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An Internet of Things (IoT)-Based Automatic Watering System Using Sprinklers for Water Efficiency in Kampung Baru Subdistrict

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Abstract: *Agriculture in Kampung Baru Village faces water management challenges due to labor-intensive and inefficient manual irrigation methods, especially on the 3.25 ha horticultural land of the Mekar Tani farmer group. This community service aims to implement an IoT-based automatic watering system using sprinklers with an ESP32 microcontroller and the Thinger.io application to improve water efficiency. Using action research with a participatory community development approach, a purposive sample of 20 farmers from five farmer groups (7,421 people) was taken. Instruments including soil moisture sensors, solenoid valves, sprinklers, and ESP32 integrated monitoring applications were analyzed using qualitative-quantitative descriptive techniques and water efficiency formulas. The results show significant water savings, soil moisture stability, optimal growth of horticultural crops (lettuce, mustard greens, kale, spinach, chilies, tomatoes), and increased farmer capacity through training. In conclusion, the IoT system provides a sustainable smart farming model that can be replicated in rural Jambi for food security.*

Introduction

The horticultural agricultural sector plays a crucial role in supporting national food security and improving the welfare of the Indonesian people, with extensive development potential thanks to the diverse agro-climatic conditions across the region. In Kampung Baru Village, Muaro Tembesi District, Batang Hari Regency, Jambi Province, the "Mekar Tani" farmer group utilizes 3.25 hectares of agricultural land to grow vegetables and fruits, supported by fertile alluvial soil and a strategic location near Jambi City that facilitates harvest distribution [Halawa, 2024][Pamungkas et al., 2023]. The development of digital technologies such as the Internet of Things (IoT) has opened up opportunities for smart farming, where the integration of sensors and microcontrollers enables real-time monitoring of land conditions to support sustainable productivity [Hefri Juanto et al., 2023][Lee & Lee, 2021].

Kampung Baru sub-district, with a population of 7,421, predominantly farmers and traders, faces limited water resources from dug wells with low discharge and distances from the fields, making irrigation management increasingly challenging [Potensi et al., 2017][Rahmawati & Ulum, 2022]. Farmers still rely on manual watering using hoses or buckets, which requires significant labor and time, while labor availability is relatively limited in the area. This conventional method often leads to excessive or uneven watering, resulting in inefficient water use and reduced productivity of horticultural crops such as lettuce, mustard greens, kale, spinach, chilies, and tomatoes [Hefri Juanto et al., 2023][Goap et al., 2021].

The problem is further complicated by the lack of adoption of modern technology at the local level, where farmers struggle to accurately determine crop water needs without real-time soil moisture data, potentially leading to plant stress due to drought or excess moisture [Nawandar & Satpute, 2021]. Furthermore, infrastructure limitations, such as unstable internet connections in rural areas, hinder the implementation of automated systems, although IoT has been shown to reduce water wastage by 30-80% in various similar studies [Kodali et al., 2021].

This study aims to examine the implementation of an IoT-based automatic irrigation system using sprinklers to improve water efficiency in horticultural land in Kampung Baru Village. The urgency of this research lies in the urgent need to transform traditional agriculture into smart farming to overcome resource limitations in rural Jambi, while simultaneously supporting national food security amidst the challenges of climate change.The novelty of this research is the integration of an ESP32 microcontroller with the Thinger.io monitoring application for real-time sprinkler control at the scale of local farmer groups, which has not been widely implemented in the Batang Hari area despite having been successful in other locations such as Minahasa Regency [Hefri Juanto et al., 2023][Pamungkas et al., 2023]

Research Methods

This research adopts a community service approach based on community development and participatory action research, emphasizing collaboration between academics and local communities to address practical agricultural problems [Sugiyono, 2021]. The study focuses on implementing an IoT-based automatic sprinkler irrigation system through stages of socialization, land preparation, system installation, and outcome evaluation to improve water efficiency in horticultural farming in Kampung Baru Village [Creswell & Poth, 2021]. Quantitative data analysis was centered on key indicators, particularly soil moisture levels and comparative water usage before and after system implementation, while qualitative observations assessed system performance and farmer capacity development. This approach supports the sustainable adoption of smart farming technology through direct farmer training and contextual application [Sudaryono, 2022].

The research instruments included IoT hardware such as an ESP32 microcontroller, soil moisture sensor, 1/2-inch solenoid valve, water pump, 1-inch and 1/2-inch PVC pipe, and a 2-meter diameter sprinkler integrated with the Thinger.io monitoring application for real-time control [Emzir, 2021]. Data analysis techniques were carried out descriptively qualitatively and quantitatively, including periodic measurements of soil moisture levels, comparisons of water volume before and after implementation, observations of plant growth (plant height, number of leaves, harvest time), and interviews with farmers to assess increased capacity and work efficiency [Sugiyono, 2021] [Rahmawati & Ulum, 2022]. Data were analyzed using source triangulation to validate the effectiveness of the system, with the water efficiency formula calculated as (Manual water volume - IoT water volume) / Manual water volume × 100% to empirically measure savings [Creswell & Poth, 2021].

The study population was all farmers from five active farmer groups in Kampung Baru Village, with an agricultural land area of 3.25 ha in the "Mekar Tani" group as the main focus, totaling approximately 7,421 people, the majority of whom are horticultural farmers. The sample was determined by purposive sampling of 20 farmers directly involved in the socialization on October 17, 2025, and program implementation, representing farmer groups facing manual irrigation constraints, with inclusion criteria based on willingness to participate and land access [Emzir, 2021]. This sample selection ensures relevant representation for local generalization, in line with sampling strategies in community service research.

The research procedure was carried out in stages over three weeks, starting with program socialization to farmers and village governments to introduce the IoT concept and explore the problems, followed by the creation of beds (20 m long, 70 cm wide, 30 cm high) using a rotary tillage ridger tractor mixed with chicken manure fertilizer at 7 days after planting (DAP) [Pamungkas et al., 2023]. The next stage included the installation of sprinklers with primary water lines from the well to a 1200 L tank, installation of distribution pipes, solenoid valves, and assembly of ESP32 for automatic watering algorithms; sowing seeds (225 lettuce, 225 mustard greens in rockwool; 40 chilies, 40 tomatoes in 6×7 cm polybags); construction of a greenhouse with UV plastic; transplanting seedlings when 4 leaves appear; daily observations including fertilization at 2-3 MST; and harvesting (spinach-kangkung 25-30 days, mustard greens-lettuce 35-40 days, chili-tomato 80-100 days) [Halawa, 2024]. These procedures are systematically documented for final evaluation, ensuring a logical flow from preparation to sustainable impact [Emzir, 2021].

Results and Discussion

Partners

Local Government

University as activity manager

Kampung Baru Village Agricultural Center

Figure 1. Partners

Collaboration with the Association of Agricultural Centers in Kampung Baru Village is a key component of this program's implementation. This collaboration focuses on improving farmers' capacity and skills in implementing IoT-based agricultural systems, particularly in more efficient and sustainable land irrigation management. Through this partnership, communities receive training and direct assistance in the use of digital tools and systems that help monitor land conditions in real time. In addition to strengthening farmers' technical capabilities, this collaboration also fosters a spirit of mutual cooperation, expands networks between farmer groups, and increases community participation in village agricultural development. With the support of the agricultural center, this program is expected to serve as an example of implementing agricultural technology innovation at the village level that encourages resource efficiency and strengthens community independence in a sustainable manner.

Program Socialization

The program socialization was held on Friday, October 17, 2025, at the Kampung Baru sub-district agricultural hall. It was attended by the local community, the head of the agricultural division, and community leaders. The socialization plays a crucial role in ensuring the successful implementation of the program. The socialization serves to:

1. **Increasing Public Understanding and Awareness**

   The outreach program helped village residents understand the basic concepts and benefits of sprinklers and the application of the Internet of Things (IoT), particularly in more efficient water and land management. Through the delivery of clear and practical information, the community realized the potential of this technology in supporting sustainable and environmentally friendly agriculture. This activity also fostered collective awareness of the importance of utilizing modern technology to improve farmer effectiveness and maintain village food security.

2. Encouraging Active Participation

Through outreach, the Kampung Baru community was given the opportunity to directly observe the program and explain the process, from planning to implementation. Effective outreach fosters a sense of ownership and shared responsibility for implementing an IoT-based agricultural system. This active participation is crucial because the program's success depends on community involvement, commitment, and awareness in sustainably managing and utilizing technology to support the village's agricultural progress, especially after the program concludes.

Program Implementation

After conducting community outreach, the next stage is program implementation, which involves creating agricultural media with an IoT-based irrigation system. The automated irrigation installation and land preparation will take approximately 2–3 weeks. The program's activity cycle is outlined in the diagram below:

The process, from equipment preparation to system testing, takes approximately three weeks. Once the media is ready, horticultural crops such as kale and spinach are planted, along with easy-to-cultivate chilies and tomatoes that benefit the community. The implementation of this IoT system allows for automated and efficient irrigation management, saving farmers time, energy, and water usage.

This community service activity was carried out in Kampung Baru Village, Muaro Tembesi District, Batang Hari Regency, Jambi Province. The implementation method was structured in stages to ensure a systematic process and meet the needs of the partners.

The initial phase of the activity began with outreach to farmers and village officials. The outreach aimed to introduce the concept of smart farming and the benefits of an IoT-based automatic watering system, while also exploring the challenges farmers face in water management.

Next, land preparation was carried out by creating raised beds using a rotary tractor. The beds were 20 m long, 70 cm wide, and 30 cm high. To improve soil fertility, organic fertilizer was added, consisting of chicken manure, mixed evenly into the planting medium.

The next step is the installation of an IoT-based sprinkler system. This system consists of a water pump, distribution pipes, sprinklers, solenoid valves, soil moisture sensors, and an ESP32 microcontroller connected to an internet-based monitoring application. The system is designed to automatically water plants based on soil moisture levels.

Seeds were sown using rockwool and polybags for mustard greens, lettuce, chilies, and tomatoes. Water spinach and spinach were planted directly in the beds using the row and rowing method. To support plant growth, a greenhouse was constructed using UV plastic.

Plant growth and irrigation system performance were monitored periodically until harvest. The resulting data was used to evaluate the effectiveness of the IoT-based automatic irrigation system.

Performance of an IoT-Based Automatic Watering System. The implemented automatic watering system consists of a soil moisture sensor, an ESP32 microcontroller, a solenoid valve, a water pump, and sprinklers as a water distribution medium. The soil moisture sensor functions to periodically read the water content in the soil. The moisture data is then sent to the microcontroller for processing and comparison with a predetermined threshold value. If the soil moisture is below the threshold, the system automatically activates the pump and opens the solenoid valve so that the sprinklers water the land. Conversely, when the soil moisture has reached optimal conditions, the system will automatically stop watering.

Based on field observations, the automatic irrigation system operates stably and responds to changes in soil moisture. Watering is no longer performed continuously, as with manual systems, but only when plants truly need water. This demonstrates that IoT implementation can improve the timing and volume of irrigation, resulting in more efficient water use.

Comparison of Conditions Before and After System Implementation

Before the implementation of automatic irrigation systems, farmers watered plants manually using hoses or buckets once or twice daily. This method was highly dependent on labor and time, and often resulted in excessive or uneven watering. Furthermore, it was difficult for farmers to accurately determine crop water needs because it wasn't based on soil moisture levels.

After implementing an IoT-based sprinkler system, the frequency of manual watering can be significantly reduced. Watering is carried out automatically and evenly across all beds, resulting in relatively stable soil moisture. Farmers no longer need to water daily; instead, they can simply monitor the crops using a monitoring app. This change has a positive impact on water efficiency and reduced work time.

Impact on Horticultural Plant Growth

The implementation of an IoT-based automatic watering system has had a positive impact on the growth of cultivated horticultural crops, such as mustard greens, lettuce, kale, spinach, chilies, and tomatoes. The plants exhibited relatively uniform vegetative growth, characterized by greener leaves and a fresher appearance. This demonstrates that adequate water availability plays a crucial role in supporting plant physiological processes, particularly photosynthesis and biomass formation.

Better soil moisture management also helps reduce plant stress caused by water shortages or excesses. Thus, an IoT-based automatic watering system not only functions as a water-saving tool but also as a supporting factor in improving the growth quality of horticultural crops.

1. **Improving Work Efficiency and Farmer Capacity**

   In addition to impacting the technical aspects of cultivation, the implementation of an IoT-based automatic irrigation system also has social and economic impacts for farmers. Farmers experience a reduction in workload, particularly on watering activities, which previously required significant effort and time. This freed up time can be reallocated to other activities, such as plant maintenance, pest and disease control, and other economic activities.

   Through mentoring and hands-on practice, farmers also gain new knowledge about the use of digital technology in agriculture. They begin to understand the working principles of sensors, microcontrollers, and automated control systems. This capacity building is crucial for encouraging the sustainable adoption of smart farming technology at the village level.

2. **Challenges and Constraints in Implementation**

   Although the program went well, several challenges were encountered during its implementation. The main obstacle was farmers' limited initial understanding of IoT technology, necessitating more time and intensive mentoring in the initial stages. Furthermore, unstable internet connectivity also posed a challenge to online monitoring.

   However, these obstacles can be overcome through a participatory approach and ongoing mentoring. Farmers are directly involved in the system installation and operation process, enabling them to understand and master the technology being implemented.

Conclusion

The implementation of an Internet of Things-based automatic watering system using sprinklers in Kampung Baru Village has significantly increased water use efficiency, reducing manual watering frequency from twice a day to automatic watering based on real-time soil moisture data via an ESP32 microcontroller and the Thinger.io application, thereby maintaining stable land conditions and supporting optimal growth of horticultural crops such as lettuce, mustard greens, kale, spinach, chilies, and tomatoes (Halawa, 2024; Hefri Juanto et al., 2023). Key findings indicate water savings achieved better levels compared to conventional methods, reduced farmer workload, and increased capacity through participatory training involving five farmer groups and the local agricultural center, all of which contributed to the productivity of 3.25 hectares of land in the Mekar Tani group (Pamungkas et al., 2023; Rahmawati & Ulum, 2022). Practical implications include a smart farming model that can be replicated in rural Jambi for local food security.

However, limitations of this study lie in the reliance on unstable internet networks in rural areas and the farmers' initial understanding of IoT, which requires intensive support beyond the planned three weeks. Consequently, the system's scalability across larger areas has not been thoroughly tested (Potensi et al., 2017; Sugiyono, 2021). For future research, it is recommended to integrate solar panels to address electricity dependence, expand monitoring with additional sensors such as soil pH and nutrient levels, and conduct longitudinal trials over a full growing season to measure the long-term economic impact on farmer incomes (Creswell & Poth, 2021; Sudaryono, 2022).

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