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IoT and Renewable Energy Training and Implementation for Smart Village in Karang Anyar

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Abstract– This community service program addressed productivity instability in oyster mushroom cultivation and limited utilization of digital and renewable-energy-based village infrastructure in Karang Anyar Village, South Lampung. The program aimed to strengthen agricultural productivity and support Smart Village development through training and implementation of Internet of Things (IoT) and renewable energy technologies. The activities included participatory needs assessment, installation of an IoT-based automatic misting system in mushroom houses, deployment of solar-powered lighting systems for the village sports field, and training on Content Management System (CMS)-based website management involving mushroom farmers, village administrators, and university students participating in the Community Service Program (KKN). Functional testing showed that the IoT-based misting system achieved 100% operational performance, while training activities involved seven mushroom farmers with more than 50% of participants demonstrating adequate understanding of system operation and digital platform utilization. In addition, the installation of solar-powered lighting improved the accessibility of village sports facilities at night. These results demonstrate that integrating IoT and renewable energy technologies effectively supports Smart Village development and strengthens sustainable community-based innovation in rural areas.

Keywords: Community service; IoT; Renewable energy; Smart Village; Mushroom cultivation

1. INTRODUCTION

The digital transformation of rural development has accelerated in recent years through the implementation of the Smart Village concept. This concept promotes the integration of digital technology, community empowerment, and sustainable resource management to improve rural productivity and strengthen governance (Ardhian Nugroho & Galan Prakoso, 2025). Smart villages emphasize the use of information and communication technologies (ICT) to support public services, economic development, and environmental sustainability in rural areas. The adoption of digital technologies in agriculture and rural governance has become increasingly important to address challenges related to agricultural productivity and resource efficiency.

Agriculture remains one of the primary economic sectors in rural Indonesia, including in Karang Anyar Village, South Lampung Regency. Many rural communities depend on agricultural activities such as crop cultivation and mushroom farming as their main source of income. However, traditional farming practices often rely on manual monitoring systems and conventional environmental control methods. These limitations may lead to unstable production conditions, particularly when environmental factors such as temperature and

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humidity fluctuate. In mushroom cultivation, environmental stability is essential because oyster mushrooms require controlled temperature and humidity conditions to maintain optimal growth and productivity.

The emergence of smart farming technologies based on the Internet of Things (IoT) provides promising opportunities to improve agricultural efficiency. IoT technology allows real-time monitoring and automated control of environmental parameters such as temperature, humidity, and irrigation systems. Several community service studies have demonstrated that IoT-based smart farming systems can significantly improve farmers' capacity in adopting digital agriculture technologies and enhance agricultural productivity (Juliansyah et al., 2025; Marwondo et al., 2025). Similarly, community empowerment programs in mushroom farming communities have shown that environmental monitoring and automated misting systems can improve cultivation management and reduce productivity loss caused by environmental fluctuations (Febtriko et al., 2025; Suda et al., 2025).

In addition to digital monitoring technologies, the integration of renewable energy systems has become an important component of sustainable rural development. Renewable energy sources such as solar panels can provide reliable energy for IoT devices and rural infrastructure while reducing dependence on conventional electricity sources. Several studies have shown that integrating IoT technology with renewable energy systems can support sustainable agricultural operations and improve energy efficiency in rural communities (Afiyat et al., 2025).

Previous community service activities conducted by the authors have implemented an IoT- and renewable energy-based automatic misting system in the oyster mushroom farming group Kepung Seto Sejahtera in South Lampung. The results demonstrated that the implemented system was able to maintain environmental stability inside mushroom houses and improve farmers' understanding of technology-based cultivation methods through training and mentoring activities (Prasetyawan et al., 2025). Therefore, there remains a need for a more comprehensive community service program that expands the implementation of smart farming technologies to other members of the mushroom farming group while simultaneously supporting village infrastructure and digital governance. Karang Anyar Village has significant potential in oyster mushroom cultivation, but farmers still experience declining productivity during hot weather due to unstable environmental conditions inside mushroom houses. In addition, although the village already has an official website, the digital management of village data and information has not yet been fully optimized to support public services and village promotion. However, previous community service activities generally focused on single-technology interventions, while integrated implementation combining IoT-based agriculture, renewable energy infrastructure, and village digital governance within one Smart Village framework remains limited.

Based on these challenges, this community service program proposes the implementation and training of IoT and renewable energy technologies to support Smart Village development in Karang Anyar Village. The program expands the implementation of the IoT-based misting system to other members of the Kepung Seto mushroom farming group to maintain optimal environmental conditions in mushroom cultivation houses. In addition, the program introduces a solar panel-based lighting system for the village sports field as part of renewable energy utilization in rural infrastructure. Training and mentoring activities were also conducted for village administrators to improve their capacity in managing the village website using a content management system. Another distinctive aspect of this program is the involvement of university students through the Community Service Program (Kuliah Kerja Nyata / KKN). The activities conducted in this program were recognized as part of the KKN course, allowing students to participate directly in community empowerment activities, technological implementation, and village development initiatives.

The contributions of this program are threefold. First, it expands the implementation of IoT-based smart farming technology to improve environmental control in mushroom cultivation among multiple farmers in the village. Second, it introduces renewable energy applications through solar-powered village infrastructure to support sustainable rural development. Third, it strengthens community empowerment and digital governance through training, mentoring,

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and student participation in community service activities. Through these integrated approaches, the program is expected to improve agricultural productivity, enhance technological literacy among rural communities, and support the implementation of the Smart Village concept in Karang Anyar Village.

2. IMPLEMENTATION METHOD

The community service program was conducted in Karang Anyar Village, Jati Agung District, South Lampung Regency. The activities were designed to address the identified problems related to the instability of environmental conditions in oyster mushroom cultivation houses and the limited capacity of village administrators in managing digital information systems. The program's implementation involved several stages, as seen in Figure 1, including program initiation, technology implementation, training and mentoring, and evaluation. The overall activities also involved collaboration between lecturers, village officials, mushroom farmers, and university students participating in the Community Service Program (KKN).

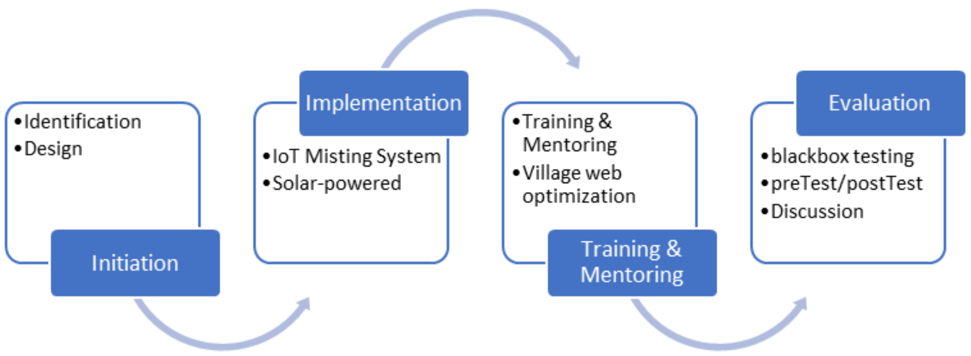

Figure 1. Stages of the Community Service Program.

2.1 Program Initiation and Needs Assessment

The first stage involved field observation, discussion with village officials, and identification of community needs. This stage aimed to analyze the existing conditions of mushroom cultivation and village digital infrastructure. Data were collected through interviews with mushroom farmers, observation of mushroom houses, and discussions with village administrators regarding website management and village digitalization.

Needs assessment is an essential stage in community service programs to ensure that technological interventions are aligned with community needs and local conditions. Previous studies emphasize that participatory approaches in community empowerment programs can increase the effectiveness and sustainability of technological adoption in rural communities (Rusadi et al., 2023).

2.2 Technology Design and Implementation

The second stage involved the design and implementation of technological solutions to improve agricultural productivity and rural infrastructure. Two main technological applications were implemented in this program: an IoT-based automatic misting system for mushroom cultivation houses and a solar-powered lighting system for the village sports field.

2.2.1 IoT-Based Automatic Misting System

The application of IoT technology in agriculture has been widely recognized as an effective approach to improve environmental monitoring and automated control systems in farming practices (Yesankar et al., 2024). IoT-based monitoring systems enable farmers to collect real-

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time environmental data and automate agricultural processes, thereby improving productivity and efficiency.

In addition, the automatic misting system follows the environmental control principle in mushroom cultivation, where temperature and humidity stability are crucial factors for optimal growth of oyster mushrooms. Environmental monitoring and automated misting systems have been proven to improve productivity in mushroom farming by maintaining stable microclimate conditions in mushroom houses (Febtriko et al., 2025). The design of the IoT-Based Automatic Misting System can be seen in Figure 2.

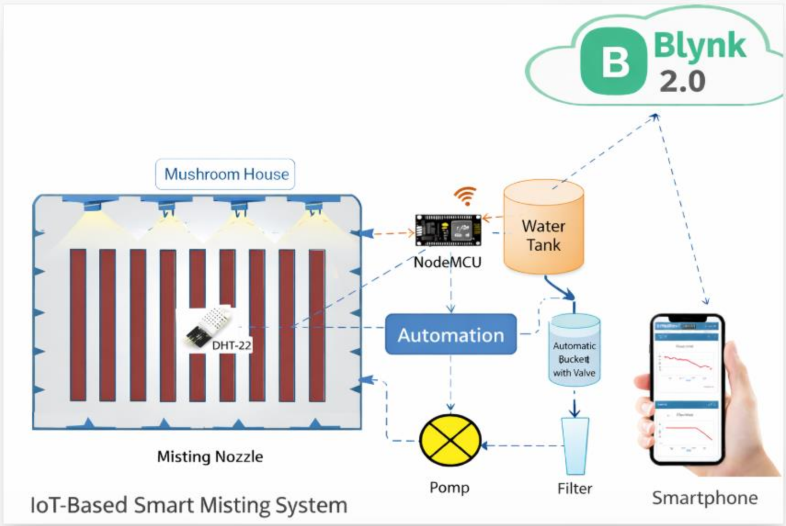

Figure 2. Design of the IoT-Based Automatic Misting System.

2.2.2 Renewable Energy-Based Village Infrastructure

To support sustainable energy utilization in rural areas, a solar-powered lighting system was installed for the village sports field. The system uses photovoltaic (PV) panels to convert solar energy into electrical energy stored in batteries and used to power LED lighting during nighttime.

The use of renewable energy technologies in rural infrastructure has been widely promoted to support sustainable development and reduce dependence on conventional electricity sources. Solar photovoltaic systems are considered suitable for rural applications due to their scalability, environmental sustainability, and relatively low operational costs (Rumbayan et al., 2025). The design of solar lamp placement in the field can be seen in Figure 3.

Figure 3. Solar Lamp Placement Design in the Field.

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2.3 Training and Mentoring Activities

Training and mentoring activities were conducted to ensure that community members could effectively operate and maintain the implemented technologies. The training sessions involved mushroom farmers, village administrators, and students participating in the KKN program.

The training materials included:

a. Introduction to IoT technology and Renewable Energy
b. Operation and maintenance of the automatic misting system
c. Basic maintenance of solar-powered lighting systems
d. Management of the village website using a Content Management System (CMS)

Training-based community empowerment approaches are widely used in community service programs to improve community capacity in adopting digital technologies. Such programs can significantly increase participants' knowledge and technical skills in utilizing technology-based agricultural systems (Juliansyah et al., 2025).

2.4 Program Evaluation

Program evaluation was conducted to measure the effectiveness of the implemented technologies and training activities. The evaluation methods included functionality testing of the IoT misting system and solar lamp, pre-test and post-test assessments during training.

Black-box testing was used to evaluate the functionality of the implemented IoT system, focusing on whether the system operates according to its intended functions without analyzing the internal program structure. This approach is commonly used in system evaluation to verify the operational performance of hardware and software systems (Pressman & Maxim, 2020). The results of the evaluation were used to measure the level of success of the community service program and to identify potential improvements for future activities.

3. RESULTS AND DISCUSSION

3.1Implementation of IoT-Based Automatic Misting System for Mushroom Cultivation

One of the main activities of this community service program was the implementation of an Internet of Things (IoT)-based automatic misting system in oyster mushroom cultivation houses belonging to members of the Kepung Seto Sejahtera farmer group in Karang Anyar Village. The system utilized temperature sensors, microcontroller-based controllers, and automated misting actuators connected through an IoT platform to maintain stable environmental conditions inside mushroom houses.

Functional testing results showed that the implemented system achieved 100% operational functionality based on black-box testing, indicating that the system operated according to its intended design. The automatic activation of the misting mechanism helped maintain temperature and humidity stability, particularly during hot weather conditions that previously reduced mushroom productivity. The following documentation of the automatic misting system installation work can be seen in Figure 4.

(a) Installation Misting Nozzle (b) IoT sub-system

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Figure 4. Installation of the IoT-Based Automatic Misting System.

These findings indicate that the application of IoT-based environmental monitoring systems can reduce dependence on manual watering practices and improve cultivation stability in small-scale rural mushroom farming systems. Similar results were reported in previous community service programs showing that automated misting systems contribute to improving productivity stability and increasing farmers' readiness to adopt smart farming technologies (Febtriko et al., 2025). Furthermore, this program represents the continuation and expansion of previous IoT-based misting system implementation activities conducted by the authors in the Kepung Seto Sejahtera farmer group, demonstrating the scalability of smart farming technology in supporting village-level agricultural productivity.

3.2 Implementation of Renewable Energy-Based Village Infrastructure

Renewable energy technology was implemented through the installation of a solar panel-based lighting system in the village sports field as part of efforts to strengthen sustainable rural infrastructure. The photovoltaic system converts solar energy into electrical energy stored in batteries and used to power LED lighting during nighttime activities.

The installation improved the availability of public lighting infrastructure and supported community activities in the village environment, particularly during evening events. In addition to improving infrastructure accessibility, this activity introduced practical applications of renewable energy technologies to the community and increased awareness of sustainable energy utilization in rural areas. The activity of installing solar lamps on the village sports field can be seen in Figure 5.

(a) Solar lights are on (b) Setting solar lamp

Figure 5. Installation of the Solar-Powered Lighting System.

The integration of solar energy systems into village infrastructure supports the Smart Village framework, particularly in strengthening the smart environment and smart living pillars through environmentally friendly infrastructure development. Similar community service activities have reported that solar-powered infrastructure contributes to improving rural energy accessibility and promotes community participation in renewable energy adoption (Prasetyawan et al., 2025; Rumbayan et al., 2025).

3.3 Optimization of Village Website and Community Capacity Building

Digitalization of village information systems was carried out through optimization of the official Karang Anyar Village website using a Content Management System (CMS). Students participating in the Community Service Program (KKN) collaborated with village administrators to update village profiles, activity documentation, and information related to village potential.

Training and mentoring activities were conducted for mushroom farmers and village administrators to improve their technical capacity in operating the implemented IoT systems and managing the village website. The training involved seven mushroom farmers and village administrators responsible for managing digital information services. Evaluation results indicated that more than 50% of participants demonstrated adequate understanding of system

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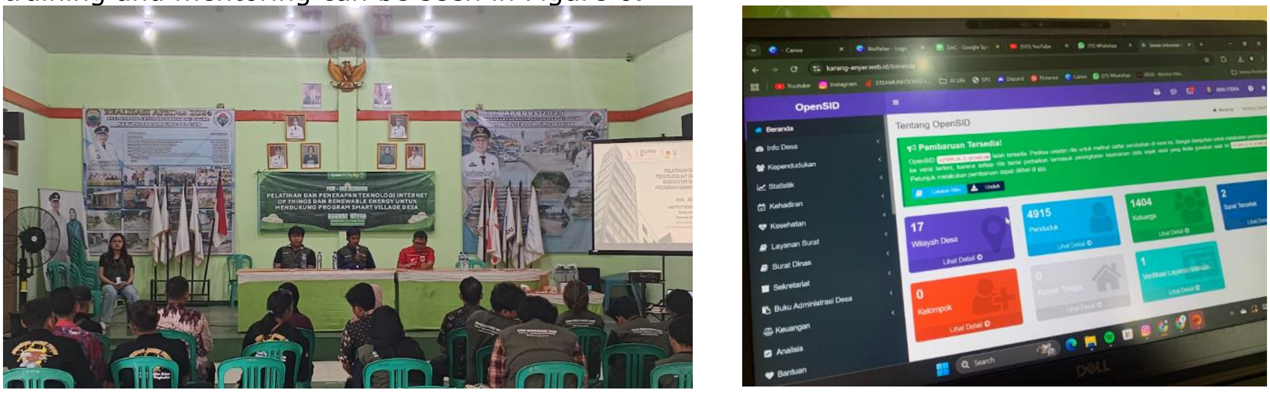
operation and CMS-based website management after the training activities. The activity training and mentoring can be seen in Figure 6.



(a) Training IoT, Renewable energy, and Website (b) Web Optimization

Figure 6. Training and Village Website Optimization.

These results indicate that training-based community empowerment approaches play an important role in supporting the adoption of digital technologies in rural communities. Strengthening village digital governance through website optimization also supports transparency and accessibility of public information as part of Smart Village implementation. Previous studies have similarly reported that CMS-based village information system training improves administrative capacity and supports digital transformation at the village level (Juliansyah et al., 2025).

3.4 Program Impact and Student Participation through KKN Activities

Another important outcome of this community service program was the involvement of 15 university students through the Community Service Program (KKN), which was formally recognized as part of academic coursework. Students actively participated in field surveys, installation of IoT systems, optimization of village website content, and documentation of program implementation.

The involvement of students contributed to accelerating the implementation of technology transfer activities and strengthening collaboration between universities and local communities. In addition, student participation provided practical learning experiences related to the application of engineering technologies in community empowerment programs. The activity of discussion and evaluation program can be seen in Figure 7.

(a) Participant photo session (b) Discussion/Evaluation

Figure 7. Evaluation and Discussion Activity.

Overall, the integration of IoT-based smart farming technology, renewable energy utilization, and village digitalization activities demonstrates that collaborative community service programs involving universities, village governments, farmer groups, and students can effectively support the implementation of Smart Village initiatives. The program not only

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improved environmental control in mushroom cultivation but also strengthened rural infrastructure and increased digital literacy among village stakeholders, supporting sustainable rural innovation in Karang Anyar Village.

Table 1. Measurable outcome indicators.

Aspect	Before	Intervention	After
Mushroom house environmental control	Manual misting system	IoT-based automatic misting system	Stable temperature and humidity conditions maintained
Renewable energy utilization	No solar-powered public lighting	Installation of solar panel-based lighting system	Improved accessibility of sports field infrastructure at night
Village website information availability	Limited and incomplete data	CMS-based website optimization and training	Increased availability of village profile and activity information
Administrator technical capacity	Limited experience in CMS usage	Website management training and mentoring	Administrator able to manage website independently
Community technology adoption	Limited exposure to IoT and renewable energy applications	Training and mentoring activities	>50% participants demonstrated understanding of system operation
Student participation in community empowerment	-	KKN-based implementation support	15 students involved in technology transfer activities

The measurable outcome indicators presented in Table 1 demonstrate that the implementation of IoT-based smart farming technology, renewable energy infrastructure, and CMS-based village website optimization significantly improved both agricultural support systems and digital governance capacity in Karang Anyar Village. The transition from manual misting systems to IoT-based automatic environmental control contributed to maintaining stable temperature and humidity conditions in mushroom cultivation houses. In addition, the installation of solar-powered lighting systems enhanced the accessibility of village sports facilities during nighttime activities. Training and mentoring activities also strengthened community technological capacity, as reflected by more than 50% of participants demonstrating adequate understanding of IoT system operation and website management. Furthermore, the involvement of 15 students through the Community Service Program (KKN) supported the effectiveness of technology transfer activities and strengthened collaboration between universities and local communities.

4. CONCLUSION

The community service program conducted in Karang Anyar Village successfully addressed key challenges related to agricultural productivity and village digital governance through the training and implementation of Internet of Things (IoT) and renewable energy technologies. The installation of IoT-based automatic misting systems in oyster mushroom cultivation houses helped maintain stable environmental conditions, particularly during periods of high temperature, thereby supporting production stability among members of the Kepung Seto Sejahtera mushroom farming group. Functional testing results indicated that the implemented system achieved 100% operational performance, demonstrating the reliability of smart farming technology in supporting rural agricultural activities.

In addition to supporting agricultural productivity, the installation of solar panel-based lighting systems improved the accessibility of village sports facilities during nighttime activities and introduced practical applications of renewable energy technologies to the community. Training and mentoring activities involving mushroom farmers and village administrators also strengthened community technological capacity, with more than 50% of participants demonstrating adequate understanding of IoT system operation, renewable energy and CMS-based website management after the program implementation.

Furthermore, the involvement of university students through the Community Service Program (KKN) strengthened the implementation of technology transfer activities while providing experiential learning opportunities related to community empowerment and rural technology applications. This program represents the continuation and expansion of previous IoT-based mushroom cultivation technology implementation activities conducted in the Kepung Seto Sejahtera farmer group and demonstrates the scalability of integrated IoT and renewable energy solutions in supporting Smart Village development.

For future work, further development is recommended through the expansion of IoT-based monitoring systems to additional agricultural sectors in Karang Anyar Village, such as irrigation management and livestock monitoring, as well as the integration of village data platforms into a more comprehensive smart village information system. Strengthening renewable energy utilization through the expansion of solar-powered infrastructure and integrating student-based community service programs into multi-year village development roadmaps are also expected to enhance the effectiveness of Smart Village implementation in supporting sustainable rural development.

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Vol 7, No 1, Maret 2026, Hal 129-138
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