Abdimas Umtas: Jurnal Pengabdian Kepada Masyarakat
LPPM-Universitas Muhammadiyah Tasikmalaya
Volume: 8, Issue: 4, October, 2025; pp: 1929-1940
E-ISSN: 2614 - 8544

Rooftop Solar Power Plant (PLTS) and Smart Watering Implementation for Agricultural Development: A Community Service Program in Sindulang Village, Indonesia

Nurwathi [a], Ivany Sarief, Rangga Satria Perdana, Fitria Syafarina Dwi Cahya, Alsy Sauzan Noor, Wisnu Wijaya, Kusmadi, Khaerul Manaf, Ade Geovania Azwar, Sofiani Nalwin Nurbani, Dea Yunita Sari, Nina Lestari

Universitas Sangga Buana, Bandung, Indonesia

[a]Corresponding author: nurwathi@usbypkp.ac.id

ABSTRACT

The Community Service Program (PKM) in Sindulang Village, Cimanggung District, Sumedang Regency, aims to enhance agricultural productivity by utilizing renewable energy and implementing smart irrigation systems. The main problems faced by the partners are limited access to energy and a manual irrigation system that is labor- and water-intensive. This program involved 20 members of the Baruimun-Hill Farmers' Group with activities including surveys, training on the practice of using and maintaining rooftop solar power plants (PLTS) and Smart Watering systems, the installation of an off-grid Solar Power Plant (PLTS), and the application of IoT-based Smart Watering. The implementation results demonstrated irrigation efficiency, with watering time reduced from approximately 4 hours to 1.5–2 hours per session, and irrigation points reduced from three points to two. The application of PLTS successfully eliminated electricity operational costs that were previously incurred, while supplying electrical energy for water pumps, lighting, and IoT devices. Questionnaire results indicated that understanding of the use and maintenance practices of rooftop PLTS and Smart Watering increased from 29% to 76%.

ARTICLE INFO

Submitted/Received: 17 Sept. 2025
First Revised: 19 September 2025
Accepted: 25 September 2025
First Available online: 31 October 2025
Publication Date: 31 October 2025

Keyword:
Rooftop Solar Power Plant (PLTS)
Smart Watering
Internet of Things (IoT)

https://doi.org/10.35568/abdimas.v8i4.7163
©LPPM Universitas Muhammadiyah Tasikmalaya

INTRODUCTION

Agriculture is one of the strategic sectors in supporting national food security while also serving as the main source of the rural economy in Indonesia. Sindulang Village is located in Cimanggung District, Sumedang Regency. Topographically, the village lies in a hilly area with sloping terrain (Egar Garnia, Hidayat, & Saputra, 2023). Agricultural land in Sindulang Village is divided into two types, namely paddy fields and non-paddy fields. The proportion of agricultural land reaches 12.02% of the total area, equivalent to 90.28 hectares. Paddy fields cover 48.75 hectares, while the remaining 41.53 hectares consist of non-paddy land such as plantations, fields, and dryland farms. In addition, settlement areas and house yards account for 1.48% or 11.12 hectares, while 1.2% or about 9 hectares are used for other purposes (Profil Desa Sindulang, 2024).

The main problems faced by the Baruimun-Hill Farmers Group are limited access to energy and labor-intensive irrigation systems that consume excessive water. These issues have resulted in low productivity, high production costs, and declining competitiveness of local agriculture. This challenge is in line with Azzahra, Mahatmayana, & Primajaya (2024), who argue that inadequate infrastructure and low adoption of modern technology are key barriers to rural agricultural development. Halawa (2024) also emphasizes that the availability of renewable energy is crucial to improving agricultural efficiency in rural areas.

A situational analysis of the Baruimun-Hill Farmers' Group, chaired by Budi and consisting of 20 members, shows that despite frequent training from local authorities, the outcomes have not been optimal. One of the causes is that the group's farmland is situated on a hill where access to PLN electricity is limited, even though electricity is crucial for agricultural operations such as water pumping. As a result, the group lags behind other farmer groups.

Electricity supplied by PLN requires high operational costs and is less environmentally friendly. In Baruimun Hill, the use of renewable energy remains very limited, even though the area has high solar potential due to abundant sunlight throughout the year (Azzahra, Mahatmayana, & Primajaya, 2024).

The irrigation system in Baruimun Hill is still conventional. Most farmers rely on manual irrigation and diesel-powered pumps. This requires more effort and creates challenges, such as irrigation schedules being determined by weather estimates. Irrigation is conducted at night for about four hours by two workers, using small manual sprinklers with a coverage of less than 10 meters, which must be moved to three different points.

Various studies indicate that the application of Internet of Things (IoT)-based smart farming can improve the efficiency of water and energy use, as well as enhance agricultural productivity through automated monitoring and control systems (Ariawan, 2024; Li, Zhang, & Zhao, 2020). However, most studies focus on large-scale plantations or commercial sectors, while applications for smallholder farmers in rural communities remain limited. This reveals a research gap, particularly in developing smart farming models that are relevant to rural community empowerment.

Based on discussions with the partner, namely the Baruimun-Hill Farmers' Group, and the PKM team, it was agreed to implement a technology-based agriculture program: Smart Watering and Renewable Energy for Sustainable Economic Development in Sindulang Village, specifically for the Baruimun-Hill Farmers' Group. The solutions offered by the PKM team, consisting of lecturers and students from USB, include:

https://doi.org/10.35568/abdimas.v8i4.7163
©LPPM Universitas Muhammadiyah Tasikmalaya

- Rooftop Solar Power Plant (PLTS) to support electricity needs for water pumps, lighting, and other activities.
- An IoT-based Smart Watering system, using air temperature sensors to determine the appropriate irrigation schedule.
- Community empowerment through training on the operation and maintenance of the technology to ensure sustainability.

This intervention focused not only on technical solutions but also on strengthening the institutional capacity of farmers to promote local economic independence on a sustainable basis.

The purpose of this program is to utilize renewable energy, particularly solar energy, as a power source for the Baruimun-Hill Farmers' Group. The activities included the installation of Rooftop PLTS, implementation of the Smart Watering system, training and workshops, as well as mentoring and maintenance carried out jointly with the community and the PKM team, involving lecturers and students.

The success of this program is determined not only by the availability of technology but also by the level of adoption among farmers. International studies have shown that IoT adoption in rural agriculture is influenced by factors such as digital literacy, institutional support, and economic incentives (Li, Zhang, & Zhao, 2020). Furthermore, other studies stress that the use of solar energy for rural development often faces challenges in initial financing and sustainability, although it can improve energy independence and community empowerment (Smith & Porter, 2019). This is highly relevant to the context of Sindulang Village, where digital literacy and financial sustainability models remain the main challenges in adopting smart watering and PLTS.

METHOD

Based on the issues presented in the introduction, the research methodology applied in this program is Participatory Action Research (PAR). PAR was chosen because it involves the active participation of the community at every stage of the activity, from problem identification, planning, implementation, to evaluation. By engaging the community directly, this approach can generate contextual solutions that are relevant to local needs (Khafsoh & Riani, 2024).

The study employs both quantitative and qualitative descriptive approaches. The qualitative approach is used to gain an in-depth understanding of farmers' experiences, perceptions, and challenges in implementing technology. Meanwhile, the quantitative approach is applied to measure changes before and after the program, for example, through pre-test and post-test analysis, allowing the real impact of the program on participants' knowledge and skills to be identified (Sugiyono, 2021).

The use of these methods and approaches is justified because PAR enables the community to become both subjects and active partners in the research, ensuring that the results are more sustainable. The combination of descriptive, quantitative, and qualitative approaches also provides a more comprehensive overview, both in the form of numerical data related to water, time, and cost efficiency, as well as farmers' insights into their experiences with the technology in the field. This is in line with Coombs & Hayden (2022), who emphasize that participatory approaches yield nuanced and detailed understandings of the case subject while fostering the emergence of new theories and insights.

The instruments used in data collection include field observations, in-depth interviews, and questionnaires:

https://doi.org/10.35568/abdimas.v8i4.7163
©LPPM Universitas Muhammadiyah Tasikmalaya

- Observations were conducted to assess the technical conditions of irrigation and energy infrastructure.
- Interviews were held with farmer group members to explore their perceptions and challenges.
- Questionnaires were distributed to measure satisfaction levels, technology adoption rates, and the impact of the program on agricultural productivity.

To clarify the relationship between problem identification, solutions, expected outcomes, and problem resolution targets, a summary of the program methodology is presented in Table 1.

TABLE 1. Mapping of Farmers' Problems, Solutions, and Target Outcomes of the PKM Program

BARUIMUN-HILL FARMERS GROUP			
Identification of Problems	**Solution**	**External Target**	**Problem Solving Targets**
Innovation In Production Support Tools Is Unevenly Distributed Among Farmer Groups	Installation of a Solar Power Plant with Smart Watering at The Baruimun-Hill Farmers Group	IoT-Based Smart Watering Innovation Integrated with Power Plants	Overall, The Installation of the Smart Watering Sprinkler Impact with A Radius Of 2-25 Meters with A 250 W Module Power Source Has Been Installed and Can Be Utilized (100%)

The table illustrates the interconnection between the main problems faced by the farmers, the technology-based solutions, the expected outcomes, and the final results in the form of practical and sustainable problem-solving.

The PKM program was implemented in five interrelated stages:

- Initial survey and problem identification, conducted to map the actual agricultural conditions of the partners, including irrigation patterns, energy use, and post-harvest management.
- Training on the practice, use, and maintenance of rooftop solar PV (PLTS) and smart watering systems.
- Installation of off-grid Solar Power Plants (PLTS), which serve as the main energy source for water pumps, lighting, and IoT devices (Halawa, 2024; Rante Kayangan & Rantung, 2018; Belakang & PLTS, n.d.).
- Implementation of IoT-based smart watering, integrating soil moisture sensors, automatic sprinklers, and a control application to regulate irrigation according to land needs. This system aims to reduce water wastage, decrease manual labor, and enhance agricultural productivity (Ariawan, 2024; Li, Zhang, & Zhao, 2020; Smith & Porter, 2019).
- Mentoring and monitoring are carried out to evaluate the program's effectiveness, provide additional training, and ensure operational sustainability.

To further illustrate the program's implementation flow, Figure 1 presents the stages of the PKM program.

https://doi.org/10.35568/abdimas.v8i4.7163
©LPPM Universitas Muhammadiyah Tasikmalaya

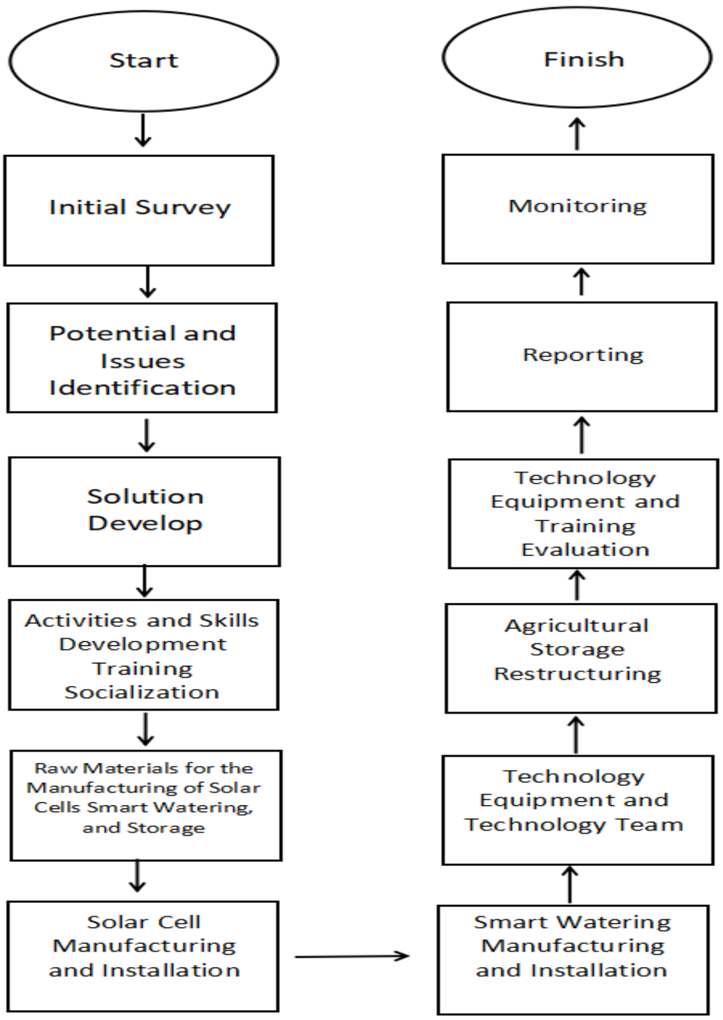

FIGURE 1. Stages Of Program Implementation
(Source: Processed Data)

DISCUSSION

This community service program focuses on the application of renewable energy technology and agricultural systems through the installation of Solar Power Plants (PLTS) and IoT-based smart watering. The rooftop solar PV installation process was carried out through several technical stages involving lecturers and students from Electrical, Industrial, Civil, and Mechanical Engineering. The next stage included system installation, namely assembling PLTS components, smart watering devices, irrigation pumps, sensors, and control units according to the predetermined design.

The PLTS installed uses Maysun Solar monocrystalline panels with a capacity of 250 Wp as the main energy generator. The energy from the panels is regulated by a 30A Solar Charge Controller (SCC) to ensure safe and stable battery charging. The power is stored in a total battery capacity of 110Ah, serving as a reliable backup source. Furthermore, the inverter converts DC into 220V AC to operate water pumps and IoT devices that support the agricultural system. To ensure safety, the system is equipped with protection devices in the form of MCB and SPD on both DC and AC lines to prevent overcurrent, short circuits, and voltage surges. With this configuration, the PLTS is capable of providing

https://doi.org/10.35568/abdimas.v8i4.7163
©LPPM Universitas Muhammadiyah Tasikmalaya

stable and safe electricity for agricultural activities.

The installation of PLTS as the driving force for smart watering was designed to optimize irrigation, save water, and increase agricultural efficiency. Unstable water availability can reduce crop quality because plants do not receive optimal care (Halawa, 2024). This program successfully introduced an off-grid PLTS in Sindulang Village, providing independent access to energy without relying on the PLN grid. The system consists of photovoltaic (PV) modules connected to an MPPT to ensure efficient battery charging.

The PLTS system is equipped with a DC MCB and SPD as protection against overcurrent and lightning, as well as an inverter to convert DC from the batteries into 220V AC used to operate pumps and IoT devices. In addition, the system is supported by grounding to maintain device stability and safety. The presence of PLTS provides a stable and environmentally friendly source of energy, thereby supporting the success of the program while improving agricultural productivity in Sindulang Village. This finding is consistent with Halawa (2024), who emphasized that renewable energy plays an important role in reducing production costs and increasing energy independence in rural areas.

Figure 2 presents photo documentation of the installation and operation of the Solar Power Plant (PLTS). The photos show various field activities, including the installation of solar panels, teamwork at the site, and the appearance of the completed electrical system. The images also capture the tools and equipment used, as well as the surrounding environment of the PLTS location, illustrating the implementation process from beginning to end.

FIGURE 2. PLTS Installation Activities
(Source: Personal Documentation)

The development of the smart watering system was carried out step by step by the lecturers and the student team, starting with component quality inspection, assembly, and initial testing to ensure compliance with technical specifications. The installation process included the placement of water pumps, temperature sensors, and control units, as well as integration with the PLTS as the main power source. The system was then tested in the field through calibration and adjustments until optimal performance was achieved according to the irrigation needs of agricultural land.

The implementation results showed significant improvements compared to the conventional system. Before the program, irrigation at Baruimun Hill, Sindulang Village, relied on manual water flow and diesel-powered pumps. This system required high labor and effort, such as determining irrigation schedules based only on weather estimates. Irrigation was carried out manually at night for about 4 hours by two workers, using small manual sprinklers with a limited reach of less than 10 meters. The

https://doi.org/10.35568/abdimas.v8i4.7163
©LPPM Universitas Muhammadiyah Tasikmalaya

sprinklers had to be moved across three different points, making the process inefficient.

After applying the IoT-based smart watering technology, irrigation became more efficient and practical. Remote control and real-time land temperature monitoring allowed watering to be adjusted to environmental conditions. With sprinklers and soil moisture sensors, irrigation frequency decreased, the duration per session was reduced to 1.5–2 hours, and the process was limited to only two points based on actual land needs detected by the sensors. These findings are consistent with Daulay et al. (2024), Ariawan (2024), and Li, Zhang, & Zhao (2020), who reported that smart irrigation technology increases water-use efficiency in agriculture. The irrigation reach also increased to 20–30 meters due to the use of larger sprinklers, making a single sprinkler sufficient to water a wider area without relocation. Thus, IoT-based smart watering in Sindulang Village significantly improved irrigation efficiency in terms of both time and water use.

Sprinkler irrigation sprays water into the air to fall onto the soil surface like rainfall. This method is recognized as efficient and effective, with water distribution uniformity reaching more than 85% (Ariawan, 2024). With the new system, irrigation duration was reduced from 4 hours and could be automatically controlled through an on-off feature operated remotely. This change not only saved farmers' time and labor but also optimized water use effectively and efficiently. Furthermore, IoT integration has also been proven to support real-time device monitoring for security purposes (Pradana, Wibowo, & Khumaedi, 2022).

FIGURE 3. Irrigation Using Sprinkler
(Source: Personal Documentation)

To ensure the sustainability of PLTS utilization in Sindulang Village, device protection from risks such as damage, theft, or external disturbances was required. As a preventive measure, an ESP32-CAM–based monitoring system was employed. This low-cost camera module connects to the internet, enabling real-time monitoring of the PLTS condition. With this system, PLTS devices can be monitored both directly and remotely, thereby enhancing security, providing more accurate visual information, and maintaining optimal PLTS operations.

https://doi.org/10.35568/abdimas.v8i4.7163
©LPPM Universitas Muhammadiyah Tasikmalaya

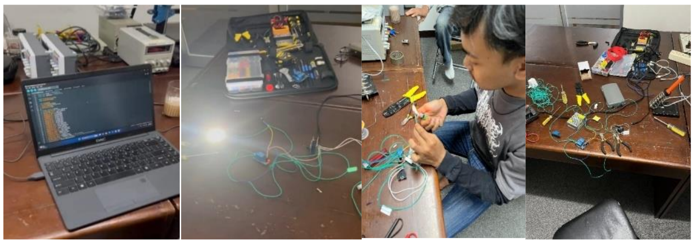

FIGURE 4. ESP32-CAM Assembly with Coding
(Source: Personal Documentation)

RESULTS

After the discussion above regarding the development and implementation of PLTS and Smart Watering, the results show an overall improvement in the agricultural system's performance in Sindulang Village. The application of these technologies increased the efficiency of energy and water use, while also accelerating the irrigation process. This indicates that the program not only succeeded technically but also had a tangible impact on empowering farmers to manage their land independently and sustainably.

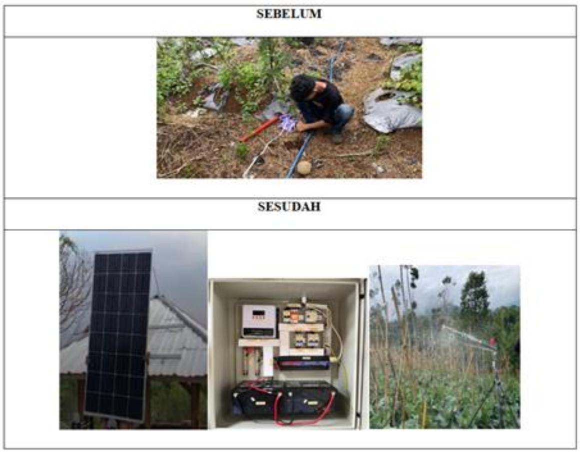

FIGURE 5. Conditions Before and After the Implementation of PLTS and Smart Watering
(Source: Personal Documentation)

Figure 5 illustrates the conditions before and after the program. The upper section shows conventional irrigation activities still carried out manually by farmers, while the lower section displays the technological implementation, including solar panels (PLTS), control units, and batteries for energy storage, and the Smart Watering system with automatic sprinklers to support efficient land irrigation.

On August 28, 2025, a training session was conducted in Sindulang Village. The activity began with pre- and post-training questionnaires to map participants' baseline conditions and assess changes in knowledge, attitudes, and skills after the training. The comparison results served as indicators of program effectiveness and provided the basis for recommendations to improve future activities.

The training took the form of a workshop on the operation and maintenance of rooftop PLTS and Smart Watering, aimed at introducing and familiarizing the community with the use and upkeep of these

https://doi.org/10.35568/abdimas.v8i4.7163
©LPPM Universitas Muhammadiyah Tasikmalaya

technologies. The expected outcome was that the farmer group would be able to optimize the technology provided for more effective and efficient production. The results of the questionnaires are presented in the following table:

TABLE 2. Analysis Before Training on PLTS and Smart Watering

No	Aspect of PLTS & Smart Watering	Number of Participants "YES"	Percentage
1	Understanding what PLTS is	3/8	38%
2	Understanding what Smart Watering is	6/8	75%
3	Knowing the main components of PLTS	3/8	38%
4	Understanding the benefits of using PLTS for Smart Watering	2/8	25%
5	Understanding how to maintain PLTS and Smart Watering	0/8	0%
6	Understanding how to monitor the performance of the Smart Watering system	0/8	0%
	Average Percentage		**29%**

(Source: Processed Data)

TABLE 3. Analysis After Training on PLTS and Smart Watering

No	Evaluation Aspect	Average Score	Percentage
1	Clarity of PLTS & Smart Watering materials	3.38	85%
2	Motivation to Implement	3.38	85%
3	New insight into the main components of PLTS	3	75%
4	Understanding the benefits of using PLTS for Smart Watering	3.13	66%
5	How to maintain PLTS and Smart Watering	2.63	66%
6	Monitoring the performance of the Smart Watering system	2.63	66%
	Average Percentage		**76%**

(Source: Processed Data)

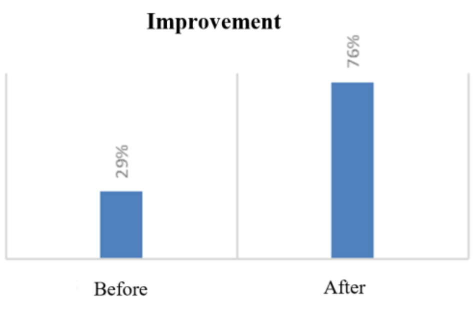

FIGURE 6. Improvement Graph of PLTS and Smart Watering
(Source: Processed Data)

The analysis of the questionnaire data shows that before the training, participants' understanding and practical skills in operating and maintaining PLTS and Smart Watering were still very low. The average score was only 29%, with most participants unaware of the benefits of PLTS for Smart Watering, how to perform maintenance, or how to monitor the system. In several aspects—such as benefits, maintenance,

https://doi.org/10.35568/abdimas.v8i4.7163
©LPPM Universitas Muhammadiyah Tasikmalaya

and monitoring—none of the participants had prior knowledge. This indicates that farmers' initial knowledge of PLTS and Smart Watering was very limited.

After the training, there was a significant improvement, with the average understanding rising to 76%. The highest aspect was clarity of the material (85%), followed by motivation and insights into PLTS components. This confirms that the training was effective in providing new knowledge and increasing participants' interest in adopting the technology. However, understanding of maintenance and monitoring remained relatively low (66%), suggesting the need for additional reinforcement through hands-on practice and technical assistance to enhance participants' operational skills.

FIGURE 7. Training on the Operation and Maintenance of Rooftop PLTS and Smart Watering (Source: Personal Documentation)

Despite the positive outcomes, several challenges remain. First, farmers' limited digital literacy hindered the use of control applications. Second, the cost of IoT device maintenance posed an additional burden. Compared with similar studies in other regions (Belakang & PLTS, n.d.; Smith & Porter, 2019), the program achieved relatively high success rates, but its sustainability depends on long-term support. Therefore, this program has the potential to be replicated in other rural areas, but strategies for sustainability are essential, including the establishment of local technical teams and community-based financing models.

The program's sustainability will continue to be monitored through periodic evaluations to ensure each target output is achieved. The next step is to expand the technology to more agricultural land, involve a wider local community, and provide continuous training so that Sindulang Village can serve as a model of technology-based, sustainability-oriented agriculture.

CONCLUSION

The PKM program in Sindulang Village successfully implemented renewable energy technology and IoT-based agricultural systems through the installation of an off-grid Solar Power Plant (PLTS) and Smart Watering. These technologies not only provided a solution to limited energy access but also introduced innovation in more efficient irrigation management.

The implementation results showed significant improvements in the production aspect. Water use was reduced by 30–40%, irrigation duration decreased from approximately four hours to 1.5–2 hours per session, and the number of irrigation points was reduced from three to two. Farmers' understanding of the technology also increased from 29% to 76%. The system enabled real-time monitoring of land temperature and moisture, remote control, and extended sprinkler coverage from less than 10 meters to 20–25 meters with only two irrigation points, supported by a solar-powered booster pump.

The adoption of this technology has proven effective in reducing manual labor and enhancing farmers' empowerment in managing their land independently. However, the program's sustainability still requires

https://doi.org/10.35568/abdimas.v8i4.7163
©LPPM Universitas Muhammadiyah Tasikmalaya

ongoing technical assistance, improvements in farmers' digital literacy, and a more detailed cost-benefit analysis to ensure its replication in other rural areas.

ACKNOWLEDGMENTS

The authors would like to express their gratitude to the Directorate of Research and Community Service (DPPM) of the Ministry of Education, Culture, Research, and Technology (KEMDIKTISAINTEK) for funding this Community Service Program (PKM) under the Community Empowerment Scheme with the scope of Community Partnership Empowerment in 2025, which enabled this project to be successfully implemented. Sincere appreciation is also extended to the leadership of USB, the USB Research and Community Service Institute (LPPM) for their invaluable in-kind support, the Government of Sindulang Village, the Baruimun Hill Farmers' Group, and the entire community of Sindulang Village for their active participation. Finally, heartfelt thanks go to fellow lecturers and students who actively contributed to this community service activity.

REFERENCES

Ariawan, A. (2024). Smart sprout: Irigasi cerdas berbasis AIoT untuk pertanian modern dan ramah lingkungan. bit-Tech, 7(2), 434–444. https://doi.org/10.32877/bt.v7i2.1841

Azzahra, F., Mahatmayana, I. K. M., & Primajaya, A. (2024). Model smart farming dalam efisiensi dan peningkatan produktivitas buah durian di Kecamatan Pangkalan, Kabupaten Karawang. Jurnal Abdimas Mandiri, 8(3), 397–408. https://doi.org/10.36982/jam.v8i3.4649

Coombs, S. J., & Hayden, M. (2022). Participatory research approaches in community development: Generating contextual knowledge and practical solutions. Journal of Community Development, 57(3), 345–360.

Daulay, D. P., Yogi, & Rokhandi, R. T. (2024). Smart farming automatic irrigation system berbasis IoT dalam optimalisasi suplai air lahan pada perkebunan di Desa Pondok Meja. J-Innovation, 13(2), 78–85. https://doi.org/10.55600/jipa.v13i2.293

Egar Garnia, R., Hidayat, R., & Saputra, A. (2023). Pengembangan ekonomi masyarakat kaki Gunung Kerenceng berbasis infrastruktur dan pengelolaan berkualitas. Jurnal Pengabdian Kepada Masyarakat, 13(2), 176–182. https://doi.org/10.30999/jpkm.v13i2.2824

Halawa, D. N. (2024). Peran teknologi pertanian cerdas (smart farming) untuk generasi pertanian Indonesia. Jurnal Kridatama Sains dan Teknologi, 6(2), 502–512.

Khafsoh, N. A., & Riani, N. (2024). Implementation of participatory action research (PAR) in a community service program. Jurnal Pengabdian Masyarakat, 5(1), 20–29.

Khafsoh, S., & Riani, D. (2024). Participatory action research dalam pemberdayaan masyarakat desa: Studi efektivitas partisipasi aktif dalam pengambilan keputusan. Jurnal Pengabdian dan Pemberdayaan Masyarakat, 6(1), 45–56.

Li, M., Zhang, X., & Zhao, J. (2020). Adoption of IoT-based smart farming in rural China: Opportunities and challenges. Journal of Rural Studies, 75, 102–111. https://doi.org/10.1016/j.jrurstud.2020.01.003

https://doi.org/10.35568/abdimas.v8i4.7163
©LPPM Universitas Muhammadiyah Tasikmalaya

Profil Desa Sindulang Tahun 2024. Pemerintah Desa Sindulang.

Rante Kayangan, L. K. E., & Rantung, R. A. (2018). Jurnal Teknologi Pertanian. Fakultas Pertanian, Universitas Sam Ratulangi.

R.Y. Pradana, A. N. M. Wibowo, and A. F. Khumaedi, "IoT Application in a Vision-Based Security System at the At-Taqwa," ABDIMAS: Jurnal Pengabdian Masyarakat, vol. 5, no. 1, pp. 12–21, 2022.

Saputra, T., & Surapati, U. (2024). Analisis efektivitas sistem kendali otomatis PJU berbasis IoT menggunakan mikrokontroler ESP32 dengan metode regresi linier. Jurnal Indonesia Manajemen Informasi dan Komunikasi, 5(3), 2582–2595. https://doi.org/10.35870/jimik.v5i3.932

Smith, A., & Porter, G. (2019). Solar energy for rural development: Adoption barriers and community empowerment. Renewable Energy, 141, 327–335. https://doi.org/10.1016/j.renene.2019.03.120

Sugiyono. (2021). Metode penelitian kuantitatif, kualitatif, dan R&D. Alfabeta.

https://doi.org/10.35568/abdimas.v8i4.7163
©LPPM Universitas Muhammadiyah Tasikmalaya