Development of Mobile Application for Irrigation System in Smart Farming

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Abstract− The agricultural sector plays a vital role in supporting national food security. However, irrigation management, which is still carried out manually, often leads to various problems such as water wastage, suboptimal watering, and the significant time and labor required by farmers to monitor land conditions. Advances in Internet of Things (IoT) technology offer an opportunity to improve the efficiency of irrigation management through automated monitoring and control systems. This study aims to develop an Android-based smart irrigation system application for agriculture that can assist farmers in monitoring land conditions and controlling the irrigation system remotely. The development method used is the Prototype method; the prototype method is a system development approach consisting of the stages of communication, rapid planning, design, prototyping, and testing. The application was developed using Flutter and Firebase Realtime Database and integrated with IoT devices to display soil moisture data, control irrigation pumps, display watering history, and provide real-time weather information. System testing was conducted using Black Box Testing to test the application's functionality and the System Usability Scale (SUS), which involved 10 respondents to evaluate the application's usability. The research results indicate that the application was successfully developed and is capable of connecting to the IoT system in real-time, thereby aiding the process of land monitoring and irrigation management more effectively and efficiently.

Keywords: Smart Irrigation; Android App; Internet of Things; Firebase Realtime Database; Flutter.

1. Introduction

The agricultural sector is one of the main pillars of national food security (Abrar & Tukino, 2023). Agriculture currently plays a strategic role as a supplier of raw food materials in Indonesia; therefore, Indonesia is referred to as an agrarian country (Putri et al., 2024). Meanwhile, according to Panunggul et al. (2023), agriculture is the use of natural resources by humans through various productive plant cultivations that can be developed throughout life. One of the most important historical milestones in agricultural development was the discovery of water-based agriculture or irrigated agriculture. The role of farmers is very important in meeting the food needs of the community. However, problems that still arise today include measuring the amount of water, managing farmers' time in managing agricultural land, and especially in the aspect of water management or irrigation (Hasibuan, 2023). Manual irrigation systems are still widely used by farmers in villages, which tend to be ineffective, because they require a large workforce and are certainly time-consuming. Given these problems, smart farming can help utilize the application of information and communication technology in agriculture to assist farmers in increasing productivity and the community's economy (Irianto, 2022a).

Water use in the agricultural sector presents a serious challenge for farmers, especially in areas with limited water availability (Anggraini et al. 2025). Uncontrolled water use can reduce agricultural productivity. Plants lacking water experience stress, which can hinder growth, while plants receiving too much water can potentially experience root rot. Therefore, solutions are needed to help farmers manage water supply according to plant needs, in a timely manner, and with the right amount of water.

According to Anggraeni et al. (2024), irrigation is an important part of the agricultural system, especially for areas with excessively high or prolonged rainfall. With ideal irrigation and soil moisture, plant growth and development can take place perfectly. There are several irrigation methods, namely surface irrigation, subsurface irrigation, sprinkler irrigation, and drip irrigation (Budiman et al. 2024). The irrigation system commonly used by farmers in Indonesia is surface irrigation. Surface irrigation is an irrigation system that distributes water to agricultural land following the earth's gravitational force, namely water will flow from higher ground to lower ground (Haris et al. 2022).

The development of Internet of Things (IoT) technology opens opportunities for solutions in the form of smart irrigation systems. Agricultural technology is expected to provide tangible benefits in Indonesian agriculture, including increasing plant growth and productivity and improving soil fertility. The potential of the Internet of Things in agriculture aims to help increase crop yields and time efficiency for farmers with more modern technology (Dianta & Winarto, 2025). In addition to being applied to irrigation systems, IoT technology has also been used in the concept of smart agriculture to support the automation of various agricultural activities. The development of the FARMEYE-AI system based on Edge AI and IoT, which can monitor rice fields and controlling pests automatically, shows that the integration of IoT and artificial intelligence can increase the effectiveness of agricultural land management and reduce reliance on manual monitoring by farmers (Wicaksana & Irianto, 2026). Long Range (LoRa) technology in Internet of Things (IoT)-based agricultural irrigation systems can be applied in agriculture. Research results show that LoRa can support long-distance communication on agricultural land with low power consumption, making it suitable for the implementation of real-time irrigation monitoring and control systems (Irianto, 2022b). These findings suggest that integrating wireless communication technology into smart irrigation systems can improve the effectiveness of monitoring agricultural land conditions. With soil moisture sensors connected to a microcontroller and an Android application, farmers can monitor land conditions in real time and automatically regulate watering wherever they are. According to Ariawan (2024), smart irrigation systems can reduce water consumption by up to 30% compared to conventional irrigation methods without sacrificing crop productivity.

IoT technology has been widely developed in various sectors. The potential for IoT-based applications is vast; almost all aspects of life and industry utilize IoT-based applications (Djamen & Kamasi, 2025a). However, the implementation of IoT in the form of applications that are easy to use by users, especially farmers, is still very limited. So far, most automatic irrigation systems still focus on hardware, while operational aspects have not received optimal attention. In fact, the majority of farmers have now started to keep up with the times, most farmers have started using smartphones in their daily activities. IoT enables real-time data collection through sensors that can provide information on the condition of agricultural land (Goda & Neta, 2024).

Technological advances can be utilized to address the shortcomings of ineffective irrigation systems. In the context of modern irrigation, applications integrated with IoT systems enable the creation of smart irrigation systems (Djamen & Kamasi. 2025b). Amidst demands for increased agricultural yields, climate change, labor shortages, and the need for water efficiency, the existence of Android-based Smart Irrigation System Applications is crucial to develop. Through this research, researchers will develop an Android-based Smart Irrigation System Application for Agriculture. This application will function as an application to assist farmers in monitoring soil pH conditions, controlling pumps automatically, and displaying watering history. This innovation is expected to produce an Android-based Smart Irrigation System Application and become the right solution for farmers in supporting agriculture and water use in the digital era.

According to Qodriyah et al. (2025), the development of a smart irrigation system for greenhouses through an IoT-based mobile application using a prototype method is capable of automatic watering based on soil conditions, increasing water efficiency compared to conventional irrigation systems. According to Ary Esta Dewi Wirastuti et al. (2022), the developed application successfully monitored subak water conditions in real time but did not provide an automatic control feature. According to Suwardoyo & Mk (2025), the application was capable of monitoring and automatic watering through an Android application but did not provide comprehensive data analysis and history. Meanwhile, according to Suryanti et al. (2024), the implementation of drip irrigation technology in community activities was successful. Monitoring showed improvements in water distribution and increased understanding and use of irrigation technology by the community. However, it lacked detailed quantitative measurements, and specific testing was only carried out at certain locations.

Based on these issues, this study developed an Android-based smart irrigation system application for agriculture that is directly integrated with the Internet of Things system. The application was developed using Flutter and integrated with the Firebase Realtime Database to display soil moisture information, pump control, notifications, watering history, and weather information. This research aims to produce an application that can help farmers monitor land conditions and manage irrigation systems more effectively, efficiently, and flexibly.

2. Research Methods

This research focuses on the development of an Android-based smart irrigation system application for agriculture. In the application development process, the developer used a prototype method. Prototyping is a software development method that involves creating a mockup or initial system design to illustrate user needs before the system is fully developed. This method is suitable for this research because it allows developers to interact directly during the development process, allowing system requirements to be identified and adapted to field conditions.

This research was conducted from November 2025 to May 2026. The data used by the developer came from direct field observations and interviews with farmers who use the application. The main objective of this research is to develop an Android-based smart irrigation system application that farmers can use to control irrigation systems directly integrated with the Internet of Things (IoT) system.

This research uses the Prototype software development method to develop an Android-based Smart Irrigation System application for Agriculture. The following details are the prototyping stages carried out by the developer.

a. Communication
   The communication phase is conducted to understand user needs and identify issues encountered in irrigation management. Data is collected through direct observation and interviews with farmers. The information obtained serves as a basis for developers to determine system requirements.
b. Quick Plan
   The quick plan stage involves compiling system requirements based on observations and interviews. This stage aims to determine the functional and non-functional requirements of the application, ensuring a clear direction for the development process. Functional requirements directly relate to the features that must be available in the application, while non-functional requirements relate to performance, user-friendliness, and security.

c. Modelling Quick Design
At this stage, the system is designed using the Unified Modeling Language (UML), Entity Relationship Diagrams (ERDs), and application interface wireframes. The design is used to ensure that user requirements obtained in the previous stage can be translated into a structured and easily understood design by developers. UML is used for system modeling, while ERDs are used to describe the relationships between data stored in the database, and wireframes are used to illustrate component layout.

d. Construction of Prototype
This stage is the prototype implementation process using Flutter as the application development framework and Firebase Realtime Database as the real-time data storage medium. The application system will be connected to IoT devices so that users can use the application directly connected to the IoT system. This stage allows developers to gradually improve the application system to meet user needs.

e. Deployment and Feedback
At this stage, the prototype that has been successfully tested to users to obtain input and evaluation is used to improve the system to better suit user needs. Testing is carried out using the Black Box Testing method, Black Box Testing is a testing technique that aims to identify application system errors, such as system function errors or errors in finding missing menus in the application (Suwardoyo & Mk. 2025). Not only using Black Box Testing, to ensure the application is perfect, developers also conduct System Usability Scale (SUS) testing, SUS testing is a testing technique used to measure usability in the system from the user's perspective.

3. Results and Discussion

3.1. System Implementation

The system implementation results show that the application was successfully developed in accordance with the functional and non-functional requirements analyzed during the design phase. The application was successfully developed using Flutter and successfully integrated directly with the Firebase Realtime Database as a data storage medium. System implementation included the development of key features that support the monitoring and control of irrigation pumps. The monitoring feature functioned as intended, allowing users to view soil moisture values obtained from sensors directly on the dashboard display.

Soil moisture information also successfully implements a water pump control mechanism in three operating modes: automatic, scheduled, and manual. In automatic mode, the system activates the pump based on a predetermined soil moisture threshold. In manual mode, users can directly control the pump as needed. Meanwhile, in scheduled mode, users can specify watering times, and the pump will automatically turn on based on the user's predetermined schedule.

The weather information feature has been successfully integrated into the app to provide additional information that can help users make decisions regarding plant watering. The weather information is successfully integrated with OpenWeather, a global weather data provider offering up-to-date weather information. The displayed weather information includes current weather conditions and a week-long forecast, allowing users to consider the possibility of rain before watering. This feature allows for more efficient water use and minimizes the risk of overwatering.

The implementation of a watering history feature system that functions to store all watering activities carried out by the system and users was successfully used in the application. The stored historical data includes watering times, soil moisture values, and pump status. This information can be used to monitor and evaluate the watering patterns that have been carried out. Thus, the implementation of the developed smart irrigation system has successfully met the research objectives, namely providing an irrigation monitoring and control solution that can be easily accessed via Android devices, increasing water use efficiency, and helping users in managing the plant watering process more effectively.

3.2. Interface Implementation

The application interface was implemented to translate the system design results into a display that can be used directly by users. The application interface was developed using the Flutter framework, taking into account aspects of usability, display consistency, responsiveness, and user convenience in accessing information. All pages are designed with a simple display so that it can be used by users from various groups, including farmers who are not used to using technology-based applications. The smart irrigation system application consists of several main pages, namely the login page, dashboard, watering history, notifications, weather information, and user accounts. All pages are interconnected and integrated with the Firebase Realtime Database so that the displayed data can be updated in real time according to the conditions of the IoT system in the field.

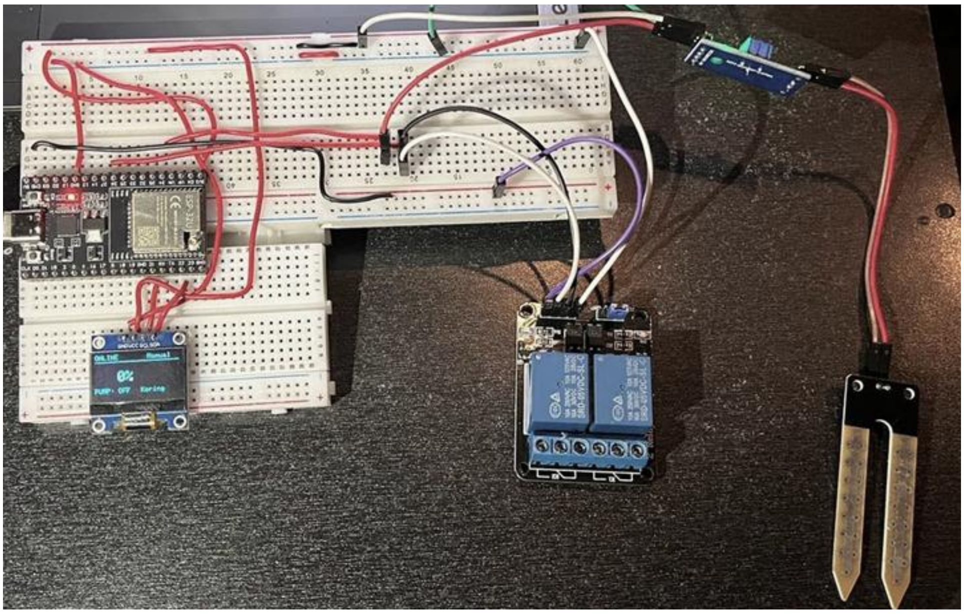

Figure 1. Smart Irrigation System Device

Figure 1 shows the smart irrigation system used in this study. The device consists of a NodeMCU ESP32 as the main microcontroller, a soil moisture sensor as an input device, a relay connecting the water pump, and a pump used for the plant watering process. All devices are connected to the internet, allowing them to send land condition data to the Firebase Realtime Database and receive commands from the Android application. This hardware implementation is crucial in supporting the remote monitoring and control of irrigation.

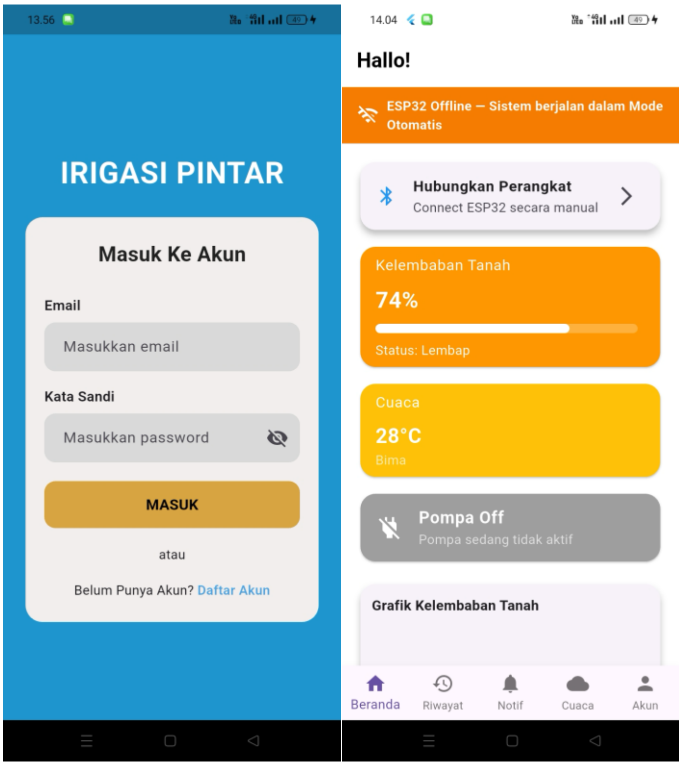

Figure 2. Login Page and Dashboard View

Figure 2 displays the application's login and dashboard pages. The login page is the first page users will access when opening the application. This page provides email and password fields used for user authentication. Additionally, a registration button is available for new users who do not yet have an account. The login page is implemented to maintain user data security and ensure that only users with accounts can access the application's features. After successfully logging in, users are directed to the dashboard page. The dashboard serves as the main information center, displaying various important data related to agricultural land conditions. Information displayed includes soil moisture values, soil condition status, water pump status, and active watering modes. Data displayed on the dashboard is obtained directly from the

Firebase Realtime Database, allowing users to monitor land conditions in real time without having to manually refresh the page.

In addition to displaying soil moisture information, the dashboard also provides pump controls that allow users to directly manage the irrigation system. Users can select automatic, manual, or scheduled modes as needed. In automatic mode, the pump operates based on the soil moisture value detected by the sensor. In manual mode, users can turn the pump on or off through the app. In scheduled mode, users can specify specific times for automatic watering.

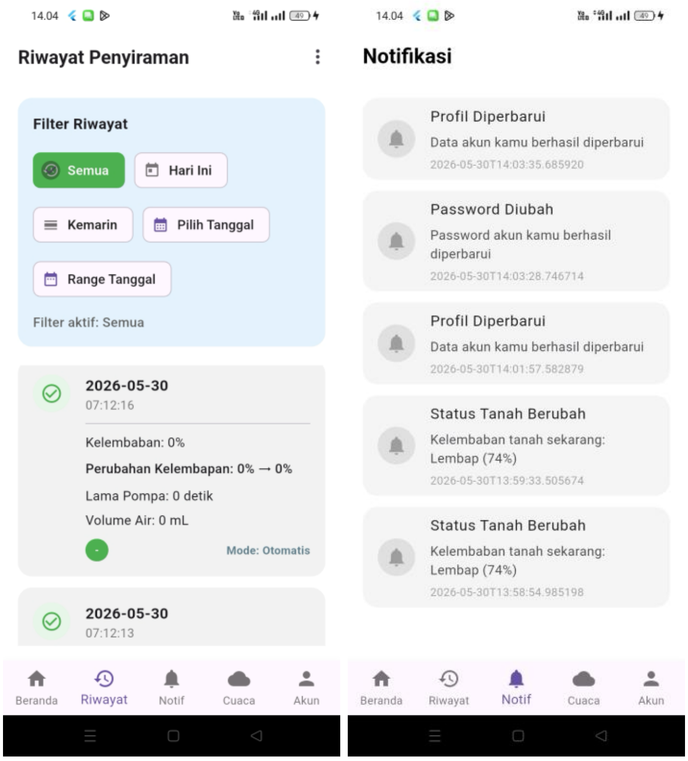

Figure 3. History and Notifications Page View

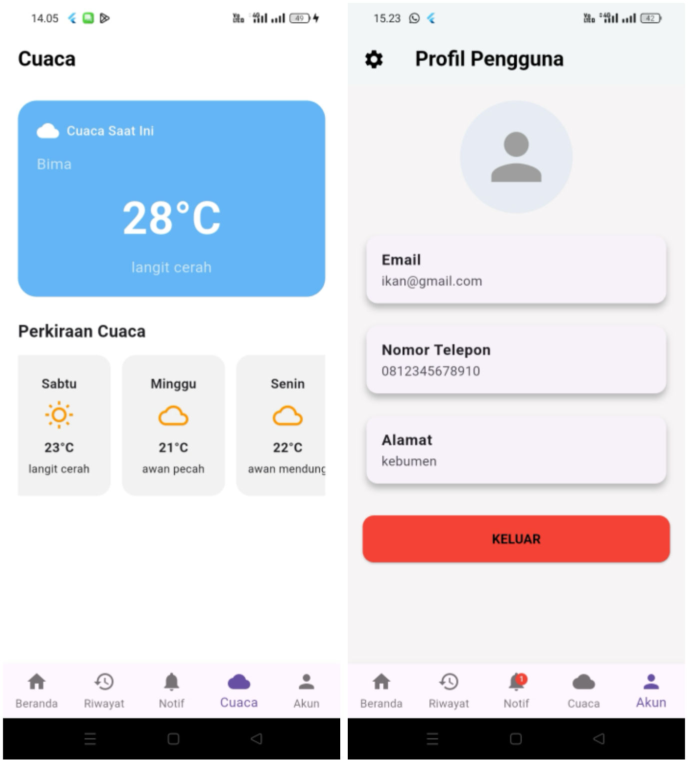

Figure 4. Weather and Account Page View

Figure 3 shows the watering history page and the notification page. The watering history page displays all watering activities performed by the system and the user. Stored data includes watering times, soil moisture values during irrigation, and pump status. This information can be used by users to monitor past watering patterns and assist in evaluating water use on agricultural land. The history feature allows users to determine the last watering period and the condition of the land at that time.

Meanwhile, the notification page provides users with important information regarding system conditions. Notifications appear when there are changes in soil conditions, pump status, or user information. The notification feature allows users to quickly access information without having to continuously open the application. Notifications allow users to take immediate action if conditions require attention, such as excessively dry soil or changes in system status that are not in line with expectations.

Figure 4 displays the weather information page and the user account page. The weather page has been successfully integrated with the Open Weather API, which provides real-time weather data. The information displayed includes current weather conditions, air temperature, humidity levels, and forecasts for the next few days. The weather feature significantly assists users in determining appropriate watering strategies. For example, if the weather forecast indicates a possibility of rain soon, users can delay watering, thereby using water more efficiently.

The user account page displays the identity information of users registered with the system. On this page, users can view and update their profile data as needed. The edit profile feature allows users to change personal information such as name, email address, and other data related to their account. The implementation of this feature aims to increase user flexibility in independently managing account information.

3.3. Test Results

A. Black Box Testing

Black Box Testing is performed by examining the application's main functions without looking at the program's code structure. Black Box Testing results indicate that all functions are functioning as intended.

Table 1. Black Box Testing Results

No	Fitur Yang Diuji	Skenario Pengujian	Hasil yang Diharapkan	Hasil Uji	Keterangan
1.	*Login*	*Email* dan *Password* benar	Masuk ke halaman *Dashboard*	Berhasil	Valid
2.	*Login*	*Email* dan *Password* salah	Muncul pesan *error*	Berhasil	Valid
3.	Registrasi	Mengisi data diri	Akun berhasil dibuat	Berhasil	Valid
4.	Dashboard	Membuka aplikasi setelah *login*	Data tampil lengkap	Berhasil	Valid
5.	Hubungkan Perangkat	Menghubungkan perangkat android ke sistem IoT	Perangkat dapat terhubung dengan sistem IoT	Berhasil	Valid
6.	Kontrol Pompa	Tombol *ON/OFF* ditekan	Pompa berubah status	Berhasil	Valid
7.	Notifikasi	Status tanah berubah	Notifikasi muncul	Berhasil	Valid
8.	Notifikasi	Edit informasi pengguna	Notifikasi muncul	Berhasil	Valid
9.	Cuaca	Membuka menu cuaca	Data cuaca tampil	Berhasil	Valid
10.	Edit Profil Pengguna	Mengubah data diri	Data berhasil diubah	Berhasil	Valid

Based on the results of black box testing on 10 test scenarios, all features achieved valid and successful test results. These results demonstrate that the application can perform all primary functions according to user requirements and the designed system specifications.

B. System Usability Scale Testing

The System Usability Scale (SUS) test is conducted to determine the level of application usability based on user perception. The test uses a 10-question questionnaire with a rating scale of 1 to 5.

Table 2. System Usability Scale Testing

Respondents	SCORE										Number of Respondents (NoR)	NoR*2,5
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10		
R1	3	4	3	2	3	4	3	3	4	4	33	82,5
R2	4	4	4	3	4	4	3	4	4	4	38	95
R3	4	4	4	0	4	2	4	4	4	4	34	85
R4	3	4	3	2	4	4	2	1	4	4	31	77,5
R5	4	1	4	2	4	4	4	3	4	4	34	85
R6	4	3	4	2	4	3	3	4	4	4	35	87,5
R7	4	4	4	0	4	2	4	2	4	4	32	80
R8	4	3	4	3	4	4	2	4	4	3	35	87,5
R9	4	4	3	3	4	4	3	4	4	4	37	92,5
R10	4	2	3	1	3	0	1	3	4	2	23	57,5
Average												**83**

Based on the test results, the average SUS score was 83. Based on SUS interpretation standards, this score falls into the Acceptable category, receiving Grade A, and is at the Excellent rating level. These results indicate that the application has a high level of usability and is easy for users to use.

3.4. Discussion

This research successfully developed an Android-based smart irrigation system application for agriculture integrated with Internet of Things (IoT) technology. The application was successfully developed using Flutter as a framework and Firebase Realtime Database as a real-time database storage medium. The application was also connected to IoT devices such as a NodeMCU ESP32, a soil moisture sensor, and a pump, enabling the application to monitor and control irrigation pumps automatically, manually, or via a schedule.

The implementation results showed that the application was able to display real-time soil moisture information based on data sent by the sensor. Sensor data received by NodeMCU ESP32 is sent to the Firebase Realtime Database, which then automatically displays the data. This mechanism allows users to obtain information on land conditions without having to visit the agricultural area directly. This demonstrates the successful integration of IoT devices with the Android application.

4. Conclusion

Based on the results of the research, design, implementation, and testing conducted, it can be concluded that the Android-based smart irrigation system application for agriculture was successfully developed in accordance with the research objectives. The system was able to integrate Internet of Things (IoT) devices, including soil moisture sensors and NodeMCU ESP32, with a mobile application, allowing users to monitor land conditions and control irrigation processes in real time via Android devices. The application also integrated directly with the Open Weather API, a global weather data provider offering up-to-date weather information.

The developed application has several key features that support agricultural irrigation management, including real-time soil moisture monitoring, automatic, manual, and scheduled water pump control, land condition notifications, weather information, and watering history. All these features were successfully implemented and integrated with the Firebase Realtime Database, which serves as a data storage and exchange medium between the application and IoT devices. These features enable users to quickly obtain information on land conditions and more easily manage irrigation without having to be directly on the farm.

Based on the results of black box testing, all the system's main functions functioned as designed. Testing demonstrated that the application correctly displayed soil moisture data, controlled the water pump according to user commands and predetermined automatic conditions, displayed weather information, sent notifications, and effectively stored and displayed watering history data. These results demonstrate that the system has a good level of functionality and is ready for use as intended.

The System Usability Scale (SUS) test, involving 10 respondents, yielded an average SUS score of 82.5, which falls into the Acceptable category, achieving Grade A, and achieving an Excellent rating. These results indicate that the application has a high level of ease of use, is easy for users to understand, and provides a good user experience in supporting agricultural irrigation monitoring and management activities.

Overall, this research has successfully produced an Android-based smart irrigation system application that can help farmers monitor land conditions and manage irrigation more effectively, efficiently, and in an integrated manner. The use of IoT technology and mobile applications in this system also has the potential to increase water use efficiency and support the implementation of modern, technology-based agriculture. For further development, the system is expected to be implemented in larger agricultural land areas and with various crop types to obtain more comprehensive evaluation results. Furthermore, development can be carried out by adding an offline data storage feature so that the application can continue to be used when the internet connection is unstable. Development on other platforms such as iOS and the Web is also possible to increase user access flexibility.

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