

# Towards a Sustainable Agriculture: A Mobile-Based Expert System for Rice Disease Diagnosis in Nigeria

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**Abstract**—Every facet of human endeavour has been impacted by technology. With the diverse application of artificial intelligence and its associated digital tools across various fields, the requirements for sufficiency and sustainability have necessitated the integration of digital platforms and tools into the agricultural sector. Nigeria, with its vast arable land and varied agro-ecological zones, holds great promise for achieving self-sufficiency in rice production. Nevertheless, it continues to grapple with several challenges, including low crop yields per hectare, high production costs, ineffective pest and disease management, and limited access to agricultural extension services, particularly in rural areas. These factors create significant disparity between rice production and demand, jeopardizing food security and sustainable agricultural development. This study addresses these challenges by proposing the design and development of a mobile-based expert system specifically crafted to assist rice farmers in Nigeria. Functioning as a digital agricultural advisor, the system is designed to diagnose rice plant diseases, provide pest control recommendations, and suggest best farming practices based on user inputs. By combining a knowledge base, an inference engine, and a user-friendly interface, the expert system replicates the reasoning abilities of agricultural experts, offering timely, location-specific advice. Accessible via Android phones, this system empowers smallholder farmers with real-time, expert-level decision support, helping them enhance yields, minimize production losses, and adopt more sustainable and resilient rice farming methods. The system usability score was 76.5. Findings reveal an improvement in farmers' access to actionable knowledge, problem-solving, and self-confidence in decision-making. The implementation of such digital tools could significantly contribute to bridging Nigeria's rice production gap and improving national food security.

**Keywords**—Rice production, Expert system, Mobile Application, Rice disease diagnosis

## I. INTRODUCTION

Nigeria is endowed with extensive arable land and diverse agro-ecological zones, which have significant potential for rice cultivation. Despite this, the country's average rice yield remains low, at approximately 2.0 to 2.5 tons per hectare, considerably below the global average of about 4 tons/ha and Asia's 6 tons per hectare [1, 2]. This low productivity is attributed to several factors, including limited mechanization, reliance on traditional farming methods, small landholdings, and inadequate pest and disease management [3]. These challenges contribute to a substantial supply-demand gap; local rice production meets only about 57% of the nation's

annual demand of 6.5 million metric tons, resulting in a deficit of approximately 2 million metric tons [1].

In Nigeria, rice farmers are increasingly relying on agricultural scientists and extension officers for guidance on improving yields, managing pests, and selecting suitable rice varieties. However, these experts are often unavailable in remote areas when farmers need timely advice [4]. To address this challenge, expert systems software applications that emulate human expert reasoning are being developed to assist farmers in decision-making processes [4]. Developing a mobile-based expert system for rice production management can significantly enhance the accessibility of critical information for farmers, leading to improved decision-making and increased crop yields [5]. Such systems integrate expert knowledge into user-friendly mobile applications, providing real-time guidance on various aspects of rice cultivation [6]. Expert systems have become increasingly valuable in agriculture, particularly in diagnosing crop diseases and supporting decision-making processes. Globally, these systems have shown potential to enhance farming practices, especially in areas with limited access to extension agents. Expert systems have been widely applied in various areas of agriculture, particularly in supporting decision-making for disease diagnosis and crop management.

These expert systems can be accessed via mobile phones, enabling farmers to receive real-time advice on issues such as disease diagnosis, pest control, and crop management. For example, a mobile-based expert system was created to diagnose rice diseases in real-time data from the field, making the diagnosis process faster and more accurate by allowing farmers to identify diseases based on observed symptoms and receive appropriate recommendations.

Rice is one of Nigeria's most important staple foods; however, it struggles to meet its domestic demand due to low productivity [3]. Diseases in rice plants are a significant contributor to this issue, often resulting in substantial yield losses [3]. Traditional farming methods, lack of access to expert guidance, and poor disease management practices have created a critical need for technological intervention [7]. This paper proposes a mobile-based expert system to assist farmers in identifying and managing rice diseases in real time. These systems can be accessed via Android phones, enabling farmers to receive real-time advice on disease diagnosis, pest control, and crop management [6]. By inputting symptoms through a user-friendly interface, the system's inference engine utilizes a knowledge base to diagnose potential issues and provide tailored recommendations. Implementing such expert systems in Nigeria could empower rice farmers,

particularly in remote areas, to make informed decisions, enhance productivity, and bridge the existing supply-demand gap in rice production [5].

The following research questions aim to guide the design of the expert system. Are rice farmers willing to adopt a mobile-based expert system? What are the information needs of users on the proposed mobile-based expert system?.

The Nigerian agricultural sector is dominated by smallholder farmers, most of whom operate without adequate support from agricultural extension officers. Given the shortage and inaccessibility of experts in rural areas, farmers often rely on trial-and-error methods or outdated practices. This gap leads to delayed or incorrect disease diagnosis and mismanagement of rice crops, resulting in decreased productivity and increased post-harvest losses. Rice is a staple food for most of the Nigerian population, and its cultivation is vital for food security. Rice plants are susceptible to diseases that severely impact yield and quality. Farmers face challenges in accurately identifying these diseases due to similarities in symptoms and a lack of immediate access to agricultural experts. Misidentification leads to inappropriate treatment measures, exacerbating crop losses. There is a need for an accessible, reliable, and efficient diagnostic tool to help farmers identify rice plant diseases. Few expert systems developed in Nigeria are in English, and most farmers in Nigeria are less educated. Hence, the proposed expert system will incorporate the local languages to help rural farmers diagnose rice plant diseases. To develop a mobile-based expert system for rice disease diagnosis, provide farmers with timely expert advice on disease identification and management, bridge the gap between farmers and agricultural experts through digital technology, and contribute to sustainable rice production and food security in Nigeria.

#### A. Contributions to Knowledge

Unlike generic agricultural advisory tools, this study presents a domain-specific expert system tailored to diagnose rice diseases commonly found in Nigeria. Additionally, many already developed systems lack contextual adaptation to the Nigerian farming environment, particularly regarding language, digital literacy, and regional disease prevalence. This study contributes new knowledge by developing a mobile-based expert system specifically designed for diagnosing rice diseases in Nigeria, while considering local agricultural practices, environmental factors, and user behavior among smallholder farmers. The system leverages mobile technology to provide real-time, location-independent access to expert-level recommendations. This addresses the limitations of physical extension services, especially in underserved rural areas, and ensures the continuous availability of diagnostic assistance to farmers. Unlike previous works that rely on generic datasets or simulation environments, this system integrates real-world farmer input, localized expert knowledge, and field-tested rule-based algorithms to deliver practical and accurate disease diagnostics. It also includes user-friendly AI-enhanced learning modules, tailored symptom queries, icon-based symptom selection, offline functionality, and multilingual support to accommodate varying literacy levels; these aspects, which are seldom addressed in prior research, have been integrated to improve usability and adoption among smallholder farmers. Furthermore, case studies from Nigerian rice-producing areas evaluate the system's usability,

adoption potential, and diagnostic accuracy in real-world contexts. These elements present a novel, scalable, and impactful tool that supplements agricultural extension services, empowering farmers to make informed decisions and closing a critical gap in Nigeria's rice production management. This localized and applied approach significantly advances over the large contextual frameworks in the current body of literature.

## II. LITERATURE REVIEW

In the global agricultural research community, the diagnosis of diseases in rice plants has been a critical area of study due to rice's role as a staple food for more than half of the world's population. Disease outbreaks such as rice blast, bacterial leaf blight, sheath blight, and brown spot have caused significant yield losses, sometimes reducing harvests by up to 30–50% in severely affected areas.

Several studies and initiatives have shown that mobile and digital technologies can be effective for extension service delivery. Dlodlo and Kalezhi [8] noted that widespread adoption of mobile phones in rural areas has created unprecedented access to information and advisory services for farmers and significantly improved information dissemination among farmers, particularly those in remote communities. These platforms, however, often focus on general advisory services and do not provide specific, real-time diagnostic capabilities for crop diseases.

Notably, the mAgri app in Kenya, which allows farmers to access market information, weather updates, and agronomic tips, leads to increased participation in agricultural markets [9]. However, it lacked interactive expert decision support features, which limited its capacity to diagnose and respond to specific crop health issues. Another example is the Esoko platform in Ghana, which offers up-to-date agricultural market prices, weather forecasts, climate-smart agricultural advisories, and agronomic advisory content and combines SMS, IVR, and voice messaging in local languages, enabling farmers to receive personalized advice, thus boosting their efficiency in agriculture by making well-informed decisions [10].

A study by Grunfeld and Houghton [11] emphasized the integration of ICT tools into agricultural systems to improve climate adaptation strategies and scale organic inputs. They suggested that expert systems could serve as climate-resilient advisory tools to mitigate the effects of plant diseases exacerbated by erratic weather patterns. Eleke *et al.* [12] emphasized the importance of ICT in agricultural transformation, underscoring the need for intelligent systems that provide expert-level support, thereby enabling farmers to optimize their agrarian practices by facilitating the transfer of information across different locations.

Several intelligent systems have been developed to identify rice diseases using various artificial intelligence approaches, including rule-based systems, image processing, and machine learning approaches. Benali and Boukhalifa's [6] mobile-based expert system was developed for diagnosing rice diseases, incorporating forward chaining algorithms alongside real-time data integration from IoT sensors and GPS-enabled devices. The system's knowledge base was built from information gathered from agricultural experts and research literature. Field trials on ten farms showed that the system achieved high diagnostic performance, with 97.01% accuracy, 90.69% sensitivity, and 85.37% specificity.

Other researchers have adopted visual and pattern recognition models to automate disease detection. For example, Kumar and Sakthivel [13] introduce an innovative approach for detecting rice diseases by leveraging the fusion vision boosted classifier (FVBC), which integrates VGG19 for feature extraction and LightGBM for classification. The model offers a non-invasive and scalable approach for early detection of rice diseases, enabling farmers to take timely action and enhance overall crop productivity. While highly promising, these systems require high-resolution images and consistent lighting, which may limit their effectiveness in field conditions typical of rural Africa.

Recent advancements in artificial intelligence (AI) and machine learning have significantly enhanced the diagnosis of diseases in rice plants. These technologies offer promising solutions to challenges faced by farmers, particularly in regions like Nigeria, where access to extension agents may be limited.

Deng *et al.* [14] developed a methodology using deep learning on a dataset of 33,026 images of six various kinds of rice diseases, which was integrated in a smartphone app. An accuracy of 91% was achieved. The study employed a deep learning model, such as CNN, to analyse images of rice leaves and identify various diseases. The goal is to equip farmers with a simple yet reliable tool for the early detection of rice diseases, helping them manage outbreaks promptly and minimize crop losses.

Bari *et al.* [15] utilized Faster R-CNN algorithm for real-time detection of rice leaf diseases with over 99% accuracy for multiple disease types such as brown spot, leaf blast, and Hispa diseases, showcasing the potential of deep learning in precise disease identification. Using a self-constructed database and Kaggle, the models were assessed with 2400 images.

Li *et al.* [16] reviewed image processing techniques using machine learning and deep learning models related to multi-scale rice diseases, summarizing applications of different detection techniques, including genomic, physiological, and biochemical approaches. Recent developments in disease detection technologies have demonstrated the strong potential of machine learning and deep learning models, achieving remarkable accuracy in diagnosing rice diseases and paving the way for smarter, data-driven agricultural solutions.

These studies underscore the potential of AI-driven expert systems in enhancing rice disease diagnosis. Nevertheless, there remains a critical need for context-specific solutions that address the unique agronomic conditions and operational challenges encountered by Nigerian rice farmers. Developing mobile-based expert systems that incorporate local disease profiles and farming practices can bridge this gap, offering accessible and effective tools for disease management.

#### A. Related Work

Okai *et al.* [17] designed a Knowledge Management System (KMS) to facilitate the sharing of information and promote smart agricultural practices in rice cultivation. Employing a system prototyping approach, they developed a KMS prototype, which was assessed using the System Usability Scale (SUS). The lack of real-time diagnostics and dynamic support for farmers was overlooked, thus limiting practical application in an actual field scenario.

Agus *et al.* [18] developed the Expert System for Rice Plant Disease Diagnosis (ESforRPD2), capable of detecting 48 symptoms and eight types of rice diseases. The system achieved a sensitivity of 87.5%, providing treatment

recommendations. However, the system encompassed only eight diseases and there was no mobile integration, which limited access for smallholder farmers.

Sran *et al.* [19] developed a mobile-based expert knowledge system called Farm-n-Pedia to support Indian farmers in improving agricultural practices and boosting crop productivity. The app integrates a crowdsourcing system and expert insights, offering users personalized guidance, access to agricultural information, interaction with local farming communities, and updates on modern farming techniques via a single platform. However, it did not target rice disease management specifically, which undermined its value for rice extension services.

Khoerunisa *et al.* [20] developed a rule-based expert system to diagnose major rice diseases by collecting symptoms from the user and matching them with a rule set derived from domain experts. Their system achieved satisfactory accuracy in identifying diseases like leaf blast and bacterial blight and demonstrated the practical value of expert systems in supporting smallholder farmers with limited access to agronomists. The static rule-based system was limited in its lack of adaptive reasoning and contextual intelligence, and was therefore incapable of responding to the diverse, dynamic, and contextual variability of the environment and fields.

Jearanaiwongkul *et al.* [21] created ontologies using reliable sources to represent various abnormalities associated with rice diseases and developed an expert system named RiceMan. This system aids users in diagnosing issues with rice plants based on visible symptoms and offers suitable control recommendations. Nevertheless, the system works with pre-defined ontologies and thus may fail to accommodate the local disease and environmental changes, and the system also fails to address mobile optimization, which makes it less accessible for smallholder farmers who depend on smartphones.

In a different context, albeit more related to the work at hand, the mobile-based diagnostic tool for cassava mosaic disease designed by Adedokun *et al.* [5] does demonstrate potential. Even though the focus is on a different crop, the diagnostic tool does not interface with rice production systems. The system's lack of integration and thorough assessment in varied agricultural systems is of concern, despite its promising interface and rule-based querying system.

These gaps necessitate an evaluation-focused Design Science Research (DSR) approach to systematically assess the effectiveness, usability, and contextual adaptability of a mobile-based expert system designed specifically for rice disease diagnosis and management in Nigeria.

These successes also provide a valuable reference point for localizing similar technologies for Nigerian rice farmers. Overall, while there have been commendable efforts to integrate ICT into Nigerian agriculture, few systems are designed specifically for rice disease diagnosis with real-time mobile-based functionality. The current study fills this gap by providing a tailored, farmer-friendly expert system that leverages local knowledge and digital infrastructure to improve rice health management and boost productivity.

#### B. Existing Mobile-Based Expert Systems for Rice Production

Several mobile applications have been developed to assist rice farmers. This includes:

- **riceXpert:** Developed by the ICAR-National Rice Research Institute, this app offers comprehensive information on rice cultivation practices, pest and disease management, and post-harvest technologies.
- **TNAU Paddy Expert System:** Created by Tamil Nadu Agricultural University, this Android application provides detailed guidance on paddy cultivation, including variety selection, nutrient management, and pest control. User feedback has been analyzed to enhance its effectiveness.
- **Rice Doctor:** Developed by the International Rice Research Institute (IRRI), this mobile app is an interactive diagnostic tool developed to diagnose insect pests and diseases and enables farmers to make timely decisions for better pest management.

Despite these technological advancements, there is a significant gap in the literature and applications focused on African and Nigerian agricultural contexts. Most rice disease expert systems are developed and tested in Asian countries with different environmental conditions, disease variants, and farming practices. Thus, there is a pressing need to localize such technologies by training the systems on data from Nigerian rice fields and tailoring the interface to local languages and usage patterns.

This study builds on these insights by developing a mobile-based, rule-driven expert system for diagnosing rice diseases specifically within the Nigerian context. The knowledge base encompasses symptoms and management practices for the most prevalent rice diseases in major rice-producing states, including Kaduna, Kano, Ebonyi, and Nasarawa. The system's design also considers constraints such as limited internet connectivity, varying literacy levels, and the need for offline functionality. Such systems typically comprise three main components:

1. **Knowledge Base:** The knowledge base makes up the most important part of the developed expert system, as it contains the essential components of expert knowledge needed for diagnosing diseases affecting rice plants. It compiles a range of rules, facts, and heuristics derived from agricultural experts, peer-reviewed literature on rice pathology, and crop management literature. These rules were constructed to form a set of IF-THEN statements for a given set of diseased symptoms to allow for dependable reasoning and ensure diagnosis consistency. For instance, a rule might say: IF the diseased plant is at the tillering stage AND the leaf spots are grayish with necrotic centers, THEN it is likely to be leaf blast.
2. **Inference Engine:** The inference engine is the system's reasoning component. It processes input from users and applies logical operations on the knowledge base to arrive at diagnostic conclusions. The system uses a forward-chain reasoning approach, where the engine sequentially checks the rules until an input symptom matches a disease pattern stored in the system. The inference engine performed well during evaluation, providing diagnostic results almost instantaneously, even on devices with limited memory.
3. **User Interface:** The system employs a menu-driven, icon-based interface for the user-guided input of symptoms and diagnosis, where farmers can choose

symptoms from dropdown menus or images that illustrate the symptoms, reducing the textual overload and cognitive burden of manual recording. Diagnostic outputs are in simple, unambiguous language and are accompanied by pertinent visuals and practical management suggestions. This system also supports interaction in English and major local Nigerian languages: Hausa, Yoruba, and Igbo. This is to expand accessibility for smallholder farmers. The addition of voice-assisted prompts and context-sensitive help features may help users who struggle with reading.

### III. METHODOLOGY

The expert system is designed using a rule-based approach and developed for mobile devices to maximize accessibility. The study took a methodical approach that integrated knowledge-based system development with Design Science Research (DSR) in the planning and implementation of a mobile-based expert system for diagnosing rice diseases. The approach used sought to ensure that the developed artefact had both technical credibility and real-life farming relevance to the field. The sample included 50 smallholder rice farmers who owned smartphones, using purposive sampling and a structured questionnaire.

#### A. Requirement Gathering for the Mobile-Based Expert System

To answer the research question, data were collected using a semi-structured questionnaire. The respondents interviewed comprise rice farmers in Zaria, Ibadan, and Umudike. These locations are in Kaduna, Oyo, and Abia states, respectively.

To select the participants, both random and purposive sampling techniques were employed. A total of 90 respondents were randomly chosen from each location, resulting in a sample size of 270. The data was analysed using the IBM Statistical Package for Social Sciences (SPSS) version 26 to generate descriptive statistics.

The study also examined the farmers' willingness to adopt the mobile-based expert system. It was found that 129 respondents (47.78%) strongly supported adopting the system, while only 5 respondents (1.85%) were opposed to it, as shown in Table 1.

TABLE 1 WILLINGNESS TO ADOPT AN EXPERT SYSTEM (N=270)

Willingness to Adopt ES	Frequency	Percentage
Strongly Disagree	5	1.85
Disagree	9	3.33
Neutral	12	4.44
Agree	115	42.59
Strongly Agree	129	47.78

Source: Author's Field Survey, 2025

Table 2 shows the information needed by the respondents. This further reveals that 74.07% of the respondents need information on crop disease diagnosis and management, 57.78% need information on fertilizer application, 56.67% need information on irrigation techniques, and 44.44% need information on early warning for disease outbreak.

TABLE 1 INFORMATION NEEDS OF RICE FARMERS (N=270)

Information Need*	Frequency	Percentage
Crop disease diagnosis and management	200	74.07
Fertilizer application	156	57.78
Irrigation technique	153	56.67
Nursery management	91	33.70
Pesticide usage and safety	100	37.04
Early warning information	120	44.44
Market price information	98	36.30

Source: Author's Field Survey, 2025– \*Multiple Responses

Therefore, the most crucial information for rice farmers focuses on diagnosing and managing crop diseases. In response to this need, a mobile-based expert system was developed to assist in diagnosing diseases in rice plants.

### B. System Analysis and Design of the Proposed Mobile-Based Expert System

The next critical phase in this study was the system analysis and design of the Mobile-Based Expert System, aimed at creating an effective knowledge management solution for rice farming communities in Nigeria. This process began with a comprehensive needs assessment to identify rice farmers' knowledge gaps and informational needs. The foundation was laid by understanding the most valuable knowledge types needed and how farmers accessed information, to ensure the system would directly address their real-world challenges.

Following the assessment, the system architecture was carefully designed. This involved selecting the most suitable knowledge-based tools and technologies, including databases, intelligent search engines, and collaboration features, while ensuring seamless integration with existing farming practices. The Mobile-Based Expert System was developed from the ground up, tailored specifically to the requirements of rice farmers. Special attention was given to designing a user-friendly and accessible interface, making the system easy to navigate for users across different literacy levels. A detailed conceptual model and system flowchart were also created, providing a clear blueprint for implementation.

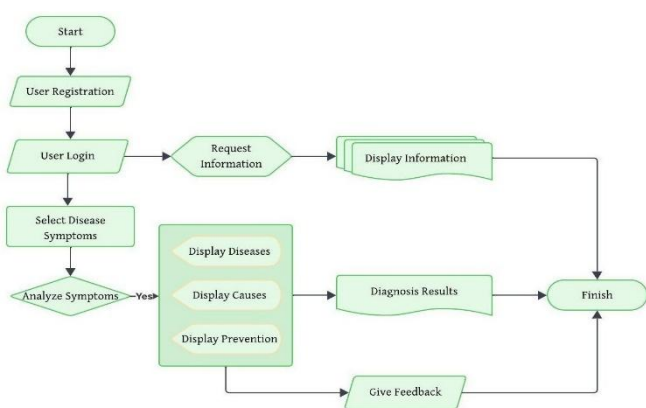


Fig. 1 Flow Chart Rice Plant Disease Diagnosis Expert System

### C. System Design and Development

The system follows a modular architecture with the following steps:

1. Knowledge Acquisition: Data was collected from agricultural experts, research papers, and field observations.
2. Rule Formulation: Symptoms and diagnostic criteria were encoded as "if-then" rules.
3. UI Development: A mobile app was created using lightweight design principles to ensure compatibility with low-end Android devices.
4. Testing and Validation: The system was tested in the adopted villages in rice-producing areas of Kaduna State.

### D. System Implementation

The RiceAdvisor system was developed specifically for Android mobile devices to ensure ease of access for farmers, even in rural areas. Recognizing that many users might face connectivity challenges, the advantage of this system is the offline functionality for disease diagnosis and management. This feature is specifically useful for farmers who live in remote areas with poor or no internet connectivity. Internet access is required for supplementary functions like retrieving weather information, receiving system updates, and syncing the system with the central knowledge base. Also, the system offers support in local languages to promote inclusiveness and facilitate interaction with farmers of varying language proficiency. The mobile application was built using Android Studio, Google's Integrated Development Environment (IDE), leveraging XML (eXtensible Markup Language) to create an intuitive and visually appealing user interface. The Dart programming language was employed to develop the inference engine, enabling it to intelligently match farmers' input symptoms with the appropriate diagnostic rules. SQLite, a lightweight SQL database optimized for Android, was used to structure the backend. The database is organized into several key tables, including the "Farmers' Information Table", which stores personal user details like name and phone number. The "Android Metadata Table" is essential for the database's smooth operation within the Android environment. The "Disease Table" contains disease profiles and recommended management strategies. The "Weather Information and Risk Alert Table" monitors weather conditions and issues early warnings. Symptoms Table, managing symptom data, and linking symptoms to potential diseases for effective diagnosis. This integrated architecture ensures farmers can easily navigate the application, input relevant information, and receive timely, expert-level support in managing their rice crops. By inputting symptoms through the user interface, the inference engine utilizes the knowledge base to diagnose potential issues and provide tailored advice. This approach enables Nigerian rice farmers, especially those in remote areas, to make informed decisions.

RiceAdvisor is a mobile-based expert system designed to enhance precision rice farming, accessible on Android and iOS devices. The system delivers expert advisory services, bridging the gap between conventional farming practices and modern technological innovation. A key feature of the application is its secure and efficient user registration protocol, which requires prospective users to provide essential credentials, including a full name, a secure password, and a valid mobile phone number, to facilitate authentication and personalized system access.

The prototype design features a user-centered interface that facilitates farmers' interaction with the Mobile-Based Expert System, as depicted in Figures 3 and 5. By integrating an intuitive layout with comprehensive functionality, RiceAdvisor seeks to enhance decision-making processes and

streamline agricultural operations by adopting intelligent mobile technologies. This approach underscores the transformative role of mobile applications in modern agriculture, particularly in expanding access to advanced rice production knowledge among a wider range of users.

Following successful registration, users are prompted to log in via the interface illustrated in Figure 3. Authentication can be completed by entering the phone number and password provided during registration. The System also features a user profile management interface, allowing users to update their personal information. Users can conveniently log out of the system through the same interface.

Beyond its core practical diagnostic functions, the Mobile-Based Expert System functions as a critical knowledge repository, offering rice farmers access to daily tips on best practices in rice cultivation. These insights are prominently displayed on the home page, ensuring that farmers have easy and regular access to up-to-date farming advice. Figure 6 highlights how the home page interface is designed to make accessing these daily tips straightforward and intuitive, supporting farmers in adopting improved techniques to boost productivity. Figures 6 and 7 illustrate the diagnosis result of possible disease and recommended treatment in English and in one of the Nigerian local languages (Hausa).

The user signs up by inputting their name, phone number, password, and selecting their language preference from the language settings. There are four languages, namely English, Hausa, Yoruba, and Igbo. After logging in, the system will display the main menu of the application. The main menu has options such as the Dashboard, the Diagnose, the Smart Advisor, the RiceAdvisor Tutor, and the Chatbot. The diagnosis comprises a Symptom Checker with a list of symptoms of rice diseases, and the Diagnosis Result. On the rice symptom menu, the system will display a list of symptoms for selection, and then click the analyse symptom button. Then the system will display the type of rice disease, along with explanations and prevention. Initial testing showed that the system could accurately identify common rice diseases such as bacterial leaf blight, blast, and yellow mottle based on symptom inputs. This will improve farmers' confidence in managing diseases, which will aid reduction of crop loss. The ease of use and availability on mobile devices will be key factors in user adoption.

### E. Usability Evaluation of the Knowledge-Based Expert System (KBES)

Satisfaction, effectiveness, and efficiency are the most common metrics used to measure usability. To assess how users perceived the usability of the Knowledge-Based Expert System (KBES), the widely recognized System Usability Scale (SUS) was employed. According to Zheng *et al* [21], it is a standardized tool in usability research that provides a prompt and consistent method for measuring a system's efficacy, efficiency, and satisfaction. It has 10 items, all of which focus on the user's direct experience with a system. Each statement is evaluated using a 5-point Likert scale with 1 being "Strongly Disagree" and 5 being "Strongly Agree".



Fig. 2 RiceAdvisor Homepage

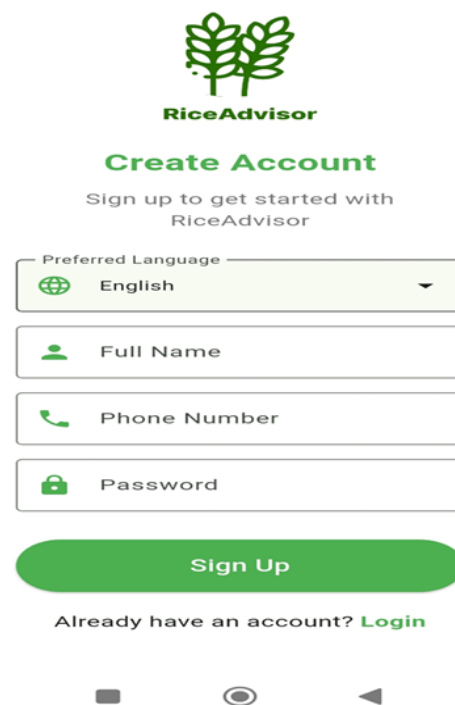


Fig. 3 User Login Interface

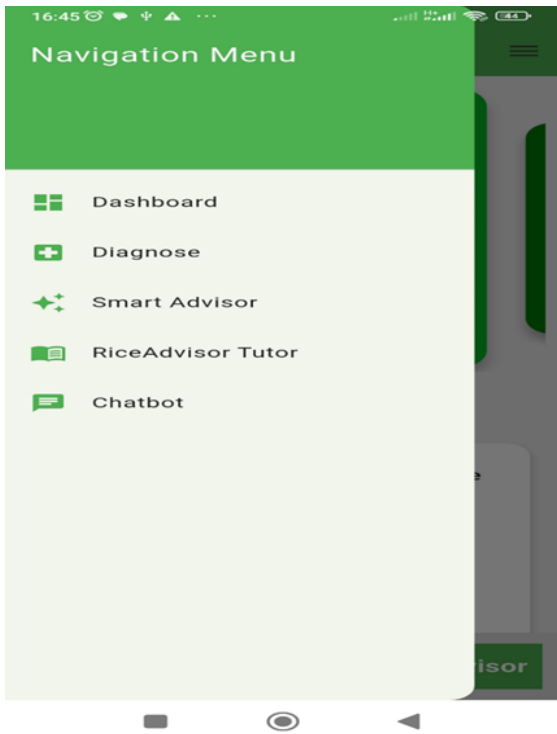


Fig.4 Navigation Menu Interface

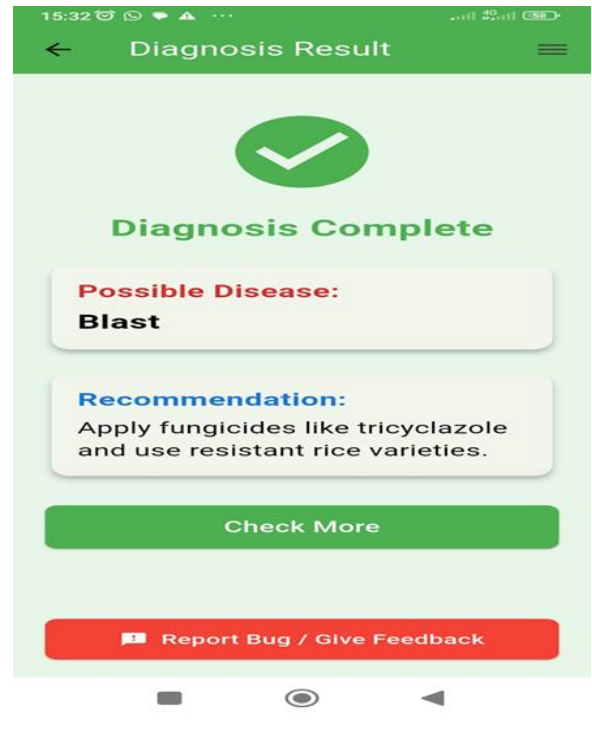


Fig. 6 Diagnosis Result Interface in English



Fig. 5 Tips on Prevention Interface



Fig. 7 Diagnosis Result Interface in Hausa Language

#### IV. RESULTS AND DISCUSSION

The usability assessment of the RiceAdvisor, conducted using the System Usability Scale (SUS), produced a mean score of 76.5. This places the system within the “Acceptable Usability” category, as defined by established SUS guidelines, and slightly above the widely accepted average benchmark of 68 [22]. This score indicates that users found the system sufficiently usable and satisfactory for practical application. Given the system's purpose to support intelligent rice farming,

this outcome is encouraging and suggests the RiceAdvisor App holds promise as a functional tool for agricultural extension services. The usability findings highlight the system's accessibility and adaptability to different user profiles. A SUS score of 76.5 signals accomplishment of user-centered design principles and success relative to Okai *et al.* [16], whose score was 70.025. Therefore, the RiceAdvisor's score reinforces its feasibility as a digital innovation for addressing the knowledge and resource gaps faced by rice farmers.

## V. CONCLUSION AND FUTURE WORK

This paper has presented the architecture, design, and development of a mobile-based expert system for the diagnosis of diseases in the rice plant. It is easy to access for users as the knowledge base is being loaded in memory in a compiled format. The expert system tool forms the start section just after the program runs. This is the main section of the expert system and the control rule of the system. The knowledge base contains knowledge about the different diseases of the rice plant, represented in separate sections. Such a system is especially useful for those farmers who cannot access information from the extension agents at any time for solutions to challenges faced with their rice farms. The architecture presented here is an integrated system with an interactive user interface, control and coordinating units, a mobile application, and structured knowledge representations. The design considered the involvement of intermediate interventions in runtime and considered rule application and the structuring of knowledge representations.

The mobile-based expert system provides a promising solution for enhancing rice production in Nigeria through early and accurate disease diagnosis. It empowers farmers with expert-level knowledge and bridges the gap left by limited access to extension services. Future work includes strengthening the system's functionality by integrating real-time environmental and sensor data to promote flexible diagnosis based on varying field conditions, expanding the knowledge base, and incorporating machine learning to improve diagnostic accuracy over time. Improvements in these areas will reinforce the system's impact on the management of rice production and the development of agriculture in rural areas.

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