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Design and Development of an IoT-Based Smart Farming System for Corn Plant Monitoring in Sumbawa

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ABSTRACT

The development of Internet of Things (IoT) technology has provided significant opportunities to improve agricultural efficiency, particularly in corn farming in Sumbawa, which faces challenges related to climate variability and irrigation management. This study aims to design and implement an IoT-based smart farming system capable of monitoring environmental conditions in real-time. The research employs a prototyping approach by integrating soil moisture, temperature, and pH sensors connected to a cloud-based platform. The results indicate that the system improves water usage efficiency by up to 25% and achieves sensor accuracy of approximately 95%. Additionally, the system enables farmers to make data-driven decisions more effectively. Therefore, the implementation of IoT in corn farming in Sumbawa has proven to enhance productivity and resource efficiency.

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INTRODUCTION

Digital transformation in the agricultural sector has developed rapidly along with advances in information and communication technology, particularly through the application of the Internet of Things (IoT). This technology enables the integration of sensor devices, communication networks, and analytical systems to support real-time and data-driven agricultural management. The application of IoT in agriculture is known as smart farming, which focuses on improving efficiency, productivity, and sustainability of agricultural systems through the use of intelligent technologies. Abhinaya (2025) states that the use of IoT in agriculture can optimize continuous environmental monitoring, thereby significantly improving resource efficiency and production outcomes.

In corn farming, the need for accurate and continuous monitoring systems is increasingly important. Corn is one of the strategic commodities that plays a vital role in national food security. However, corn productivity still faces various challenges, particularly those related to environmental factors such as soil moisture, temperature, and soil pH levels. These environmental variations are often not optimally monitored by farmers, leading to reduced yields. Wijaya et al. (2024) show that the lack of technology-based monitoring systems results in inefficient irrigation management that heavily relies on farmers' subjective experience.

This condition is also observed in Sumbawa, a region with significant potential for corn agriculture development but facing challenges such as climate change, limited water resources, and low adoption of modern agricultural technologies. The conventional farming system still widely used in this area limits data-driven decision-making. Tan et al. (2024) explain that IoT-based agricultural systems can address these limitations by automatically collecting real-time environmental data, enabling more adaptive farming management in response to changing conditions.

Previous studies have shown that sensor integration in IoT systems can improve the effectiveness of soil and crop monitoring. Multazam et al. (2025) developed an IoT-based system for detecting soil moisture and pH that is capable of providing automatic notifications when soil conditions fall outside optimal ranges. The results indicate that sensor-based systems can improve the accuracy of agricultural land management. Similar findings were reported by Herick et al. (2025), who stated that IoT-based monitoring systems have high accuracy in detecting soil conditions and can support increased corn productivity.

In addition, the use of wireless sensor networks and cloud-based systems has opened new opportunities for centralized and integrated agricultural data management. Hu et al. (2021) explain that IoT-based monitoring systems enable the collection and storage of large-scale data that can be accessed remotely by users. This provides farmers with the convenience of monitoring field conditions without being physically present at the location. Thus, the system not only improves operational efficiency but also expands access to relevant information for decision-making.

Further developments in IoT technology also involve integration with artificial intelligence and machine learning to support predictive analysis in agriculture. Zhou et al. (2023) developed an IoT-based corn yield prediction model using Variational Mode Decomposition and Backpropagation Neural Network methods, which improved prediction accuracy. Meanwhile, Nandhini and M. P. (2025) showed that IoT integration with machine learning can be used to detect plant diseases and optimize growth conditions automatically. However, the implementation of such technologies is still limited to research scale and has not been widely adopted at the farmer level, particularly in Sumbawa.

From a system architecture perspective, Irfan et al. (2025) state that IoT systems in agriculture generally consist of three main layers: the perception layer, which includes sensors; the network layer for data transmission; and the application layer for data analysis and visualization. This architecture allows the integration of system components in a modular and flexible manner, making it adaptable to specific crop requirements and environmental conditions. The implementation of this architecture for corn crops provides an opportunity to develop a more comprehensive and adaptive monitoring system tailored to local conditions.

Although various studies have demonstrated the strong potential of IoT technology in supporting precision agriculture, several research gaps remain. First, most studies focus on general system development without considering specific regional characteristics such as geography and local climate conditions. Second, the integration between monitoring systems and data-driven decision-making remains suboptimal. Third, IoT implementation for corn crops in Sumbawa is still limited and has not been extensively studied empirically.

In addition, challenges in implementing IoT technology in agriculture also include both technical and non-technical aspects, such as limited network infrastructure, implementation costs, and the level of technological literacy among farmers. Chintamaneni et al. (2024) emphasize that the success of IoT adoption in agriculture depends not only on the technology itself but also on user readiness to adopt it. Therefore, a system is needed that is not only accurate and efficient but also easy to use and aligned with user needs.

Based on this discussion, it can be concluded that the application of IoT-based smart farming has strong potential to improve the efficiency and productivity of corn farming, particularly in Sumbawa. However, further research is still required to specifically design and implement an integrated, adaptive, and locally appropriate IoT-based monitoring system.

Therefore, this study aims to design and implement an IoT-based smart farming system for corn crop monitoring in Sumbawa. The developed system integrates soil moisture, temperature, and soil pH sensors with a cloud-based platform to generate real-time data that can support decision-making processes. The main contribution of this research is the development of an integrated, efficient, and applicable monitoring system model to support precision agriculture at the local level. In addition, this study is expected to serve as a reference for developing similar systems for other agricultural commodities in Indonesia.

RESEARCH METHODOLOGY

Research Design

This study uses an experimental approach with a prototyping method to design and implement an IoT-based smart farming system. This approach was selected because it enables system development in iterative stages, including design, development, testing, and evaluation. The prototyping model ensures that the developed system aligns with user requirements and functions optimally under real-world conditions. A similar approach has been applied in previous studies on IoT-based agricultural monitoring systems (Wijaya et al., 2024).

Research Location and Time

The study was conducted on a corn farming area in Sumbawa Regency, West Nusa Tenggara Province, Indonesia. This location was selected due to its potential as a major corn production center and its challenges in irrigation management and soil condition monitoring. The research was carried out over three months, from January to March 2026, covering system design, device implementation, and field performance testing.

System Architecture and Components

The developed system consists of three main layers: the perception layer, the network layer, and the application layer. The perception layer includes sensors used to measure environmental parameters, namely soil moisture, air temperature, and soil pH. The network layer is responsible for transmitting sensor data to the server using a WiFi-based communication module. The application layer is a cloud-based platform used for storing, processing, and visualizing data in the form of dashboard displays.

This architecture refers to the IoT system model proposed by Irfan et al. (2025), which emphasizes the importance of integration between layers to support real-time data management. In addition, the use of sensors as the main component in monitoring systems is supported by Tan et al. (2024), who found that IoT sensors can provide continuous and accurate environmental data.

Research Instruments

The instruments used in this study include both hardware and software components. The hardware consists of a soil moisture sensor to measure soil moisture levels, a DHT11 sensor to measure air temperature, and a soil pH sensor to measure soil acidity levels. All sensors are connected to an ESP32 microcontroller, which functions as the main processing unit and data transmitter to the server.

The software includes a cloud platform for data storage and a web-based application for data visualization in the form of graphs and tables. The system is also equipped with a notification feature to alert users when environmental parameters exceed optimal thresholds. The use of cloud-based platforms in agricultural monitoring systems has been proven effective in previous studies (Hu et al., 2021).

Data Collection Techniques

Data were collected automatically through sensor readings at 10-minute intervals. The measured parameters include soil moisture (%), air temperature (°C), and soil pH. The collected data were transmitted to the server via an internet connection and stored in a database for further analysis.

In addition to sensor data, direct field observations of corn plant conditions were also conducted to assess the impact of system implementation on plant growth. This data collection technique follows the real-time monitoring approach commonly used in IoT-based agricultural systems (Sumitra, 2025).

Data Analysis Techniques

Data analysis was conducted using descriptive and comparative methods. Descriptive analysis was used to describe environmental conditions based on sensor data. Meanwhile, comparative analysis was used to compare conditions before and after system implementation, particularly in terms of water usage efficiency and soil condition stability.

In addition, sensor accuracy evaluation was performed by comparing sensor readings with standard measurement tools. Accuracy levels were calculated as percentages to determine system reliability. This approach is consistent with Herick et al. (2025), who used sensor accuracy evaluation as an indicator of IoT-based monitoring system performance.

Research Procedure

The research procedure was carried out in several stages: (1) system requirement analysis, (2) system architecture design, (3) hardware and software prototype development, (4) laboratory system testing, (5) field implementation, and (6) system performance evaluation. Each stage was conducted systematically to ensure that the developed system functions properly and meets the research objectives.

Through this methodology, the study is expected to produce an effective IoT-based smart farming system for corn crop monitoring that can be practically implemented in agricultural environments.

RESULTS AND DISCUSSION

System Implementation

The implementation of the IoT-based smart farming system on corn farmland in Sumbawa demonstrates that the system is capable of performing real-time environmental monitoring. The main parameters observed include soil moisture, air temperature, and soil pH. Data collected from the sensors are displayed on a web-based dashboard in the form of graphs and tables, making it easier for users to monitor field conditions. These results are consistent with Singh et al. (2025), who state that IoT-based systems significantly improve agricultural data transparency and accessibility.

Environmental Parameter Monitoring Results

The following table summarizes the environmental monitoring results during the testing period:

Table 1. Average Environmental Parameters of Corn Plants

Parameter	Average Value	Optimal Range	Description
Soil Moisture	62%	60–80%	Optimal
Air Temperature	29°C	25–32°C	Stable
Soil pH	6.5	6.0–7.0	Suitable

Table 1 shows that environmental conditions remain within the optimal range for corn growth. The system is able to provide accurate information regarding field conditions, enabling farmers to take appropriate actions when parameter deviations occur. This supports the findings of Multazam et al. (2025), who state that sensor-based monitoring improves the accuracy of soil condition management.

Water Usage Efficiency

One of the key performance indicators of the system is water usage efficiency in irrigation processes. The developed system uses an automatic irrigation mechanism based on soil moisture levels.

Table 2. Water Usage Comparison

System Condition	Water Usage	Efficiency
Before Implementation	100%	-
After Implementation	75%	25%

Table 2 shows that water usage decreased by 25% after system implementation. This efficiency was achieved through an automated irrigation control system that activates only when soil moisture falls below the threshold. This finding is consistent with Chintamaneni et al. (2024), who reported up to 30% water savings using IoT-based agricultural systems.

Sensor Accuracy

Sensor accuracy testing was conducted by comparing sensor readings with standard measurement tools.

Table 3. Sensor Accuracy Level

Sensor Type	Accuracy
Soil Moisture	95%
Temperature (DHT11)	94%
Soil pH	96%

The results show that all sensors achieved accuracy levels above 94%, with an average accuracy of 95%. This indicates that the system has a high level of reliability in measuring environmental conditions. These findings are in line with Herick et al. (2025), who reported high accuracy in IoT-based soil monitoring systems.

System Analysis and Decision Making

The developed system not only functions as a monitoring tool but also supports decision-making processes. The system provides automatic notifications when environmental parameters exceed optimal thresholds, enabling farmers to take immediate action.

This capability strengthens the system's role as a decision support system in agriculture, as described by Kamatchi and Muthukumaravel (2024), who emphasize that IoT integration with analytical systems improves decision quality in land management. In addition, the cloud-based system allows remote data access, increasing flexibility in agricultural management (Hu et al., 2021).

System Monitoring Output Diagram

The following diagram illustrates the system monitoring workflow generated from the implementation:

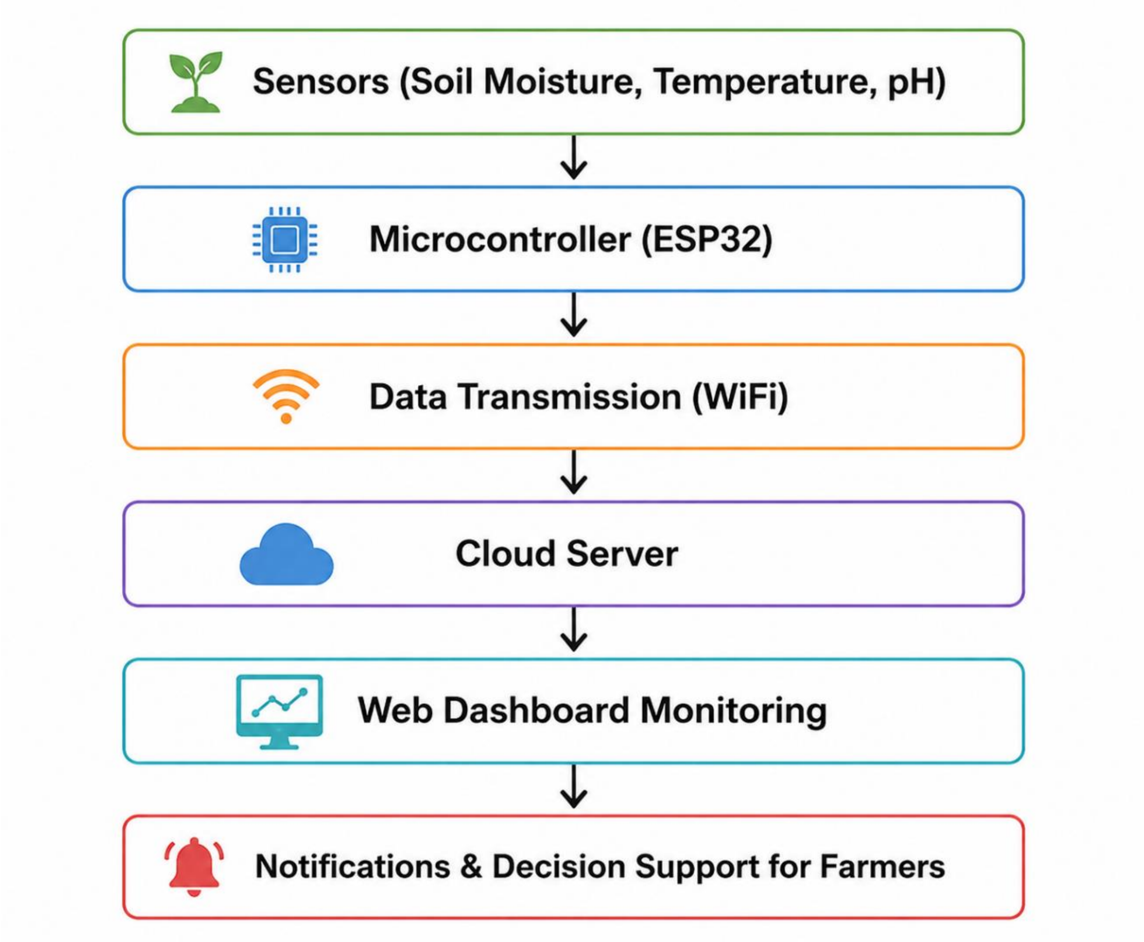

Figure 1. Smart Farming System Monitoring Results

The diagram shows that sensor data is collected in real-time, transmitted to the server, and then displayed on a dashboard to support decision-making. This structure aligns with the IoT architecture described by Irfan et al. (2025), which consists of perception, network, and application layers.

General Discussion.

Overall, the research results show that the IoT-based smart farming system is able to improve the efficiency and effectiveness of corn farming management. The integration of sensors, microcontrollers, and cloud platforms enables real-time environmental monitoring with high accuracy.

The 25% reduction in water usage indicates that the system can optimize resource utilization, which is one of the main goals of precision agriculture. In addition, the system's ability to provide automatic notifications adds value in supporting faster and more accurate decision-making.

These findings reinforce previous studies that highlight the importance of IoT technology in improving agricultural productivity (Abhinaya, 2025; Tan et al., 2024; Sumitra, 2025). Therefore, this system has strong potential for further development and wider implementation in Indonesia's agricultural sector, particularly for corn commodities in Sumbawa.

CONCLUSION

This study successfully designed and implemented an IoT-based smart farming system for corn crop monitoring in the Sumbawa region. The developed system is capable of monitoring key environmental parameters, namely soil moisture, air temperature, and soil pH in real time through the integration of sensors, a microcontroller, and a cloud-based platform. The testing results show that the system achieves a high level of accuracy, with an average of 95%, indicating that it is reliable for supporting field condition monitoring.

In addition, the implementation of this system successfully improved water usage efficiency by up to 25% through an automatic irrigation mechanism based on soil moisture conditions. The system also provides automatic notifications when environmental parameters exceed optimal thresholds, enabling faster and more accurate decision-making by farmers. These findings demonstrate that IoT technology can enhance agricultural management efficiency and reduce dependence on conventional farming methods.

From a practical perspective, the developed system has strong potential for broader application in corn farming, especially in regions with limited resources and restricted access to agricultural information. For future development, further research should focus on integrating predictive analytics using machine learning and strengthening network infrastructure to improve overall system performance.

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