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SaBaTech: A Banana Fruit Pest and Disease Detection Web Application

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ABSTRACT

Many farmers in the Philippines make a living from the banana sector, which is essential to the country's economy. Diseases and pests still have an impact on crop quality and output, though. In order to identify banana pests and diseases, this paper introduces SaBaTech, a web-based, real-time detection and classification tool that makes use of image processing and machine learning. The system, which was created using the Spiral Model, uses TensorFlow and Keras for deep learning and an ESP32-CAM for real-time picture capturing. For well-informed decision-making, it offers data visualization, SMS alerts, and report generating. SaBaTech received the highest "Functional Suitability" score (3.72), demonstrating its correctness, dependability, and efficiency, according to ISO/IEC 25010 testing. Its impact and usefulness are supported by input from agricultural practitioners, students, staff, and IT specialists. SaBaTech is a potential tool for precise agriculture; future developments include adding support for additional crops, increasing hardware-software compatibility, improving real-time processing, and lowering connectivity problems at distant fields.

INTRODUCTION

As one of the main agricultural exports from the Philippines, bananas are a vital component of the country's agricultural economy. A major staple crop and source of income for many Filipino farmers, bananas especially the Cavendish variety are among the most exported fruits in the world. The sustainability of this crop is essential to the nation's economic stability since it promotes food security and creates jobs in rural areas. However, there are significant obstacles facing the banana business that could jeopardize its long-term survival. The production of bananas is greatly impacted by environmental stressors like typhoons, drought, and more importantly pests and illnesses.

Banana monoculture cultivation is so common, there is less genetic variety, making the crops more susceptible to pests and illnesses. The likelihood of widespread crop failure from pests including Fusarium wilt, banana weevils, and caterpillars is increased by this lack of genetic variety. Farmers lose money as a result of these difficulties, and the country's food supply is put in danger. Banana crops must be protected from pests and diseases, but many smallholder farmers lack the resources, know-how, or access to put contemporary methods into practice.

To assist farmers in identifying banana pests and diseases, (Dita *et al.* 2018) created SPIDTECH, a mobile application that uses MobileNetV2 for pest identification via smartphone cameras. With more than 5,600 users worldwide and GPS-based mapping, it shows how digital tools may be used in local agriculture. In a similar vein, (Salvacion *et al.* 2019) emphasized climate change as a major role in the spread of global plant diseases like Foc TR4, endangering banana production in the Philippines, while (Kumar *et al.* 2015) emphasized the significance of cooperation and skill-based coordination in managing these diseases.

According to Blomme *et al.* 2017, Musa variants have low resilience, while Señeris *et al.* (2022) recognized bacterial and viral illnesses, such as Moko disease and BBrMV, as growing risks to banana production. (Churchill, 2011) (Bathan & Lantican 2010) highlighted how black leaf streak and other fungal infections lower yields and quality on both commercial and smallholder farms. Research conducted in Aklan and Mindoro (Montiflor *et al.,* 2019; Bathan & Lantican, 2009) demonstrated how farming methods, disease trends, and beneficial insects affect regional productivity.

With accuracy rates above 96%, Aasha *et al.* (2023) and Keshava *et al.* (2022) demonstrated the application of image processing and compressed sensing for disease identification on a global scale. In the study of Michael et. al., 2019 shows that deep learning models like ResNet50 and InceptionV3 able to classify banana diseases with over 90% accuracy, even in mobile apps (Sanga *et al.*, 2020). However in the investigation of Pal & Berntzen (2012), concentrated on PCR-based techniques for identifying banana viruses, guaranteeing early action, whereas Fang (2023) and Mohanraj *et al.* (2023) further validated CNNs' function in real-time illness diagnosis.

Despite advancements, smallholder farmers still lack adoption. The expense of developing new technologies, the scarcity of cellphones, and the lack of technological know-how in rural farming areas are major obstacles. Innovative, approachable, and user-friendly solutions that are suited to the requirements of Filipino banana producers are needed to address these problems.

This study suggests creating SaBaTech: A Banana Fruit Pest and Disease Detection Web Application as a solution to these issues. The technology is intended to give farmers access to an affordable, AI-powered platform

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that can identify pests and illnesses by processing images and offering practical advice. An imaging equipment will be used to assist the web application in order to record live images of banana fruits. When it is detected, a notification feature will send farmers an SMS with prompt treatment recommendations. To help farmers and other agricultural stakeholders make decisions, the platform will also produce comprehensive reports that include data visualizations, historical trends, and suitable management techniques.

SaBaTech will be evaluated using the Unified Theory of Acceptance and Use of Technology (UTAUT) and the ISO/IEC 25010 software quality model to guarantee system efficacy and user acceptance. These frameworks will assess the system's performance, usability, functionality, and chance of being adopted by the intended audience.

SaBaTech seeks to improve pest and disease control techniques, solve urgent issues in banana growing, and ultimately contribute to the sustainability of the Philippine banana sector by combining AI technology, real-time notifications, and extensive reporting capabilities.

MATERIALS AND METHODS

Development Method

The Spiral Model was adopted for developing the SaBaTech web application, combining iterative development with risk analysis to ensure systematic progression and adaptability. This model was selected for its suitability in handling projects with dynamic requirements, such as pest and disease management in agriculture. It provided a structured framework across four phases: planning, risk analysis, engineering, and evaluation, which were iteratively repeated to refine the system and address emerging challenges.

During the Planning Phase, stakeholders, including banana farmers, were engaged to gather requirements and set objectives. Critical technologies like image recognition and data visualization were identified to meet the needs of banana farming communities. In the Risk Analysis Phase, potential risks such as changes in pest behavior and environmental factors were assessed, and contingency measures were developed to ensure system resilience.

The Engineering Phase saw the development team iteratively creating prototypes and Minimum Viable Products (MVPs), with features like real-time pest detection and SMS notifications being refined based on user feedback. Finally, in the Evaluation Phase, the system was rigorously tested in agricultural environments, with feedback and performance metrics used to improve subsequent iterations, ensuring that the system aligned with practical farming needs.

Development Tools

The materials used for the development of the SaBaTech system were carefully chosen to support both the hardware and software requirements of the project. On the hardware side, the ESP32-CAM module was used to capture high-quality images of banana fruits for pest and disease detection. A DIY power bank, powered by dual 18650 batteries, ensured the ESP32-CAM's portability and reliability, especially in rural areas. Communication tools were employed to enable real-time alerts and notifications to farmers, while sensors and IoT devices facilitated both image capture and data transmission. For the software, development tools like PyCharm, Visual Studio Code, and Arduino IDE 2.3.2 were used for coding and debugging. TensorFlow and Keras served as the core frameworks for building and training machine learning models focused on image recognition. The Semaphore API was utilized for SMS notifications to provide timely updates to farmers. For local hosting during development, XAMPP was used to manage the web application's database and server. These materials combined to create a robust and efficient system tailored to the needs of banana farmers.

Testing and Evaluation

Data collection and analysis for the SaBaTech system were conducted through a comprehensive approach involving image data, surveys, and statistical tools. The image dataset was generated by capturing real-time images of banana fruits using the ESP32- CAM, which were then annotated for training the machine learning models. Additionally, a survey was conducted to evaluate the system's functionality, usability, and acceptance. Structured questionnaires, based on the ISO/IEC 25010 and UTAUT frameworks, were distributed to 100 respondents, including IT experts, faculty, and farmers. This feedback provided valuable insights into the system's effectiveness. Statistical analysis tools, such as Cronbach's Alpha and regression models, were applied to assess the reliability, performance, and usability of the system, ensuring that the SaBaTech platform met the expectations and needs of its users.

ISO/IEC 25010

The system evaluated using ISO/IEC 25010 follows a quality model specifying eight essential features for a complete software quality assessment. These include Functional Suitability, Performance Efficiency, Compatibility, Usability, Reliability, Security, Maintainability, and Portability, all crucial for evaluating the system's overall quality. Each feature ensures the system can meet user needs, perform efficiently, integrate seamlessly with other systems, and maintain security and

Table 1: Component of ISO/IEC 25010 Questionnaire

Criteria	Indicator
Functional Suitability	It assesses the system's capabilities fulfilled the specified requirements and achieved the intended outcomes during operation.

Performance Efficiency	It assesses the system's efficiency of resource usage inside a system, considering specific limitations.
Compatibility	It assesses the system's ability to work seamlessly with other software and hardware.
Usability	It assesses the system's effectiveness to achieve a goal in a timely and efficient manner.
Reliability	It assesses the system's ability to function well in the face of detects or challenges within certain circumstances.
Security	It assesses the system's efficiency and resilience in the storage and protection of information
Maintainability	It assesses the system's to effectively adjust to alternatives and uphold its core functionalities before and after different modification levels.
Portability	It assesses the system's ability to operate and adjust effectively in different software, hardware, and installation environments, as well as during any form of data transfer.

reliability. This comprehensive evaluation helps guarantee the system's effectiveness, adaptability, and long-term usability in real- world environments.

RESULTS AND DISCUSSIONS

System Interface

The SaBaTech system detects pests and diseases in banana fruits. Additionally, it offers data visualization, report generation, mapping, trivia, SMS notifications, prevention, and a user-friendly interface.

Admin Side

The succeeding figures are contained in system with the admin side.

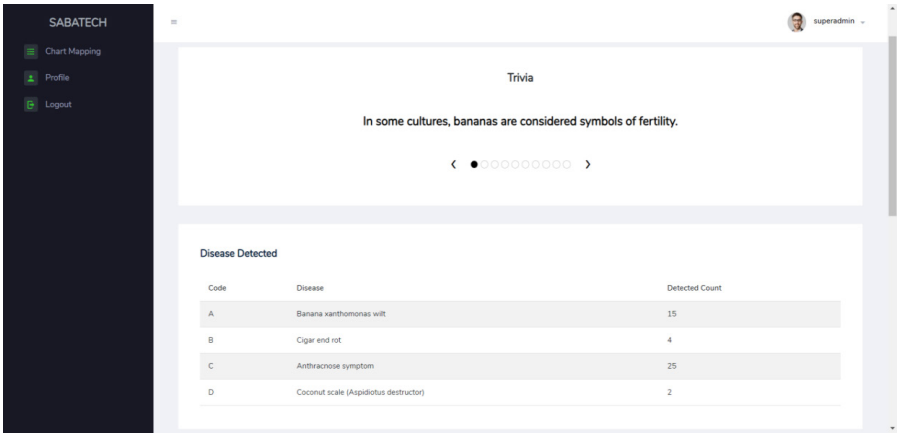

Figure 1: Dashboard

This admin control center is shown with a trivia section and actual live detection of pests and diseases. The dashboard monitors infection cases to be able to track spread and rate.

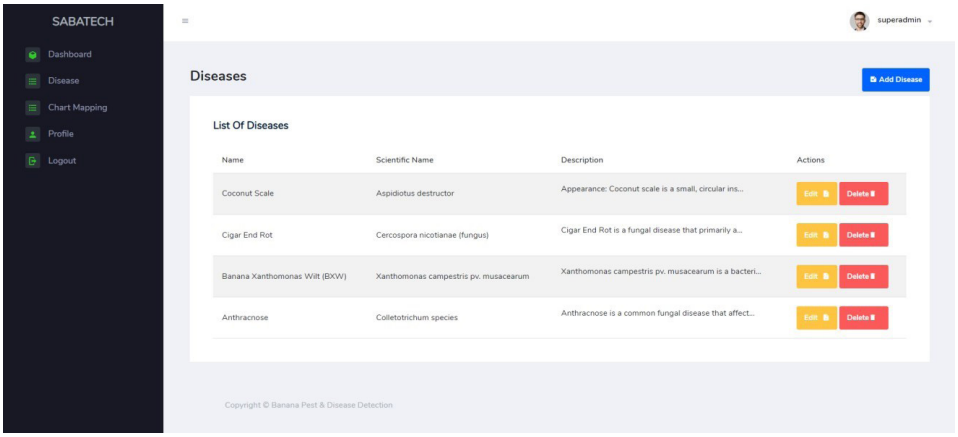

Figure 2: Diseases

The disease management interface allows admins to add, edit, or delete disease information, ensuring users access the latest data for accurate identification and diagnosis.

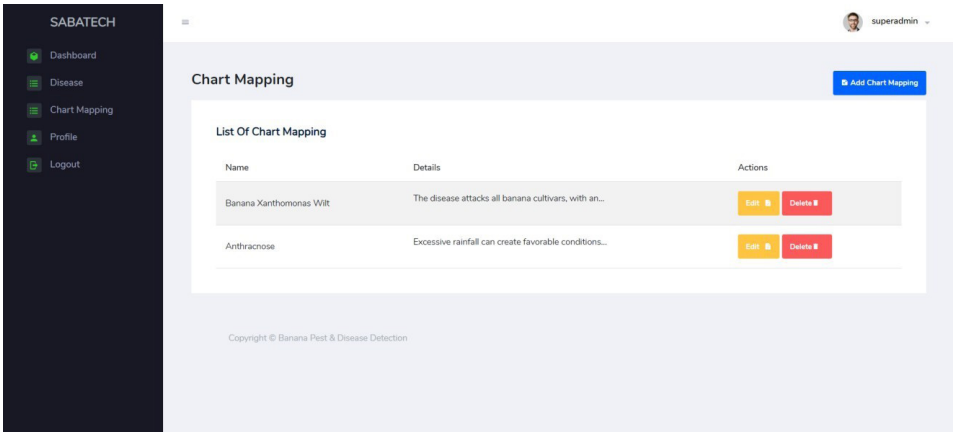

Figure 3: Chart Mapping

This figure shows the system's chart mapping, visualizing recorded disease cases. Admins can view details, update data, and analyze trends for better decision-making.

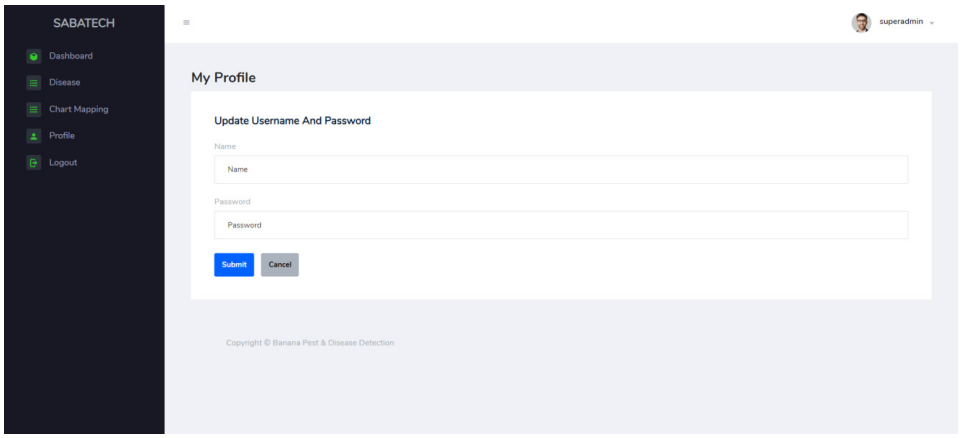

Figure 4: Profile

The figure shows the profile management module, allowing admins to update usernames and passwords, ensuring secure authentication and restricted access.

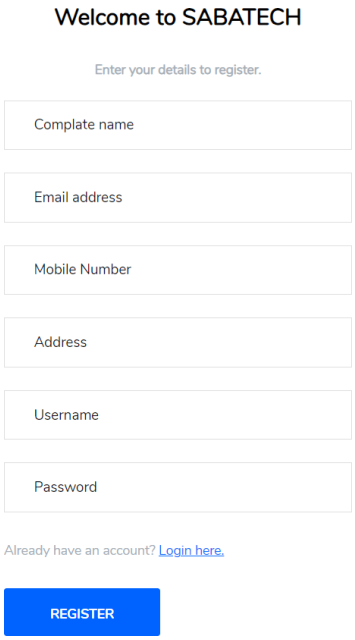

Figure 5: Register Form

This figure shows the user registration form, collecting essential details for secure authentication and system access.

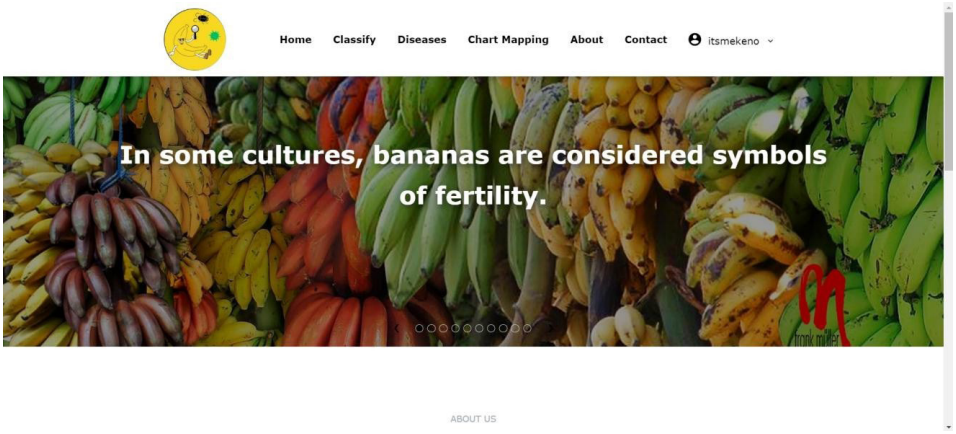

Figure 6: Homepage

This figure shows the system's homepage, featuring an interactive trivia section to educate users on banana cultivation, pests, and disease management.

This figure shows the classification feature, where users

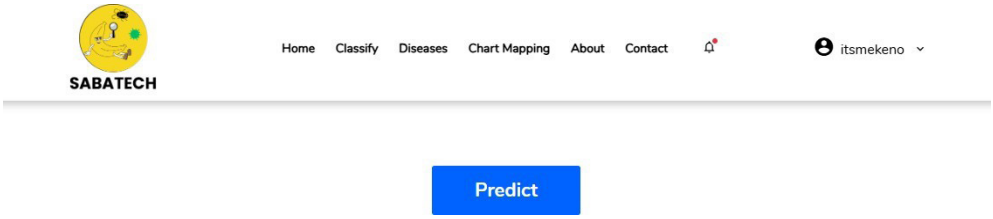

Figure 7: Classify

upload banana fruit images for analysis. A trained model predicts if the fruit is healthy or infected.

This figure shows the SMS notification system, alerting users about detected pests or diseases with diagnosis

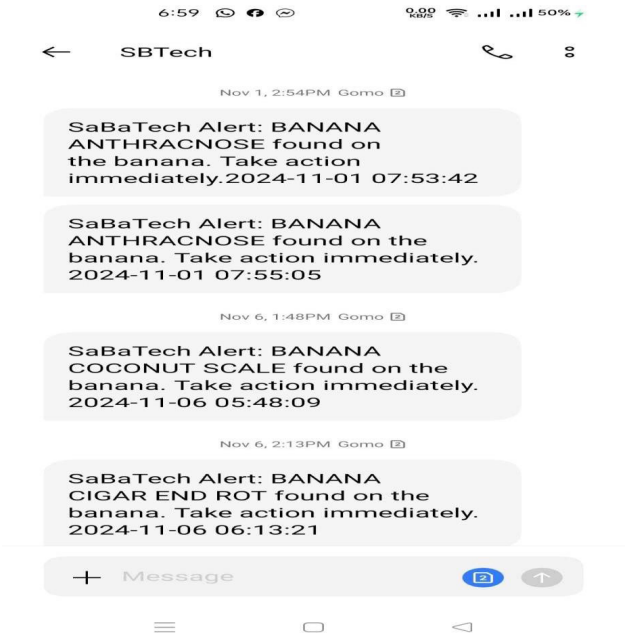

Figure 8: SMS Notification

results and timestamps for timely action.

Evaluation of the System

The evaluation assessed user satisfaction and guided system improvements by analyzing key aspects like Functional Suitability, Performance, Compatibility, Reliability, Maintainability, Usability, Portability, and Security of the SaBaTech system.

Table 2: Summary Results of the ISO 25010 Evaluation

Category	Overall Mean	Rank	Verbal Interpretation
Functional Suitability	3.72	1	Strongly Agree
Performance Efficiency	3.60	6	Strongly Agree
Reliability	3.56	7	Strongly Agree
Compatibility	3.67	4	Strongly Agree
Maintainability	3.68	3	Strongly Agree
Usability	3.63	5.5	Strongly Agree
Portability	3.69	2	Strongly Agree
Security	3.63	5.5	Strongly Agree
Overall Mean	**3.64**		**Strongly Agree**

Table 2 presents the summary results of the ISO 25010 evaluation for the SaBaTech system, with all categories rated as "Strongly Agree." The evaluation encompasses eight criteria, yielding an overall mean of 3.64. Each category demonstrates a strong level of user satisfaction, indicating that the system effectively meets the quality standards set forth by ISO 25010.

CONCLUSION

Conclusions from the study highlight the successful development of the SaBaTech System to support banana farmers with real-time detection of pests and diseases through image recognition and timely SMS alerts to reduce pesticide usage and increase productivity. User feedback shows that the system is user-friendly and efficient. Future improvement could be enhancing the system in terms of the expansion of disease detection, integrating AI-driven pest management recommendations, and addition of offline functionality for farmers in remote areas. The system would regularly undergo an update based on user feedback to become more responsive to the changing needs of banana farming, thus promoting sustainability and growth.

To improve the SaBaTech system, it is recommended to enhance usability with video tutorials and training, expand detection capabilities, and update the image recognition model. Implementing predictive analytics will enable proactive pest management, while multi-language support and smartphone compatibility will improve accessibility. Customizable alerts and stronger security measures, including two-factor authentication, will enhance communication and data protection. Future research should explore advanced machine learning techniques to further improve accuracy and efficiency.

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