



Development of an Artificial Intelligence-Based Mobile Application as a Virtual Assistant to Support Digital Transformation in the Agricultural Sector

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Abstract. The digital transformation in the agricultural sector offers significant opportunities to improve access to agricultural information and support rice cultivation management. However, farmers still encounter challenges in obtaining information regarding agronomic techniques, pest and disease identification, fertilization, and crop problem mitigation. This study aims to develop an Artificial Intelligence (AI)-based mobile application as an interactive virtual assistant to provide digital agricultural information for lowland rice cultivation. The system development methodology employs the Waterfall model, comprising requirements analysis, system design, software implementation using the Flutter framework, Large Language Model (LLM) integration, and functional testing. The application integrates the Gemini Flash LLM and provides four core features: a Multimodal Chat Feature supporting text and image inputs, a Chat History Feature, a Bookmark Feature, and a Profile Feature. The output of this research is a mobile AI application prototype that enables users to interact with an LLM through text-based and image-assisted agricultural consultation. Functional testing using the black-box testing method shows that all tested application functions operate according to the predefined functional requirements. This study demonstrates the feasibility of implementing an LLM-based multimodal agricultural virtual assistant in a mobile application for lowland rice cultivation. Further evaluation is required to assess AI response accuracy, user acceptance, and effectiveness under real agricultural field conditions.

Keywords: Agricultural Virtual Assistant, Artificial Intelligence, Large Language Model, Mobile Application, Rice Cultivation

1 Introduction

In recent years, the development of digital technology and artificial intelligence (Artificial Intelligence/AI) has had a very significant impact on various sectors of life, including the agricultural sector. Digital transformation in the agricultural sector is now growing by utilizing Artificial Intelligence technology to increase production efficiency, decision-making processes, and more optimal agricultural resource management (Kisliuk et al., 2023). However, in reality, many farmers still face limitations in accessing technical information related to cultivation practices, plant pest and disease control, fertilizer selection, and optimal land management. Agricultural

information is generally still obtained through agricultural extension workers or conventional information sources whose numbers are limited and are not always available quickly when needed by farmers. The utilization of Artificial Intelligence allows for more accurate analysis of agricultural data so that it can increase the productivity, efficiency, and sustainability of modern agricultural systems (Ali et al., 2025). Machine learning and computer vision technologies have been widely used in smart agricultural systems to support crop monitoring, disease detection, and data-driven decision-making (Zhang et al., 2023). Recent developments in Artificial Intelligence are also marked by the emergence of Large Language Models (LLMs) that are capable of understanding natural language and generating contextual responses in various conversation-based applications. Artificial Intelligence can be used to support decision-making systems in agriculture through real-time analysis of environmental, crop, and production condition data (Fadiji et al., 2023).

In the context of the agricultural sector, the utilization of AI technology as a virtual assistant has great potential to assist farmers in obtaining information related to crop cultivation activities, identification of plant problems, and recommendations for appropriate actions. By utilizing mobile devices that are currently increasingly used by the public, AI-based mobile applications can be an effective medium to bridge the information needs of farmers in a more practical and easily accessible way. However, the development of AI-based applications specifically designed as virtual assistants for farmers is still relatively limited, especially in the context of implementation integrated with practical needs in the field. The integration of Artificial Intelligence in agriculture allows for increased operational efficiency, resource management, and optimization of the agricultural supply chain (Bhat et al., 2025). The rice commodity is one of the main food crops that has a strategic role in food security in Indonesia. Rice cultivation activities in lowland fields involve various important stages, ranging from land preparation, planting, fertilization, to plant pest and disease control. In practice, farmers often face limited access to accurate and easy-to-understand technical information regarding lowland rice cultivation management. Various previous studies have examined the utilization of Artificial Intelligence technology in the agricultural sector to improve the efficiency and productivity of crop cultivation activities. Literature reviews show that the development of Artificial Intelligence technology plays an important role in supporting sustainable agriculture through transparent data analysis and AI-based recommendation systems (Rajbongshi et al., 2026).

The mapping of previous studies also shows the proliferation of data-based agricultural recommendation systems used to assist farmers in the decision-making process, such as recommendations for fertilization, pest control, and lowland rice cultivation management (Sharma et al., 2021). However, based on the reviewed literature, existing artificial intelligence-based agricultural systems have primarily focused on specific tasks such as crop disease detection, precision agriculture, fertilization recommendation, and data-driven decision support. Although several studies have explored AI-based agricultural assistants and conversational systems, the integration of a Large Language Model (LLM) into a mobile-based virtual assistant specifically oriented toward lowland rice cultivation remains relatively limited. Therefore, the novelty of this study is positioned in the development of a domain-oriented, multimodal mobile agricultural virtual assistant that integrates LLM

technology for lowland rice cultivation. The proposed prototype combines text-based consultation and lowland rice cultivation image input within a single mobile interaction framework, allowing users to describe cultivation problems using natural language or provide visual information about crop conditions. Unlike a general-purpose AI chatbot, the proposed application is specifically structured around lowland rice cultivation consultation and incorporates supporting features including chat history, bookmarking of important consultations, and user profile information.

The main contribution of this study is the development of a mobile-based multimodal prototype that integrates text and image inputs with an LLM service to support agricultural consultation. The system is specifically designed for lowland rice cultivation and demonstrates the implementation of an LLM-based agricultural virtual assistant through a structured software development process covering requirements analysis, system design, implementation, and functional testing. The resulting prototype is intended to provide a foundation for subsequent research involving AI performance evaluation, user usability testing, and field validation. In this first-stage study, the research focuses on demonstrating the feasibility and functional implementation of the proposed prototype rather than evaluating the accuracy or effectiveness of the AI in real agricultural field conditions.

2 Methodology

The proposed agricultural virtual assistant integrates the Gemini Flash Large Language Model (LLM) as the primary artificial intelligence component. Gemini Flash was selected to support conversational interaction and multimodal processing within the mobile application, particularly for handling natural language queries and lowland rice cultivation images. The LLM is accessed through an API from the Flutter-based mobile application, allowing user inputs to be transmitted to the AI service and the generated responses to be returned to the application interface. The integration process consists of several stages.

First, the user submits an agricultural question through the chat interface, either as text or accompanied by an image of a lowland rice cultivation. The application then prepares the input and sends it to the Gemini Flash API. For image-based consultation, the crop image is submitted together with the user's query to enable multimodal processing. The Gemini Flash model processes the provided input and generates a response related to the user's agricultural query. The response is subsequently returned to the mobile application and displayed through the Chat Feature. This integration enables the prototype to provide a conversational interface that supports both text-based and image-assisted consultation for lowland rice cultivation.

The system development method uses the Waterfall approach as the software development method. This method was chosen because it provides systematic and structured development stages, making it suitable for the development of an Artificial Intelligence-based mobile application within a limited scope. The development process in this study covers the stages from requirements analysis to system testing. The maintenance stage was not carried out in this cycle because the focus of this first-year research is on the design, Large Language Model (LLM) integration, and initial

development of the lowland rice cultivation agricultural virtual assistant. The stages carried out in this method are as follows:

- 1) **Requirements Analysis:** At this stage, the functional and non-functional requirements of the system were identified based on the defined research objectives and the intended functions of the agricultural virtual assistant. Functional requirements include natural language text interaction, lowland rice cultivation image input, conversation history, bookmarking of important conversations, and user profile management. The result of this stage is the requirements specification for the agricultural virtual assistant system to be developed.
- 2) **System Design:** This stage includes designing the multimodal system architecture that connects the client mobile application with the Gemini Flash LLM service through an API, designing the user interface, and designing the data storage structure. The design prioritizes intuitive navigation and efficient data management using a local database on the mobile device.
- 3) **Implementation:** The implementation stage is the process of building the system according to the results of the system design. The agricultural virtual assistant mobile application was developed using the Flutter framework and integrated with the Gemini Flash LLM API to support natural language interaction and lowland rice cultivation image-based consultation. The image input is provided directly by users through the mobile device camera or image gallery and is submitted to the Gemini Flash API together with the user's query. The prototype does not use a dedicated agricultural image dataset for model training or fine-tuning, as the LLM is accessed through its API service.
- 4) **Testing:** This stage was conducted to verify that the implemented functions operate according to the defined system requirements. Testing was performed using the black-box testing method, focusing on the functional operation of the main application features, including text and image input, communication with the Gemini Flash API, chat history, bookmarking, and profile management. The testing focuses on functional verification of the developed prototype and does not evaluate the accuracy or effectiveness of the AI-generated agricultural recommendations. AI performance evaluation, user usability testing, and field validation are considered beyond the scope of this prototype-stage study and are planned for subsequent research.

3 Result and Discussion

3.1 Result

This chapter discusses the results obtained from the development of the Artificial Intelligence-based mobile application as an agricultural virtual assistant for lowland rice cultivations, covering the stages of requirements analysis, system design, implementation, and testing. Each stage contributes to the development of the proposed prototype according to the defined research objectives and system requirements.

Requirements Analysis. In the development process of this agricultural virtual assistant mobile application, requirements analysis was conducted to identify various components and primary features that must be implemented into the system to achieve the established research objectives.

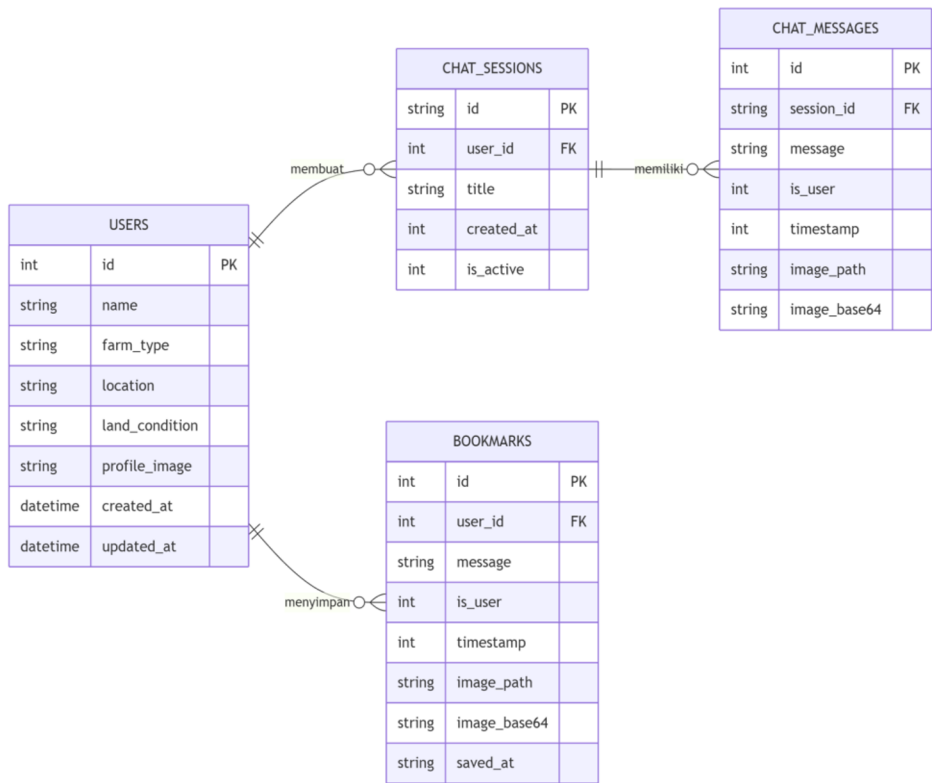


Figure 1. Database Design

The final results of this requirements analysis stage are described as follows:

- 1) **User Role:** The system is designed for rice farmers as the intended end-users, who can access the main functions for conducting cultivation consultations, submitting text-based questions, sending crop images, and viewing conversation history.
- 2) **Product Scope:** The scope of the application is limited to providing technical information and recommendations related to lowland rice cultivation. Furthermore, as an initial prototype, the application does not implement complex multi-user access rights on the client side but instead focuses on supporting interaction between the user and the artificial intelligence system.
- 3) **Product Functions:** The primary functions of the application include an interactive chat module feature in natural language, a multimodal input feature that integrates the device camera to capture crop images as well as image inputs from the device,

and the capability to send data to the Large Language Model (LLM) API to be processed and generate AI-based cultivation consultation responses.

System Design. This process is essential in software development as it provides an initial blueprint of how the database design and user interfaces are created. This database design illustrates the relationships between tables that store important information to be used within the system.

Implementation. At this stage, the development process of the agricultural virtual assistant mobile application was carried out using mobile-based technology with the Flutter framework on the client side. The application interface was built minimally by limiting the application's navigation structure to only 4 primary features, namely:

- 1) Chat Feature (Figure 2): The primary interaction module that integrates natural language text input fields and images using the smartphone's built-in camera or manual input. This feature allows users to type agricultural constraints or send photos of the physical condition of the lowland rice cultivations directly to the Large Language Model (LLM) API server to obtain AI-generated consultation responses.

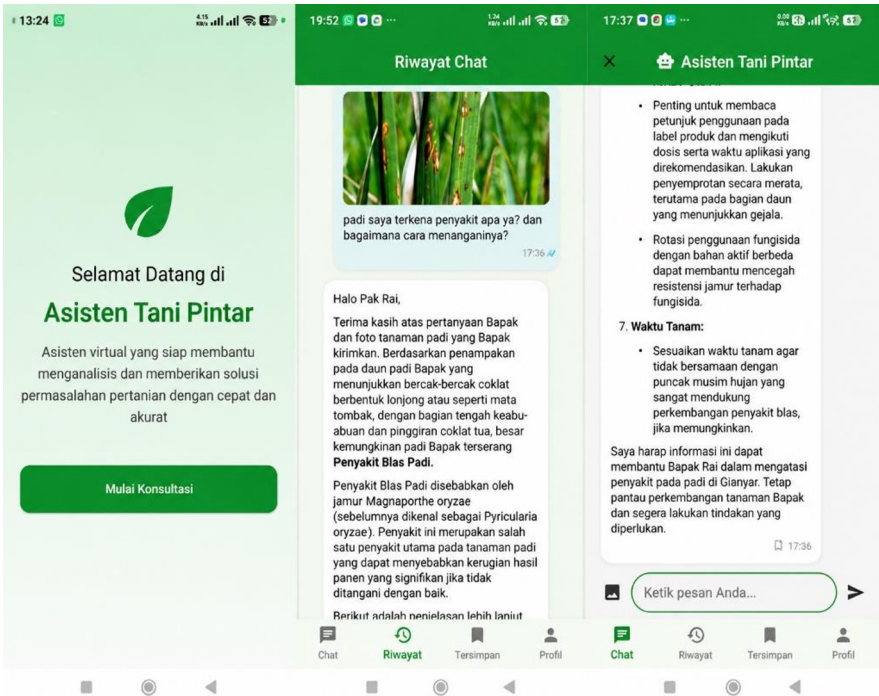


Figure 2. Homepage and Chat Feature

- 2) Chat History Feature (Figure 3): A dedicated page that contains a list of records of past conversations and consultation sessions previously conducted by the farmer. This feature is arranged chronologically to make it easier for farmers to review past question-and-answer flows.

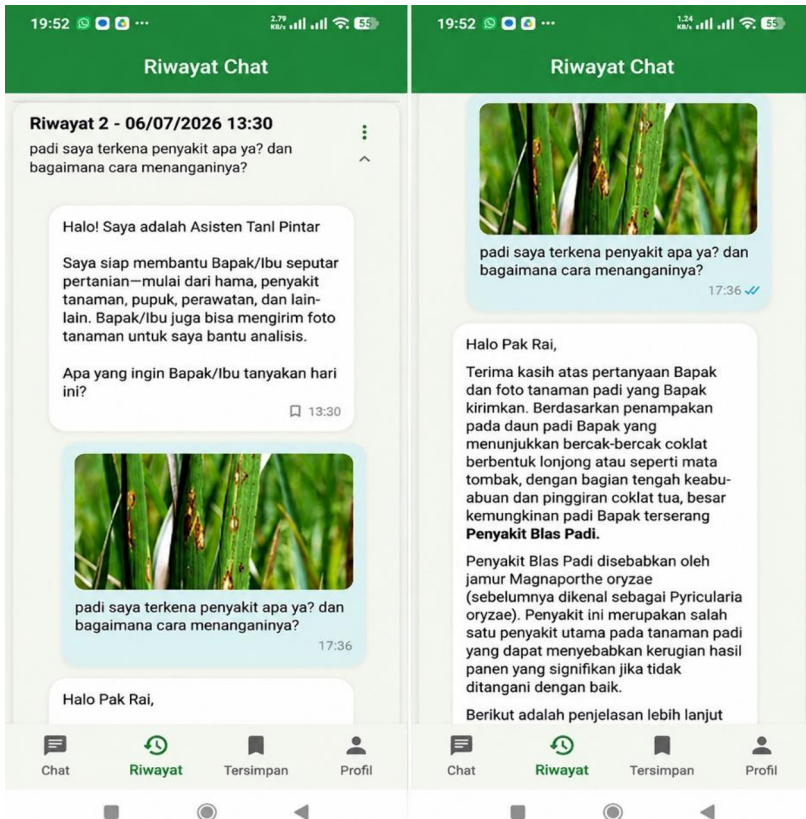


Figure 3. Chat History Feature

- 3) Bookmark Feature (Figure 4): A bookmarking feature that functions to filter, mark, and archive specific important conversation sessions or agricultural recommendations. This aims to allow important information to be found quickly by farmers without having to search through the entire history list.



Figure 4. Bookmark Feature

4) Profile Feature (Figure 5): A personalization page containing the farmer's personal identity data and information regarding the managed lowland rice commodity. This page functions to provide initial personalization parameters for the system user.



Figure 5. Profile Feature

Testing. The testing stage was conducted using the black-box testing method by observing the execution results of the implemented features to ensure that the primary functions of the application operate well in accordance with the development objectives. The black-box testing results are presented in Table 1.

Table 1. Testing Result

No	Tested Feature	Expected Result	Actual Result	Status
1	Chat Feature	Users can send natural language text messages and image inputs, and the system successfully forwards them to the LLM API to receive consultation responses	Text messages and lowland rice cultivation images were successfully processed by the AI, and the generated consultation responses were successfully returned to the application.	Pass
2	Chat History Feature	The system can display the list of all past conversation records chronologically	The page successfully loaded and displayed the complete list of past chat history	Pass
3	Bookmark Feature	Users can mark and archive specific important conversation sessions into the saved list	The bookmarking feature functioned well and the archived chat sessions were successfully grouped separately	Pass
4	Profile Feature	The system can display user personal data and save basic application preference configurations	The profile page successfully displayed the user identity and processed preference updates	Pass

3.2 Discussion

The development of the agricultural virtual assistant demonstrates the potential of integrating Large Language Model (LLM) technology into mobile-based agricultural information services. The black-box testing results show that the four main navigation features operate according to their defined functional requirements. More importantly, the integration of text and image inputs within the Chat Feature provides a more flexible interaction mechanism than text-only consultation. Users can describe cultivation problems using natural language or provide visual information about crop conditions, which is relevant to agricultural consultation because users may not always have sufficient technical knowledge to describe symptoms or crop conditions precisely. The use of LLM technology therefore provides an alternative mechanism for accessing agricultural information through a more natural interaction process (Kisliuk et al., 2023; Shaikh et al., 2025). The mobile implementation also provides practical advantages in terms of accessibility. The proposed prototype integrates the consultation function directly into a mobile application, which is particularly relevant to agricultural activities performed in outdoor and field environments. The Chat History and Bookmark features further support this interaction by allowing users to review previous consultations and retain important information. Thus, the contribution of the proposed system is not limited to the use of an LLM, but also lies in how the technology is packaged into a mobile interaction environment oriented toward lowland rice cultivation.

Compared with previous research trends in smart agriculture, artificial intelligence-based systems have been widely developed for crop monitoring, disease detection, recommendation systems, and agricultural decision support (Rajbongshi et al., 2026; Sharma et al., 2021). However, many of these approaches are designed around specific analytical tasks or data-driven recommendation processes. The proposed prototype adopts a different interaction approach by combining conversational LLM capabilities with multimodal input in a mobile application specifically oriented toward lowland rice cultivation. This approach allows users to interact with the system using natural language while also providing crop images when additional visual information is needed. Therefore, the proposed prototype applies AI in agriculture through a more interactive agricultural consultation model rather than focusing solely on task-specific analysis. This approach demonstrates the potential of LLMs to support natural-language-based agricultural information services through a mobile application.

From a practical perspective, the proposed prototype can potentially complement existing agricultural information services rather than replace agricultural extension workers. The system can provide an initial source of information when farmers encounter cultivation problems and require immediate access to digital information. However, this potential should be interpreted within the scope of the current prototype. The study only verifies the functional operation of the application and does not evaluate the accuracy of AI-generated recommendations, user acceptance, or effectiveness in real agricultural conditions. Consequently, the prototype should currently be viewed as a technological foundation for further development and evaluation. Future research should investigate the accuracy of the generated agricultural responses through expert assessment, evaluate usability among rice farmers, and validate the system under real field conditions.

4 Conclusion

This research successfully developed a prototype of an Artificial Intelligence-based mobile application as an agricultural virtual assistant for lowland rice cultivation. The application was developed using the Flutter framework and integrated with the Gemini Flash Large Language Model (LLM) to support multimodal consultation through natural language text and rice crop image inputs. The prototype also provides Chat History, Bookmark, and Profile features for managing and retrieving agricultural consultation information. The development process followed the Waterfall model, covering requirements analysis, system design, implementation, and functional testing. Based on the black-box testing results, all tested application functions achieved a passing status and operated according to the defined functional requirements, demonstrating the feasibility of implementing an LLM-based multimodal agricultural virtual assistant for lowland rice cultivation. However, this study is limited to the prototype development and functional testing stage and does not evaluate AI response accuracy, user acceptance, or effectiveness under real agricultural field conditions. Further research is required to evaluate AI-generated responses through agricultural expert assessment, conduct usability testing with rice farmers, and perform field validation.

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