic contexts in Bojong Renged Village, ensuring that subsequent activities were evidence-based and relevant to the local community's needs.

## 2. Participatory Design Phase

A Focus Group Discussion (FGD) was conducted to involve community stakeholders, including the Waru Brilliant Farmer and Fisheries Groups, in discussing current problems and potential solutions. This participatory dialogue enabled the identification of priority issues, such as limited access to technology, inefficient energy usage, and the need for real-time monitoring systems. The FGD served as a collaborative platform to co-design feasible interventions tailored to local conditions.

## 3. Field Implementation Phase

During the site visit and progress monitoring, the project team observed the ongoing construction of the greenhouse and aquaponics system. The team assessed the installation of lightweight steel structures and aquaponics frameworks over fish ponds. Environmental parameters such as temperature, humidity, and pH were measured to establish baseline data. The visit also included documentation of daily operational practices and coordination with partners to ensure the infrastructure aligns with future IoT and solar system integration.

## 4. Data Collection and Analysis Phase

Data were gathered through interviews and partner discussions with the farmer and fisheries groups to understand their operational challenges and expectations for technological support. A needs assessment was then conducted to identify suitable IoT devices, such as sensors for soil humidity, water temperature, and pH as well as solar energy solutions to power these systems. The qualitative data were analyzed to produce design recommendations that will inform the next stage of implementation.

## 5. Expert Consultation Phase

In the upcoming stage, expert consultations will be held through guest lectures and workshops featuring specialists in agriculture, aquaculture, and smart farming technology. These sessions will present the latest innovations and best practices while helping the community understand the practical aspects of sustainable technology implementation. The goal is to strengthen local knowledge and ensure that the technology adoption process is both technically sound and community-appropriate.

## 6. Technology Implementation Phase

The technology implementation phase will involve the completion of greenhouse and aquaponics infrastructure, followed by the installation of IoT-based monitoring systems and solar panels. The official handover ceremony will mark the formal transfer of these facilities to the community, symbolizing shared ownership and responsibility for maintaining the systems. This stage emphasizes functional readiness and community empowerment through direct participation in system deployment.

## 7. Capacity Building Phase

Following installation, a capacity-building program will be conducted to train members of the farmer and fisheries groups on the operation and maintenance of IoT technologies. The training will focus on how to interpret sensor data, manage the monitoring dashboard, and perform routine maintenance. This activity aims to ensure that the community can independently utilize and sustain the technology over time.

## 8. Evaluation and Sustainability Phase

The final phase will include monitoring and evaluation (M&E) to assess the performance of the implemented systems and the adaptability of community users. Key indicators such as energy efficiency, productivity improvements, and user satisfaction will be evaluated. Based on these results, a sustainability plan will be formulated to guide future maintenance, scalability, and potential replication of the model in other rural communities.

## RESULTS

### 1. Field Observation and Coordination

The community service team from Universitas Multimedia Nusantara and Universitas Siber Indonesia conducted a site visit (Figure 2) to Bojong Renged Village, Tangerang Regency, on October 21, 2025. The activity was attended by lecturers Fahmy Rinanda Saputri, Ir. Arief Iswariyadi, M.Sc., Ph.D., Satya Arisena Hendrawan, S.T., M.Kom., and Muhammad Salehuddin, S.T., M.T. The objective was to monitor the progress of greenhouse and aquaponics construction, collect environmental data, and conduct interviews with the Waru Brilliant Farmer and Fisheries Groups.



**Figure 2.** UMN and Universitas Siber Indonesia team conducting coordination and observation with partners in Bojong Renged Village.

### 2. Greenhouse Construction Progress

During the site visit, the installation of lightweight steel framework for the greenhouse was in progress such as in Figure 3. This facility will later support vegetable cultivation such as *lettuce*, *chili*, and *pokcoy*. The greenhouse design also



includes provisions for IoT-based sensors and solar panel integration to improve environmental monitoring and energy efficiency.



**Figure 3.** Ongoing installation of lightweight steel structures for the greenhouse.

### 3. Aquaponic System Development

The aquaponics system construction had also begun at the fisheries area, where the structure was placed above existing fish ponds. This setup aims to integrate fish farming and vegetable cultivation using a nutrient-recycling system. The aquaponics frame will later include IoT sensors for measuring water temperature, pH, and dissolved oxygen (DO), ensuring optimal aquatic conditions. The progress of aquaponics system is shown in Figure 4.



**Figure 4.** Aquaponics system framework above fish ponds managed by Waru Brilliant Fisheries Group.



#### 4. Environmental Measurements

Environmental data collection was performed in both the greenhouse and aquaponics areas (Figure 5). In the greenhouse, baseline measurements showed an air temperature of approximately 33.3°C, relative humidity of 63%, and solar irradiance reaching 141.2 W/m<sup>2</sup>. These conditions indicate moderate humidity but relatively high temperature during daytime operation, suggesting the need for improved ventilation and automated irrigation control. Meanwhile, in the aquaponics area, water temperature and pH were recorded to establish initial water quality benchmarks prior to system integration. These baseline measurements will guide IoT sensor calibration and parameter threshold design in the next implementation phase.



**Figure 5.** Environmental measurement activities using portable instruments in the greenhouse and pond areas.

#### 5. Partner Interviews and Technology Needs

The interview sessions revealed that farmers and fish breeders expressed strong interest in applying IoT-based monitoring to reduce manual work and improve real-time data accuracy. They also requested support for renewable energy systems to power pumps and sensors sustainably. The discussion identified several needs: environmental monitoring sensors (temperature, humidity, pH), automated irrigation systems, water-quality monitoring devices, and community training for system maintenance. This activities are shown in Figure 6.



**Figure 6.** Discussion and interview sessions with the Waru Brilliant Farmer and Fisheries Groups.

## 6. Planned Follow-up Activities

The project team and community partners agreed to proceed with several follow-up actions to ensure the sustainability and effectiveness of the initiative. These include organizing an expert lecture and workshop focusing on smart farming and aquaculture technologies, which will provide the latest insights and best practices for sustainable production. The team will also oversee the completion and official handover of the newly constructed greenhouse and aquaponics facilities to the Waru Brilliant groups as part of the program's implementation milestone. Furthermore, training sessions on IoT system operation, data interpretation, and solar energy maintenance will be conducted to enhance the community's technical capacity and ensure long-term self-reliance in managing the integrated systems.

## DISCUSSION

The field observation confirmed that the Waru Brilliant groups have developed a stable foundation in both horticultural and freshwater aquaculture practices, yet most operations remain manual. This limits productivity and efficiency, particularly in irrigation, aeration, and energy use. The integration of IoT and solar technologies presents a strategic solution to these challenges.

The IoT system enables continuous monitoring of critical parameters such as temperature, humidity, and water quality, reducing human error and providing data-driven insights for optimal decision-making (Miller et al., 2025; Shahab et al., 2025; Zerihun et al., 2022). Meanwhile, the solar energy system supports operational sustainability by reducing dependence on grid electricity, aligning with Indonesia's rural energy transition goals.

From the discussion, it is evident that the community demonstrates readiness and strong motivation to adopt technology, provided that adequate training and maintenance support are available. Thus, the upcoming activities including expert workshops, IoT installation, and capacity-building sessions are essential to ensure long-term sustainability, technology adoption, and community ownership of the system.

This initiative also aligns with the principles of sustainable agriculture, which emphasize efficiency in resource use, environmental resilience, and socio-economic viability of farming communities. The integration of IoT-based monitoring can reduce excessive water usage, minimize crop failure, and optimize nutrient inputs, thereby supporting ecological sustainability (Huang & Wang, 2024; Obaideen et al., 2022; Zamora-Izquierdo et al., 2019). Meanwhile, the adoption of solar-powered systems reduces dependence on fossil-based electricity and contributes to cleaner energy use, reinforcing the shift toward low-carbon agricultural practices. In addition, enhanced data-driven decision-making improves productivity and income stability, contributing to long-term rural economic sustainability.



This initiative further highlights the importance of participatory design in community-based technology projects. By involving local groups from the early planning stages, the solutions developed are more likely to be contextually appropriate, economically feasible, and socially accepted. The project serves as a model of collaborative empowerment integrating academic expertise, local knowledge, and technological innovation to support sustainable smart-farming ecosystems.

## CONCLUSION AND SUGGESTION

This community service activity demonstrates the strong potential of integrating IoT and solar-based technologies in improving agricultural and aquaculture practices in rural areas. The collaboration between universities and local farmer and fisheries groups has resulted in tangible progress, both in infrastructure development and community engagement. To ensure long-term sustainability, it is recommended that continuous technical assistance, monitoring, and knowledge sharing be maintained, enabling the community to operate and innovate independently in the future.

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## REFERENCES

- Feekery, A. (2024). The 7 C's framework for participatory action research: inducting novice participant-researchers. *Educational Action Research*, 32(3), 332–347. <https://doi.org/10.1080/09650792.2023.2234417>
- Handayani, K., Krozer, Y., & Filatova, T. (2019). From fossil fuels to renewables: An analysis of long-term scenarios considering technological learning. *Energy Policy*, 127, 134–146. <https://doi.org/10.1016/j.enpol.2018.11.045>
- Huang, W., & Wang, X. (2024). The Impact of Technological Innovations on Agricultural Productivity and Environmental Sustainability in China. *Sustainability*, 16(19). <https://doi.org/10.3390/su16198480>
- Miller, T., Mikiciuk, G., Durlik, I., Mikiciuk, M., Łobodzińska, A., & Śnieg, M. (2025). The IoT and AI in Agriculture: The Time Is Now—A Systematic Review of Smart Sensing Technologies. In *Sensors* (Vol. 25, Issue 12).

<https://doi.org/10.3390/s25123583>

- Nugrahni Halawa, D. (2024). Peran Teknologi Pertanian Cerdas (Smart Farming) untuk Generasi Pertanian Indonesia. *Jurnal Kridatama Sains Dan Teknologi*, 6(2), 502–512.
- Obaideen, K., Yousef, B. A. A., AlMallahi, M. N., Tan, Y. C., Mahmoud, M., Jaber, H., & Ramadan, M. (2022). An overview of smart irrigation systems using IoT. *Energy Nexus*, 7, 100124. <https://doi.org/https://doi.org/10.1016/j.nexus.2022.100124>
- Pura, M., Wenehenubun, S. P., Andarini, R., & Saputri, F. R. (2025). *Mapping the Potential and Challenges of Developing the Waru Brilliant Thematic Village in Bojong Renged*. 5(3), 1190–1198.
- Redaksi. (2022). *Bupati Tangerang Resmikan Kampung Tematik Waru Brilliant dan Kampung Olahraga Tradisional Desa Bojong Renged*. Posbumi. <https://posbumi.com/bupati-tangerang-resmikan-kampung-tematik-waru-brilliant-dan-kampung-olahraga-tradisional-desa-bojong-renged/>
- Saputri, F. R., Linelson, R., Salehuddin, M., Nor, D. M., & Ahmad, M. I. (2025). Design and development of an irrigation monitoring and control system based on blynk internet of things and thingspeak. *PLoS ONE*, 1–19. <https://doi.org/10.1109/UV56588.2022.10185526>
- Shafie, S. M., Hassan, M. G., Sharif, K. I. M., Nu'man, A. H., & Yusuf, N. N. A. N. (2022). An Economic Feasibility Study on Solar Installation for University Campus: A Case of Universiti Utara Malaysia. *International Journal of Energy Economics and Policy*, 12(4), 54–60. <https://doi.org/10.32479/ijeep.13057>
- Shahab, H., Naeem, M., Iqbal, M., Aqeel, M., & Ullah, S. S. (2025). IoT-driven smart agricultural technology for real-time soil and crop optimization. *Smart Agricultural Technology*, 10, 100847. <https://doi.org/https://doi.org/10.1016/j.atech.2025.100847>
- Vaughn, L. M., & Jacquez, F. (2020). *Participatory Research Methods – Choice Points in the Research Process*. 1, 1–14.
- Wasik, Z., Gunawan, S., & Handriana, T. (2025). *Contribution of aquaculture to future food security: Economic analysis and development in Indonesia*. 8(1), 1036–1048. <https://doi.org/10.53894/ijirss>.
- Wijaya, M. F., & Phalepi, M. Y. (n.d.). *THE ROLE OF THE AGRICULTURAL SECTOR ON ECONOMIC GROWTH IN INDONESIA* Gina Afriyanti, Ana Mariya, Charita Natalia, Sirat Nispuana M.Farhan Wijaya, M. Yoga Phalepi. 167–179.
- Zamora-Izquierdo, M. A., Santa, J., Martínez, J. A., Martínez, V., & Skarmeta, A. F. (2019). Smart farming IoT platform based on edge and cloud computing. *Biosystems Engineering*, 177, 4–17. <https://doi.org/https://doi.org/10.1016/j.biosystemseng.2018.10.014>
- Zerihun, B. M., Olwal, T. O., & Hassen, M. R. (2022). *Design and Analysis of IoT-Based aModern Agriculture Monitoring System for Real-Time Data Collection*. January, 73–82. [https://doi.org/10.1007/978-981-16-9991-7\\_5](https://doi.org/10.1007/978-981-16-9991-7_5)

