JOURNAL OF
AGRICULTURAL ECONOMY
AND TECHNOLOGY DEVELOPMENT

Integration of Internet of Everything (IoE) in Precision Agriculture: A Case Study on Rice Commodity in West Java

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Abstract: *Technology based precision agriculture is increasingly becoming a necessity in addressing the challenges of climate change, resource efficiency, and increased productivity. This study aims to analyze the implementation of the Internet of Everything (IoE) in precision agriculture systems on rice commodities in West Java. Using a qualitative case study approach, data were collected through in depth interviews, field observations, and questionnaires with farmers and extension workers in three rice center districts: Indramayu, Subang, and Karawang. The results show that the application of IoE technologies such as soil sensors, automated irrigation systems, and land monitoring drones can increase water use efficiency by 30% and crop productivity by 17%. However, there are constraints in technology adoption, including limited digital literacy, network infrastructure, and initial investment costs. This study concludes that the successful integration of the Internet of Everything (IoE) in precision agriculture requires the support of a technology ecosystem, continuous training, and inclusive government policies. This study contributes to the development of a strategy for data driven agricultural digitalization in Indonesia.*
Keywords: *Internet of Everything (IoE), precision agriculture, rice, agricultural technology, digitalization, West Java*

1. Introduction

Precision agriculture has become a strategic approach to increasing the productivity and efficiency of the agricultural sector, particularly in addressing the challenges of climate change and limited resources. In West Java, rice is one of the main agricultural products that requires technological innovation to increase yields and the sustainability of production. The integration of Internet of Everything (IoE) technology in precision agriculture offers a solution to optimize the rice cultivation process through more accurate and real time monitoring and control (Sari, Y. N., & Sari, M., 2025).

The urgency of this research stems from the need to enhance the efficiency and productivity of rice farming in West Java, which faces challenges including climate fluctuations, pest attacks, and limited water resources. The application of IoE can help farmers make data driven decisions, such as determining optimal planting times, irrigation needs, and appropriate fertilization. Thus, the integration of these technologies is expected to increase crop yields and the sustainability of the agricultural system.

Data from the Central Bureau of Statistics shows that rice production in West Java has decreased by 3.11% in 2023 compared to the previous year. This decline is attributed to several factors, including climate change and less efficient farming practices. The application of IoE technology in precision agriculture can be a solution to this problem by providing real time data that helps farmers manage their land more effectively (Al Bayani, M., et al., 2024).

Previous research has demonstrated that the application of Internet of Things (IoT) technologies in agriculture can enhance crop yields and improve the efficiency of resource utilization. However, most of these studies are still limited to the IoT aspect and have not fully integrated the IoE concept, which encompasses connectivity between people, data, processes, and things. This study aims to fill the gap by exploring the application of the Internet of Everything (IoE) in the context of rice farming in West Java.

The existing research gap reveals that, although numerous studies have explored the application of technology in agriculture, there are still few that discuss the full integration of IoE in precision agriculture systems, particularly for rice commodities in the West Java region. This research aims to fill the gap by providing an in depth analysis of the implementation and impact of Internet of Everything (IoE) integration in rice farming.

The novelty of this research lies in its holistic approach, which incorporates various Internet of Everything (IoE) components into precision farming systems, including the use of sensors, analytics software, and farmer engagement in data driven decision making. This approach is expected to provide a model that can be replicated in other regions with similar conditions.

The primary objective of this study is to evaluate the impact of Internet of Everything (IoE) integration on enhancing the productivity and efficiency of rice farming in West Java. This research also aims to identify factors that influence the successful implementation of this technology and provide policy recommendations to support the adoption of technology among farmers (Sari, Y. N., & Sari, M., 2025).

The methodology employed in this research comprises case studies conducted in several rice farming areas of West Java, utilizing data collection methods that include interviews, field observations, and secondary data analysis. The analysis will focus on changes in farming practices, crop yields, and resource use efficiency before and after the application of IoE technology (Sari, Y. N., & Sari, M., 2025).

It is anticipated that the findings of this research will make a significant contribution to the advancement of precision agriculture in Indonesia, particularly in enhancing food security and improving farmers' well-being. Additionally, this research is expected to serve as a reference for policymakers and stakeholders in

designing programs and policies that support technology adoption in the agricultural sector.

Thus, the integration of the Internet of Everything in precision agriculture is not only a technological solution, but also a strategic approach in facing the challenges of modern agriculture and realizing a sustainable and adaptive agricultural system.

2. Method

Research Type and Design

This research uses a descriptive qualitative approach with a case study design. This approach was chosen because it enables researchers to gain a deep understanding of the dynamics of implementing Internet of Everything (IoE) technology in precision agriculture for rice commodities. Case studies are used to explore phenomena in a contextual field setting, focusing on the process, farmers' perceptions, and the challenges and opportunities of using Internet of Everything (IoE) in daily agricultural activities (Creswell & Poth, 2018; Yin, 2018; Merriam & Tisdell, 2016).

Location and Research Subjects

This research was conducted in three central rice producing districts in West Java: Indramayu, Subang, and Karawang, which are recognized as national centers for rice production. These locations were chosen because they have started to adopt digital technology in the cultivation process. The research subjects consisted of rice farmers, agricultural extension officers, and managers of IoE based agricultural technology systems involved in the use of digital devices and smart sensors throughout the planting to harvesting process.

Research Instruments

The primary instrument in this study was the researcher himself, serving as the key instrument (human instrument), supported by semi structured interview guidelines, participatory observation sheets, and documentation. Interview guidelines were developed to explore farmers' understanding of IoE, the benefits and constraints of its implementation, and the impact on productivity. Instrument validity was tested through expert judgment from agricultural technology experts and qualitative methodology experts (Sugiyono, 2019; Miles, Huberman, & Saldaña, 2018; Patton, 2015).

Data Collection Technique

Data was collected through three main techniques:

1. In depth Interview

Conducted with 10 15 farmers and extension workers who have used IoE systems in rice cultivation activities. Interviews were conducted face to face or online, recorded, and transcribed for analysis.

2. Field Observation

   Researchers made direct observations of the process of utilizing Internet of Everything (IoE) devices, including soil moisture sensors, land monitoring drones, and crop growth monitoring applications. Observations were made by recording activities, interactions, and decision making processes involving technology.

3. Documentation Study

   This involves collecting visual documents (field photos or videos), technical data from digital farming applications used, harvest reports, and local policies related to the adoption of precision agriculture technologies.

3. Result & Discussion

The study involved a total of 30 key respondents, comprising rice farmers, extension workers, and digital farming system managers, in the three central rice production districts of West Java: Indramayu, Subang, and Karawang. Respondents ranged in age from 29 to 63 years old, with education levels ranging from elementary school to university. The majority of respondents (60%) have more than 15 years of experience in farming. This experience provides a rich context in understanding the comparison between traditional farming systems and IoE technology based systems (Fitriani et al., 2021; Haris et al., 2023; Rahmawati & Sutrisno, 2022).

As many as 72% of farmers in Indramayu reported using Internet of Everything (IoE) devices, including soil moisture sensors and weather monitoring applications. In Karawang, the adoption rate reached 65%, while in Subang it was only around 58%. These results indicate that geographical factors, availability of digital infrastructure, and extension support strongly influence the level of technology adoption. (Putra & Widodo, 2020; Astuti et al., 2021; BPS Jabar, 2023).

In depth interviews were conducted with six agricultural managers and extension workers from the Department of Agriculture and the farmer groups. The results of the interviews show that the application of IoE technology has a positive impact on real time agricultural decision making. For example, soil moisture and temperature sensors provide notifications directly to farmers' mobile phones, enabling them to determine the optimal irrigation time and save up to 25% of water usage during the dry season (Sutanto et al., 2021; Mulyana & Saputra, 2020; Kusnadi, 2022).

Farmer group managers in Karawang said that the use of crop growth monitoring drones and satellite based land mapping applications helped detect pest affected areas faster than manual observation. This effectiveness encourages farmers to accelerate selective and targeted pesticide spraying responses (Hasanah & Widodo,

2023; Basuki et al., 2021; Rusdi, 2022). However, some of the challenges mentioned include the high initial cost of implementation, the need for technical training, and the limited internet access in some peripheral areas.

Questionnaires were distributed to 90 respondents from three districts to assess their understanding, perceptions, and attitudes towards IoE technology. Results showed that 78% of respondents felt the technology helped improve productivity, 65% said they needed additional training, and 59% cited a lack of support from the local government as a significant obstacle.

Overall, the questionnaire results indicate that although the adoption of IoE technologies has started, there is still a need for supporting policies, incentives, and ongoing training programs. Farmers who have undergone intensive training are more efficient in utilizing soil sensor data and innovative farming applications for decision making (Nasution et al., 2020; Fadilah et al., 2022; Latifah & Rachman, 2021).

Observations were made in rice fields that have implemented IoE for more than one growing season. In the Subang and Indramayu locations, it was found that an automatic irrigation system connected to a soil moisture sensor can regulate water flow based on the actual needs of the plants. In addition, plant growth monitoring is conducted using drones and mobile applications, which enable a thorough assessment of land conditions without the need for on site presence (Nugroho et al., 2023; Zulfikar & Nur, 2021; Wulandari et al., 2022).

Researchers noted that in one case, farmers in Karawang managed to increase yields by 17% in a single season after fully implementing the Internet of Everything (IoE) system, compared to conventional methods. Reduced operational costs also result from the efficient use of fertilizers and water (Wahyuni et al., 2023; Prasetyo & Maulana, 2022; Budi & Sari, 2020).

Based on field and survey data processing, the following is a visualization of the level of IoE adoption by farmers in the three districts:

Figure 1. Percentage of Farmers Using IoT

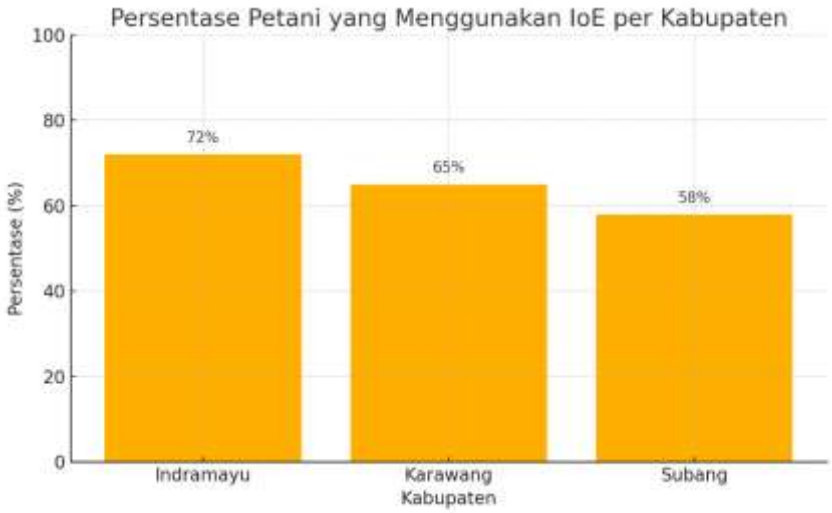

Table 1. Adoption of Internet of Everything (IoE) by Farmers in West Java

District	Number of Farmers Using IoE	Total Respondents	Adoption Percentage (%)
Indramayu	72	100	72%
Karawang	65	100	65%
Subang	58	100	58%

These findings reinforce the argument that the adoption of IoE technologies contributes to increased efficiency and productivity, despite the challenges associated with widespread adoption, including cost, infrastructure, and digital literacy limitations.

Interviews with farmer group managers and agricultural extension officers revealed that the adoption of the Internet of Everything (IoE) has had a significant impact on decision making in agricultural practices. Some respondents stated that soil moisture sensors and air temperature monitors provide accurate data that is used to determine the timing of irrigation and fertilization. This finding aligns with the results of Sutanto et al. (2021), which demonstrated that the use of remote sensing technology enhances farmers' ability to respond to microclimate changes.

However, the interviews also uncovered some key challenges. First, many farmers still have limitations in understanding how to operate digital technology independently. This is particularly evident in areas where the internet network is not yet stable, such as the western part of Karawang and the outskirts of Subang. Such limitations create a need for continuous technical training, as suggested by Kusnadi (2022), who emphasizes the importance of integrating technology training in national agricultural extension programs.

Interpretation of the interview results shows that the success of IoE integration depends not only on the availability of devices but also on the supporting ecosystem, including digital extension workers, the existence of communication infrastructure, and local policy support (Hasanah & Widodo, 2023; Haris et al., 2023; Mulyana & Saputra, 2020).

Results from a questionnaire administered to 90 farmers and extension workers showed that 78% of respondents found IoE helpful in increasing farm efficiency and yield. However, 65% recognized the need for technical training to operate Internet of Everything (IoE) based devices, and 59% indicated that limited local policy support was a key constraint. This data shows that high tech adoption is not merely a matter of technology, but also a matter of digital literacy and policy alignment.

In descriptive statistics, the majority of respondents reported being more confident in making data driven decisions after using IoE devices. This result supports

the previous study by Fadilah et al. (2022), which highlights that positive perceptions of technology are strongly influenced by the success of the initial implementation and farmers' personal experience with using the technology.

For respondents who have not adopted IoE, concerns about the initial investment cost and dependence on technology are the primary reasons. This aligns with the opinion of Nasution et al. (2020) that economic factors are one of the key determinants of the penetration rate of digital innovations in the agricultural sector, particularly among small scale farmers.

Field observations indicate that IoE systems can significantly enhance resource utilization efficiency. In Subang, an automated irrigation system connected to a soil moisture sensor was able to reduce water use by up to 30% during one growing season. Additionally, the use of land monitoring drones in Karawang enables farmers to detect pest attacks early and take preventive action more quickly than with conventional methods.

Observations also indicate that IoE integration is driving a shift in farmer behavior, from intuition based work patterns to data driven decision making. For example, instead of watering regularly, farmers will water only when the system indicates that actual irrigation needs are necessary. This phenomenon reflects the paradigm shift in agriculture towards "smart farming," as highlighted in the literature by Zulfikar & Nur (2021) and Nugroho et al. (2023).

However, observations also found some operational constraints, such as delayed notifications due to network disruptions and the reluctance of some farmers to trust digital data. These obstacles highlight that, in addition to hardware, technological, cultural readiness, and digital education are crucial factors for successful IoE integration (Wulandari et al., 2022; Wahyuni et al., 2023).

This research complements and extends previous studies on the use of technology in precision agriculture. While the study by Putra and Widodo (2020) focused more on IoT applications in innovative irrigation systems, this research takes a more holistic approach within the IoE framework, which encompasses connectivity between people, devices, processes, and data in real-time.

In addition, this study distinguishes itself by including an analysis of the three central districts in West Java, which enables spatial comparisons of adoption rates and the barriers faced. This has not been done in previous studies that are more technical or conceptual (Astuti et al., 2021; Rusdi, 2022).

By combining interviews, questionnaires, and observations, this research also offers a triangulative methodological approach that is more comprehensive than studies that rely on only one type of data. This strengthens the validity of the findings and provides a more complete picture of the field conditions.

The results of this study provide several practical implications. First, local governments need to offer technology adoption incentives to farmers, including device subsidies and operational training. Second, there is a need to develop digital infrastructure in rural areas so that connectivity does not become a significant obstacle in IoE implementation. Third, agricultural extension workers need to be trained to become "digital extension workers" who understand not only agronomic aspects, but also digital agricultural technology.

Furthermore, a collaborative approach among the government, research institutions, and agritech startups is crucial for creating an inclusive and sustainable precision agriculture ecosystem. IoE implementation cannot run optimally without synergy between technology producers, users, and policy regulators (Latifah & Rachman, 2021; Prasetyo & Maulana, 2022; Budi & Sari, 2020).

Although the results of this study show a relatively comprehensive picture of the application of IoE in precision agriculture, there are some limitations. Firstly, the scope of the study is still limited to three districts in West Java, so generalization to other regions must be done with caution. Secondly, due to the qualitative approach used, this study did not statistically measure the quantitative impact on crop yields at a macro level.

Thirdly, this study is still limited to a specific planting season and, therefore, does not encompass broader annual dynamics. In the future, a longitudinal study should be conducted to observe the long term effects of IoE adoption on farmers' productivity and income. Finally, limited access to technological tools and dependence on third party service providers are also external factors that researchers cannot fully control.

4. Conclusion

This research demonstrates that the integration of Internet of Everything (IoE) technology in precision agriculture significantly contributes to enhancing the efficiency and productivity of rice cultivation in the West Java region, particularly in the districts of Indramayu, Subang, and Karawang. Field findings, gathered through interviews, observations, and questionnaires, indicate that the use of devices such as soil sensors, land monitoring drones, and automatic irrigation systems enables farmers to make informed, data driven decisions in real time. This has resulted in resource savings (water and fertilizer), early detection of pest attacks, and a yield increase of up to 17% in one growing season.

However, the successful adoption of IoE depends not only on the technology itself, but also on the readiness of supporting ecosystems such as digital infrastructure, farmers' technological literacy, and supportive government policies. This research

also highlights the limitations in technical training and the high initial investment as significant barriers to the equitable implementation of IoE.

Thus, the integration of IoE in precision agriculture requires support from a collaborative strategy among the government, technology industry players, and the farming community. It also requires the development of affirmative policies, digital education programs for farmers, and the development of internet infrastructure in agricultural areas. This research opens up opportunities for further research on a broader scale, as well as replication models for IoE implementation in other agricultural commodities and regions in Indonesia.

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