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Automated Drip Irrigation System Based on IoT for Chili Plants Using Solar Panel Energy

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Abstract

Purpose: This research paper aims to address the challenges faced by horticultural farmers in Lauwonu Village, particularly regarding water scarcity exacerbated by hot weather conditions. The study emphasizes the significance of utilizing technology, specifically a drip irrigation system based on IoT and solar panel energy, to mitigate these challenges effectively.

Method: The research employed a qualitative approach to investigate the impact of implementing IoT-based drip irrigation systems on chili farming productivity. Data collection methods included surveys and interviews with 15 members of the Mekar Green farmer group. Thematic analysis was utilized to interpret the gathered data.

Practical Applications: The findings demonstrate the practical benefits of adopting IoT-driven irrigation technology, enhancing water efficiency and agricultural productivity. This research offers valuable insights for farmers, policymakers, and agricultural practitioners, facilitating informed decision-making and sustainable agricultural practices.

Conclusion: Implementing IoT-enabled drip irrigation systems powered by solar panels presents a viable solution to address water scarcity challenges in chili farming. The study underscores the importance of leveraging technology to improve agricultural resilience and productivity, thereby contributing to sustainable food production and livelihoods in rural communities.

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Introduction

The village of Lauwonu, Tilango District, Gorontalo Regency is located 5 km from the center of Gorontalo City with a travel time of about 15 minutes, covering an area of 1,750 km². Farmers in Lauwonu Village are mostly horticultural farmers. Besides limited land availability, their proximity to Gorontalo City makes it easy for them to sell their harvest. The hot weather in Gorontalo poses challenges for farmers, especially for members of the Mekar Green Farmer Group, as they struggle to meet the water needs of their chili crops. Thus, there is a need for technology to assist farmers without additional costs, directly affecting their productivity. Additionally, there is a need for guidance on agricultural technology, especially for the crops they cultivate, to increase technology adoption and knowledge of farming models.

Therefore, the Community Partnership Service (PKM) team offers a solution based on discussions with partners: a drip irrigation automation system powered by solar panels. This technology automatically waters plants according to their needs and utilizes renewable energy (solar panels), reducing partners' additional expenses. According to study by (Haryanto, 2021; Pambudi et al., 2023; Prasetiyo et al., 2022) solar panel is an apparatus that transforms thermal energy from sunlight into electrical energy. Solar panels are employed in several studies that have been presented as a source of electrical energy that may be linked with off-grid solar power systems (PLTS) and used to generate electricity for a variety of uses, including powering appliances and charging batteries. To increase the effectiveness of solar energy usage and produce more electricity, these solar panels can also be used with solar tracker systems.

Besides utilizing renewable energy (solar panels), the drip irrigation automation system can also save water by adjusting irrigation according to plant needs, as researched by (Anugrah et al., 2021; Azam et al., 2023). Micro-irrigation has advantages over other irrigation technologies as it saves water and can be applied simultaneously with fertilization, requiring minimal land (As'ari & Qiram, 2023; Herawati et al., 2024). The aim of this activity is to increase water availability to enhance chili farmers' productivity with IoT-based drip irrigation automation using solar panels, which can efficiently use water and improve chili farming methods by introducing IoT automation systems and solar panels as controllers and energy sources for drip irrigation.

There are three issues with partners targeted in this activity. First, in terms of Agricultural Technology Adoption (lack of appropriate technology adoption to assist farmers in clove cultivation due to limited technology adoption by farmers and many unused organic materials by partners such as clove leaves, weeds in agricultural land, clove plant stems, animal manure, and household waste). Second, in terms of Human Resources (limited knowledge of technological innovations), and third, in terms of Farmers' Cultivation Techniques (lack of understanding among farmers regarding the utilization of surrounding organic materials that can be processed into fertilizer).

The higher the productivity level of farmers, the higher their income. One of the drivers of increased farmer productivity is the utilization of time (Aulia et al., 2023). With the assistance of technology, farmers can shorten their work time, enabling them to complete several tasks in a short period.

Human resources (HR) are the most important capital and wealth in any human activity. Based on study by (Segoro & Kusuma Pratiwi, 2021) humans, as the most essential element, must be analyzed and developed accordingly. Time, energy, and abilities can truly be optimized for the benefit of organizations as well as individuals. As the primary and essential factor in the development process, human resources are always both the subject and object of development. The productivity level of labor plays a crucial role in national economic growth, where national and regional income is largely obtained by improving the quality of human resources (Maryati et al., 2021).

Clove farming has been one of the flagship agricultural endeavors for farmers. Cloves were once an export commodity promoted by the government, providing significant economic

opportunities for farmers (Ahmad et al., 2022). A surge in clove prices occurred as industrial demand for cloves increased. The efforts of some farmers who persisted in clove farming indicate reasons for their perseverance that other farmers do not possess. These reasons may include relationships with external parties who provide information to farmers to persevere, or even parties who guarantee to absorb the produce from farmers.

Clove is a crop in the plantation agriculture sector that contributes significantly to the economy, ranging from small to large industries. Because cloves are still widely used as a seasoning ingredient, a primary ingredient in cigarette manufacturing, and as medicinal ingredients for health (Patty, 2023).

Several technologies have been introduced in clove farming, which is a 15 kg capacity clove dryer. This device can dry agricultural produce regardless of the weather conditions and can also save space and drying time, replacing the sun-drying process with a machine dryer using an electric motor drive system. Here, the electric motor serves as the main driver to rotate the drum containing cloves.

Performing a similar function but designed with different components and operation methods, (Ahmad & Hariri, 2021) designed a 30 kg capacity Arduino-based Clove Dryer. This clove drying device uses the Pahl & Beitz design method to obtain a design concept that meets the requirements. To perform the drying process, it utilizes a Tubular Heater as the heating element, an Arduino Uno microcontroller system, a DHT22 temperature and humidity sensor, a centrifugal blower, a 2 × 16 LCD, a 40 × 40 mm angle iron frame, with overall dimensions of 1000 × 800 × 1200 mm. This ensures the desired drying outcome with a residual moisture content between 12 – 14%, suitable for safe storage.

Method

The operation of the drip irrigation automation system using solar panel energy is to water plants according to their measured water requirements. Water is pumped into a reservoir, and then the irrigation timing and duration are automatically regulated by the system to water chili plants using renewable electric energy generated by solar panels. Chili plants, including horticultural crops, have their production and growth determined by water supply, as evidenced by (Supriadi et al., 2018), which shows that irrigation levels significantly affect chili plants, such as plant height, number of vegetative branches, number of flowers, and fruit weight per plant. Below is a diagram illustrating the working principle and prototype of the drip irrigation automation.

Table 1. Implementation Method of the Program

Problem Priorities	Solutions	Implementation Method
Low adoption rate of technology among partners.	Socialization of the drip irrigation automation system with solar panel energy.	Focus group discussions (FGD) and educational socialization with partners regarding the benefits of drip irrigation automation with solar panels and the constraints faced by partners in chili farming.
Partner farmers manually water chili or horticultural plants (water is drawn from wells with containers and manually poured onto plants).	Designing the drip irrigation automation system with solar panel energy.	1. Determining the water requirements of plants. 2. Establishing the number of irrigation sessions per day. 3. Installation setup.
Farming practices by partners do not adhere to horticultural	Enhancing partners' understanding and knowledge of	Educational sessions on chili cultivation conducted at the

plant maintenance SOPs, such as the required water amount for plants and balanced fertilizer use.	proper horticultural cultivation practices, especially for chili plants.	plant locations.

The farmer group partners of Mekar Green in Lauwonu Village, Tilango District, Gorontalo Regency, will be provided with knowledge and understanding of drip irrigation automation systems for chili plants using solar power, as follows:

1. Focus Group Discussion (FGD) will be conducted to identify the problems or challenges faced by farmers in horticultural cultivation.
2. Socialization and education on the benefits of drip irrigation technology.

The objectives of this activity are to further understand the problems faced by partners, as well as to introduce the drip irrigation system that will be installed.

The PKM team, along with partners assisted by students, will design the drip irrigation installation at the agreed-upon location. The necessary equipment includes:

1. Drip irrigation hose
2. PVC pipes
3. Angle iron
4. Water pump
5. Inverter
6. Water reservoir
7. Automation IoT device
8. Water tap
9. Pipe glue
10. Battery
11. Solar panel
12. Electrical cables

Figure 1. Design of the IoT Drip Irrigation Automation System with Solar Panel Energy

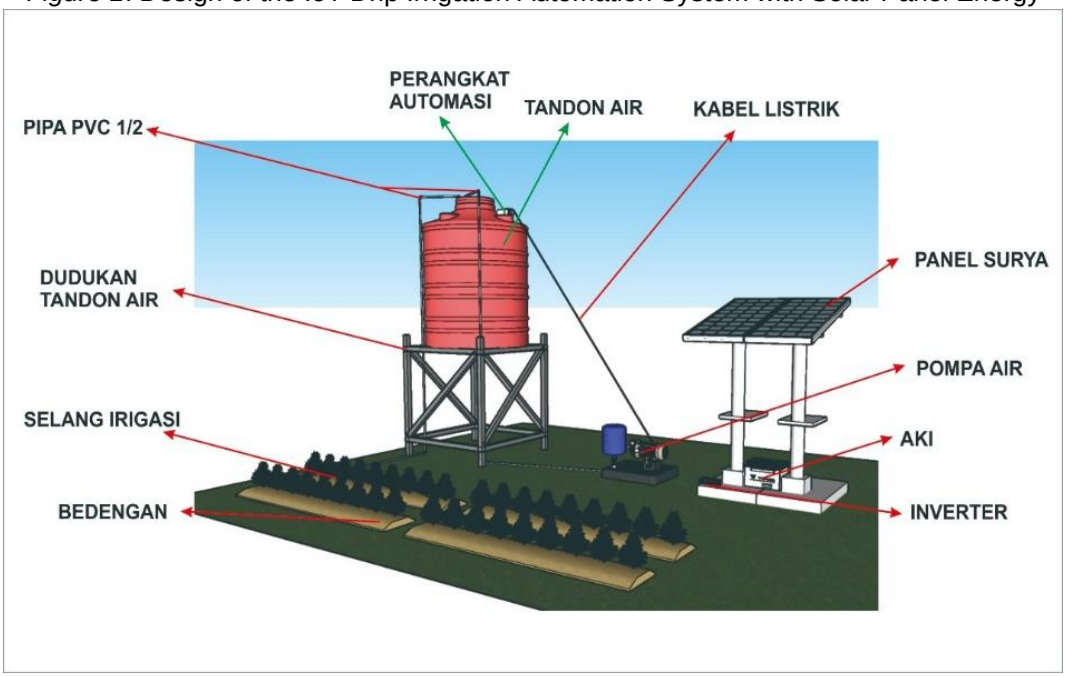
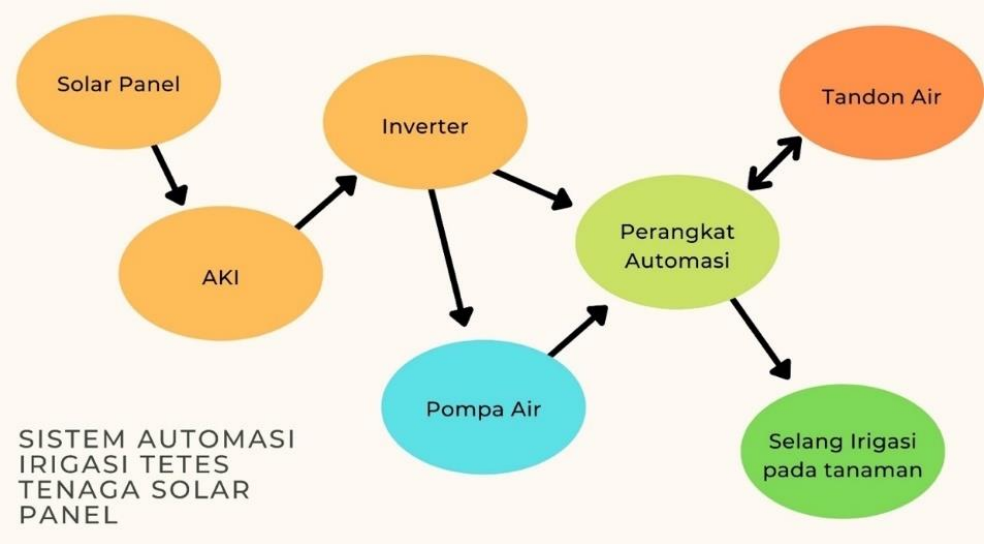


Figure 2. Working Principle of the IoT Drip Irrigation Automation System with Solar Panel Energy



The next step is the organic fertilizer production process, during which training and education on chili cultivation will be conducted. The following topics will be covered:

1. Techniques for cultivating chili plants.
2. Pest and disease management in horticultural plants.
3. Education on drip irrigation automation technology with solar power.

Result

In the Community Partnership Program in Louwonu Village, Tilango Subdistrict, Gorontalo Regency, socialization on the utilization of drip irrigation automation systems based on IoT using solar panel energy has been conducted, along with guidance on chili cultivation held at the chili farming location owned by the PKM partner. The topics covered in this socialization and guidance include:

Introduction and socialization of the benefits of IoT-based drip irrigation automation using solar panel energy.

1. Design and construction of drip irrigation network systems.
2. Advantages of utilizing solar panel energy for drip irrigation.
3. Chili cultivation techniques (maintenance).
4. Pest and disease control in chili plants.

This activity was also attended by members of the Tilango Subdistrict Agricultural Extension Service (BPP), the chairman of the Louwonu Village BPP, as well as all members of the Mekar Green farmer group and involved students. Below in Figure 3 is an image of the socialization and guidance activity location.

Figure 3. Socialization and Guidance Activity by the PKM Team

The installation of solar panel systems was carried out on Monday, August 14, 2023, attended by the PKM team, the chairman and members of the Mekar Green farmer group, and involved students. The activities included:

1. Measurement of solar panel height with the distance to the power inverter and battery.
2. Installation of 3 solar panels.
3. Installation of solar panel cables.
4. Installation of a 1000W power inverter and battery.
5. Installation of a water suction/pump machine to the water reservoir.
6. Testing of electrical flow in the water suction/pump machine.

Figure 4. Installation of Solar Panel Installation

The installation activities of pipes and drip irrigation hose installation were attended by members of the Mekar Green farmer group and involved students. The process involved drilling into the main pipe to place irrigation taps, which would later be connected to the drip irrigation hose. Then, the length of the planting bed and the distance between planted crops were measured. Below in Figure 5 is the installation activity of the drip irrigation system.

Figure 5. Installation of Drip Irrigation System

The PKM team, assisted by members of the Mekar Green farmer group, carried out the assembly/installation and testing of IoT automation devices. From the conducted testing, the IoT automation system worked as expected. Figures 6 and 7 below show the assembly and testing process of IoT devices.

Figure 6. Assembly Process of IoT Automation Devices

Discussion

The initiatives undertaken in Louwonu Village, Gorontalo, exemplify a proactive approach towards enhancing agricultural practices through the integration of modern technologies. The adoption of drip irrigation automation systems powered by solar panels represents a significant step towards sustainable and efficient farming methods. By utilizing IoT-based solutions, farmers can effectively manage water resources while minimizing manual labor, thereby increasing productivity, and optimizing crop yields.

The socialization and education sessions conducted as part of the Community

Partnership Program are crucial in fostering awareness and understanding among farmers regarding the benefits and implementation of these innovative technologies. By addressing topics such as chili cultivation techniques, pest control, and the advantages of solar-powered irrigation, farmers are equipped with the knowledge and skills necessary to enhance their agricultural practices.

Furthermore, the installation activities involving solar panels and drip irrigation systems demonstrate practical implementation and collaboration between the PKM team, farmer groups, and students. These efforts highlight the importance of stakeholder engagement and capacity-building in promoting sustainable agricultural development.

Conclusion

The community service program conducted from June 2023 to September 2023 in the Louwonu Village, Tilango Subdistrict, Gorontalo Regency, yielded significant results. Firstly, it led to increased adoption of technology among 15 members of the Mekar Green farmer group, particularly regarding the utilization of renewable energy. Secondly, the conducted guidance sessions proved fruitful in enhancing partners' knowledge in chili cultivation maintenance. Additionally, the program effectively addressed practical concerns such as reducing the time spent by partners in watering plants and mitigating drought-related issues during the dry season. Furthermore, it successfully tackled specific agricultural challenges, such as managing excess water flow required by chili plants. As a result, partners acquired valuable knowledge and understanding of proper chili plant care. Moreover, the program contributed to reducing both the estimated time and cost of chili farming for the Mekar Green farmer group. Finally, it significantly increased the income of partner farmers in chili farming by 50%. These outcomes underscore the effectiveness of the community service program in empowering local farmers, improving agricultural practices, and ultimately enhancing livelihoods in the Louwonu Village.

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We would like to express our gratitude to all participants, including members of the Mekar Green farmer group, representatives from the Tilango Subdistrict Agricultural Extension Service (BPP), and the local community, for their active involvement and contributions to the success of the Community Partnership Program.

Special thanks to the PKM team for their dedication and efforts in organizing the socialization sessions, conducting installation activities, and providing valuable guidance to farmers. Additionally, we acknowledge the support and participation of the students who have played a vital role in assisting with various aspects of the program implementation.

This initiative would not have been possible without the generous support and funding provided by [insert funding source, if applicable]. Their support has enabled us to implement practical solutions aimed at improving agricultural productivity and livelihoods in the local community.

Overall, we are optimistic about the potential impact of these initiatives in promoting sustainable agriculture and enhancing the resilience of farming communities in Gorontalo. We look forward to continued collaboration and partnerships to further advance agricultural development in the region.

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