Nanotechnology Perceptions
ISSN 1660-6795
www.nano-ntp.com

Disease Detection System in Rambutan Farming Through Machine Learning

Mc-ornoc T. Lamao

Doctor in Information Technology Student, Department of Information Technology, College of Information Technology and Computer Science, University of the Cordilleras, Baguio City, 2600, Philippines

Rambutan farming significantly contributes to the economy of Conner, often referred to as the "fruit basket of Apayao." Despite its economic importance, rambutan farming faces numerous diseases that affect its quality and marketability, resulting in considerable economic losses. This study performs a needs assessment to identify specific challenges local farmers and stakeholders encounter in disease detection and management practices. Using a mixed-methods approach, surveys and interviews with 128 local farmers and experts were conducted. Findings highlight gaps in knowledge, technology, and resources. Traditional methods for disease detection are laborious, time-consuming, and prone to errors, often failing to provide timely detection. These results will guide the design and development of smart disease detection systems for Conner, Apayao, transforming disease detection practices through the application of Machine Learning technologies.

Keywords: Machine Learning, Sustainable Agriculture, Disease Detection, Rambutan Farming, Needs Assessment.

1. Introduction

Rambutan, native to Southeast Asia, is a key crop in the Cordillera Administrative Region, especially in Conner, Apayao, Philippines, dubbed the "fruit basket of Apayao." It is vital for the local economy, providing substantial income for farmers and driving community economic growth [1]. Despite its importance, rambutan crops face significant disease challenges, reducing quality and marketability and causing economic losses. Early and accurate disease detection is critical for effective disease management.

Traditional disease detection methods rely on manual inspection by experts, which is labor-intensive, time-consuming, and prone to errors [3]. Advances in technologies like machine learning [4,5,8] present an opportunity to transform these traditional practices. Machine learning (ML) has proven to be a powerful tool for disease detection in agriculture due to its capability to analyze complex data patterns and identify early signs of disease in plants [8,9].

This research conducts a needs assessment to evaluate the potential application of machine learning for rambutan disease detection in Conner, Apayao. This study aims to develop a

precision agriculture approach, equipping Conner farmers with efficient disease detection tools to transform rambutan farming practices and promote economic prosperity through sustainable agriculture.

2. Methodology

This study utilizes a mixed-methods approach to explore the potential of machine learning in disease detection for rambutan farming in Conner, Apayao, Philippines. The mixed-methods design allows for a comprehensive understanding of the research problem by integrating data from multiple sources.

Survey questionnaires were administered to rambutan farmers in Conner, Apayao, to collect data on their current diagnostic methods, technologies, and attitudes toward machine learning. Additionally, semi-structured interviews with farmers and local officials were conducted to explore the challenges, needs, and opportunities related to disease management in rambutan farming. This study includes 128 respondents: local farmers, municipal agriculturists, and consumers.

Descriptive statistics were used to analyze the quantitative survey data, summarizing the characteristics and perceptions of rambutan farmers regarding disease detection.

3. Result and discussion

A survey conducted in Conner, Apayao, revealed a diverse range of farming experiences among respondents. 51% of farmers have been farming for less than 10 years, indicating a new generation in the municipality. 41% have 11-20 years of farming experience, and only 8% have been farming for over 20 years. This distribution affects disease detection and management in Rambutan farming. Farmers with over 20 years of experience have extensive knowledge of traditional practices, including disease management, which can be used to develop effective disease control strategies and integrate new technologies. Farmers with fewer years of experience may be more adaptable to new technologies, requiring more basic training on farming practices but more open to adopting innovative tools.

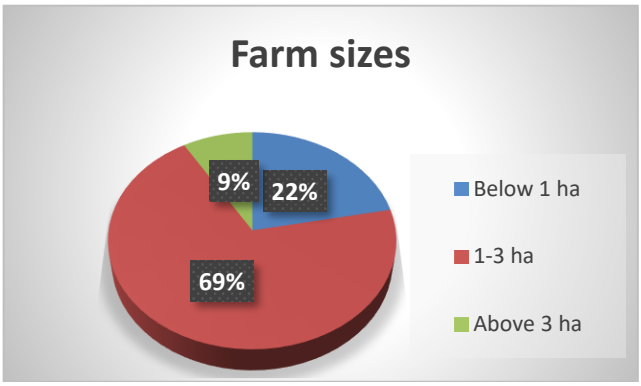

Fig. 1. Farm sizes of the respondents.

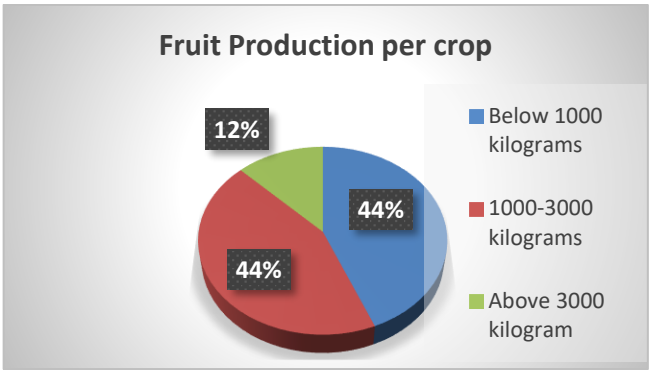

Fig. 2. Fruit production per crop

Figure 1 above shows a diverse range of farm sizes among respondents, with 69% owning medium-sized farms between 1-3 hectares. 22% own farms below 1 hectare, and 9% own farms above 3 hectares. Farm sizes impact disease detection and management in Rambutan farming. Larger farms may have more resources, leading to effective disease control measures and higher yields. Smaller farms face challenges in implementing sustainable agriculture practices, such as disease management, due to limited resources. Efforts should be made to support and resource these farmers to improve their sustainability practices and disease control.

As shown in Figure 2, the study reveals a diverse range of fruit yields among respondents from Rambutan farms. A balanced distribution of moderate to lower yields was observed, with 44% of respondents reporting fruit yields between 1000-3000 kilograms and below 1000 kilograms. However, 12% reported yields above 3000 kilograms, indicating a smaller proportion of farmers with higher productivity levels. This indicates that higher fruit yields may have more resources for disease detection and management, potentially leading to more effective disease control measures and higher profitability. Conversely, lower yields may face challenges due to limited resources, highlighting the need for support and resources to improve disease control and productivity.

Current Detection Process of Rambutan Farmers in Conner

In the agricultural landscape of Conner, the cultivation of rambutan fruit plays a vital role in the local economy. Farmers in this region have long relied on traditional knowledge and practices to navigate the complexities of rambutan production, from planting to harvesting. One critical aspect of this process is the accurate detection of rambutan ripeness, which is crucial for ensuring the quality and marketability of the fruit. Fig. 3 presents the current disease detection process of the rambutan farmers in Conner, Apayao.

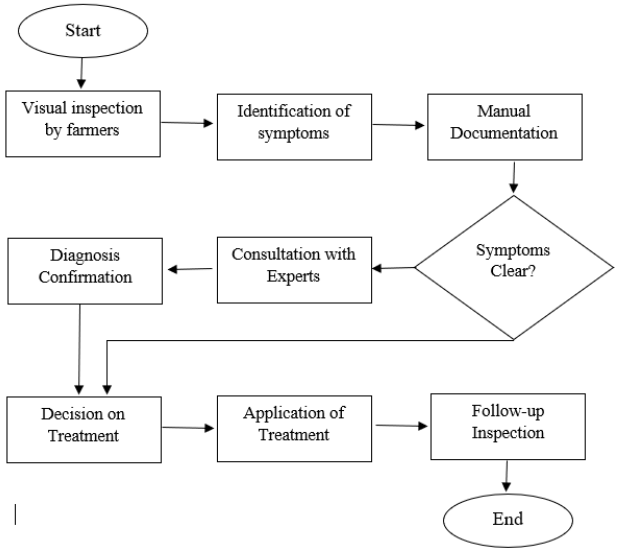

Fig. 3. Current disease detection process.

In traditional methods for disease detection in rambutan farming, the process begins with a visual inspection by the farmers. Farmers examine the rambutan trees and fruits, looking for symptoms such as discoloration, spots, and wilting. Based on their observations, they identify the symptoms by comparing them with known disease characteristics, relying heavily on their experience and knowledge of common diseases.

Once the symptoms are identified, farmers manually document their findings, recording the affected areas and the symptoms observed in notebooks or simple logs. If the symptoms are unclear or beyond the farmer's expertise, they may consult local agricultural experts or extension officers. These experts then visit the farm for further inspection to provide additional insights.

After gathering sufficient information, a diagnosis confirmation is made based on the visual inspection and expert advice. This diagnosis might involve identifying multiple possible diseases due to the overlap of symptoms. With a preliminary diagnosis in hand, farmers then decide on appropriate treatment methods, which could include the application of pesticides, fungicides, or other disease management practices.

Following the decision, farmers apply the selected treatment to the affected plants and monitor them closely to see if there is any improvement or worsening of the symptoms. Regular follow-up inspections are conducted to assess the effectiveness of the treatment. If the symptoms persist, the cycle of visual inspection and treatment might repeat until the disease is managed successfully.

Analysis of Stakeholders' Perspective

Table 1 evaluates respondents' knowledge of Rambutan farming practices, specifically disease detection and management, providing insights into their knowledge, and access to information among the surveyed individuals.

TABLE 1. KNOWLEDGE OF FARMING AMONG RESPONDENTS

Knowledge of Farming	Mean	Descriptive Rating
I have sufficient knowledge about the diseases affecting Rambutan fruit.	2.24	Disagree
I believe knowledge about disease detection and management is essential for successful Rambutan farming.	4.34	Strongly Agree
I have access to adequate training and information on disease detection and management in Rambutan farming.	2.23	Disagree
I feel confident in my ability to identify diseases in Rambutan fruit based on visual symptoms.	2.33	Disagree
I am aware of the latest research and developments in disease detection for Rambutan farming.	2.07	Disagree
Weighted Mean	2.64	Neutral

As can be gleaned from TABLE I above, the study reveals that Rambutan fruit farmers in Conner, Apayao, lack sufficient knowledge and training in disease detection and management, despite the importance of disease detection for successful farming. This gap highlights the need for a Smart Disease Detection System, which can enhance disease detection and management practices, contributing to sustainable agriculture [4,5].

Identification of Needs and Challenges in Implementing Machine Learning

The study explores the relationship between tradition and technology in Rambutan farming. The findings highlight the growing belief in technology's role in Rambutan production. It encourages a harmonious coexistence of tradition and technology, ensuring a fruitful legacy for future generations.

TABLE II. TECHNOLOGY ADAPTATION IN FARMING AMONG RESPONDENT

Technology Adaptation	Mean	Descriptive Rating
I have sufficient knowledge about the diseases affecting Rambutan fruit.	2.24	Disagree
I believe knowledge about disease detection and management is essential for successful Rambutan farming.	4.34	Strongly Agree
I have access to adequate training and information on disease detection and management in Rambutan farming.	2.23	Disagree
I feel confident in my ability to identify diseases in Rambutan fruit based on visual symptoms.	2.33	Disagree
I am aware of the latest research and developments in disease detection for Rambutan farming.	2.07	Disagree
Weighted Mean	2.64	Neutral

The survey results as shown in the TABLE II above indicates a strong preference for technology adoption in Rambutan farming in Conner, Apayao. Respondents believe technology is crucial for disease detection and management, and are interested in adopting new technologies. They believe technology can reduce disease impact on Rambutan production and is a worthwhile investment for agricultural practices. However, the mean score for currently using technology or disease detection tools in Rambutan farming is low, indicating that most local farmers are utilizing manual inspection in disease detection [3]. Despite this result, the overall weighted mean of 3.68 indicates a general agreement on the effectiveness and importance of adopting technology for disease detection and management in Rambutan farming.

TABLE III highlights the importance of resources in Rambutan farming, as they are crucial for growth and resilience, as perceived by those deeply involved in the farming process.

TABLE III. RESOURCES IN FARMING AMONG RESPONDENTS

Resources in Farming	Mean	Descriptive Rating
I have sufficient financial resources to invest in disease detection and management in Rambutan farming.	2.04	Disagree
I have access to the necessary human resources (e.g., skilled labor) for disease detection and management in Rambutan farming	1.95	Disagree
I have access to the necessary infrastructure (e.g., laboratory facilities) for disease detection and management in Rambutan farming.	1.78	Strongly Disagree
I believe that lack of resources is a major barrier to effective disease detection and management in Rambutan farming.	4.19	Agree
I believe that access to resources (e.g., funding, and equipment) would improve disease detection and management in Rambutan farming.	4.33	Strongly Agree
I believe that government support is essential for improving disease detection and management in Rambutan farming.	4.54	Strongly Agree
Weighted Mean	3.14	Agree

TABLE III above shows that respondents in Rambutan farming face challenges in disease detection and management due to a lack of financial, human, and infrastructure resources. Access to resources like funding and equipment would improve disease detection and management, and respondents strongly agree that government support is essential for improving these processes. This suggests that while respondents acknowledge the importance of resources and government support, they perceive a significant lack of access to these resources in their current farming practices. Respondents generally agree (3.14) on the significance of resources and government support in enhancing disease detection and management in Rambutan farming, thereby boosting farmers' incomes and supporting local fruit industry development [2].

Challenges and Opportunities in Implementing Machine Learning

Challenges include obtaining accurate data, requiring expertise for complex models, and high costs, particularly for small farmers. Inadequate infrastructure in rural areas further complicates implementation. However, machine learning offers significant benefits, including improved disease detection accuracy, increased farm efficiency, and enhanced environmental sustainability by enabling early disease detection and reducing crop losses.

Proposed Disease Detection Using Machine Learning

A proposed disease detection using machine learning aims to improve the accuracy and efficiency of identifying diseases in Rambutan fruit. By leveraging machine learning algorithms, such as Convolutional Neural Networks (CNNs), the system can analyze images of Rambutan fruit and detect signs of diseases with high accuracy. This can help farmers quickly identify and manage diseases, reducing crop losses and improving farm productivity. The system also provides early detection, enabling proactive measures to prevent disease spread and minimize their impact. This system offers a promising solution for Rambutan farming. Fig. 4 below presents a diagram depicting the major components of the system.

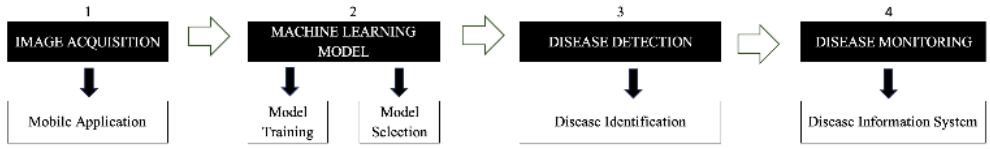

Fig. 4. Components of the system

1) Image Acquisition. The Rambutan fruit disease detection system will incorporate a mobile application for real-time image analysis, enhancing efficiency and accessibility, and utilizing flexible mobile technology for cost-effective and efficient disease monitoring.

2) Machine Learning Model. Integrating Machine learning (ML) will enhance rambutan disease detection, improving efficiency and effectiveness in agriculture by improving diagnostic systems and enabling more accurate interventions [14]. The integration of machine learning into rambutan disease diagnosis offers significant benefits, including increased accuracy [14], real-time monitoring [15], cost savings [16], and improved predictive capabilities [17].

Deep-learning architectures for plant disease detection are chosen based on factors like dataset size, computational resources, and desired accuracy level, affecting model accuracy, efficiency, and generalizability [18].

3) Disease Detection. Using machine learning (ML) for rambutan farming, disease diagnosis entails a systematic method with a focus on image analysis from the farmer's mobile application. The ML model used processes this image and identifies and classifies any diseases present.

4) Disease Monitoring. Once the image is processed, the system provides farmers with detailed information about fruit disease diagnoses and treatment options through a disease management dashboard. This dashboard identifies known diseases, their scientific and common names, and detailed descriptions of symptoms and affected areas. Fig.4 presents the proposed system architecture of the Rambutan fruit disease detection system by applying machine learning.

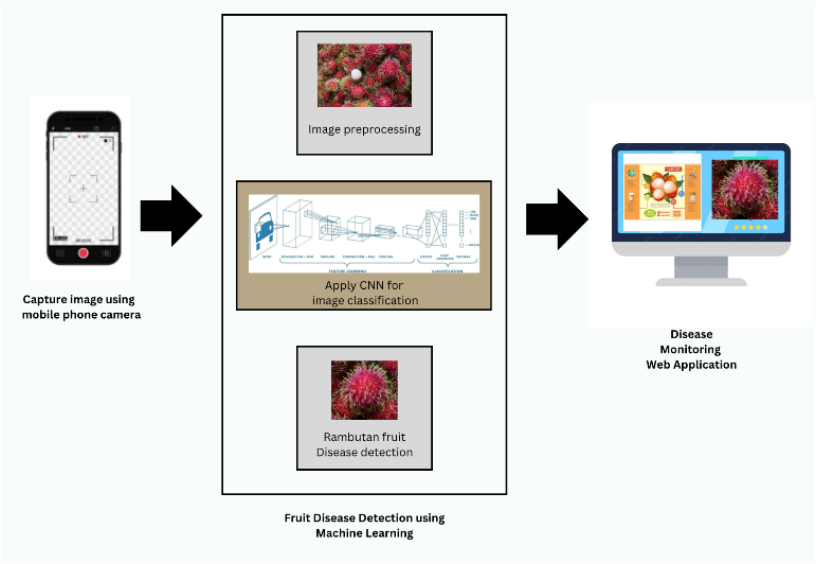

Fig. 5. Proposed system architecture

Figure 5 above shows the proposed rambutan fruit disease detection system that uses mobile phone technologies, advanced image processing algorithms, and Convolutional Neural Networks (CNN) to accurately identify and classify diseases in rambutan fruits. The system aims to provide users with a more efficient monitoring system through a web application.

The system begins by capturing rambutan fruit images using a mobile phone camera. Farmers use their mobile phones to take clear and focused pictures of rambutan fruit directly in the field. A dedicated mobile application guides users through the imaging process to ensure high-quality diagnostic results.

The core of the system is the classification of diseases using CNN. The trained CNN then accurately classifies the new image into rambutan fruit diseases, and these results are fed back to the mobile application and web monitoring system. The web-based monitoring system has a dashboard interface that provides detailed information on the results of disease detection. This proposed system aims to provide timely diagnosis, acceptable accuracy, maintainability, and simplicity. Early diagnosis through mobile image capture and real-time processing facilitates rapid correction as this proposed solution aims to promote crop health and yield in rambutan farming.

4. Conclusion

The rambutan farming community in Conner, Apayao, exhibits a diverse range of experiences and resources. There is a clear need for support in disease detection and management, as current technology use is low. To address these challenges, a machine learning-based disease detection system should be developed to transform the agricultural sector by providing early and accurate disease detection in Conner, Apayao. This would reduce crop losses, improve produce quality, and increase productivity. The integration of machine learning in agricultural

practices could foster a more sustainable and resilient farming ecosystem, ensuring the long-term viability of rambutan farming in Conner. This technological advancement would not only enhance farming practices but also drive social and economic growth in the community. Ultimately, this innovation would make farming more sustainable and productive, benefiting both farmers and the local community, and contributing to the overall social and economic development of Conner, Apayao.

Acknowledgment

I am incredibly grateful to the University of the Cordilleras and Apayao State College for their unwavering support and the resources they provided. A heartfelt thanks goes to my mentors, Dr. Nancy M. Flores, my professor, and Dr. Thelma D. Palaoag, my adviser and inspiring professor, for their guidance and encouragement and the entire UC-DIT Batch 2025 for their wise counsel and unwavering support.

References

1. Palapa1, T. M, Yalindua, A, and Maramis, A (2020). Sustainable Community Empowerment Through the Program of Self-Sufficient Village of Non-Rice Food in Raanan Baru. DOI 10.1088/1755-1315/448/1/012113. https://dx.doi.org/10.1088/1755-1315/448/1/012113
2. Agri chief: “Buy, promote local fruits” (2020). Official Portal of the Department of Agriculture. https://www.da.gov.ph/da-chief-buy-promote-local-fruits/
3. Domingues T, Brandão T, Ferreira JC. (2022). Machine Learning for Detection and Prediction of Crop Diseases and Pests: A Comprehensive Survey. Agriculture. 12(9):1350. https://doi.org/10.3390/agriculture12091350
4. Nirmal, M. D., Jadhav, P., & Pawar, S. (2022). Classification of Pomegranate Leaves Diseases by Image Processing and Machine Learning Techniques. Cybernetics and Systems, 1–15. https://doi.org/10.1080/01969722.2022.2145448
5. Madhavan, M. V., Thanh, D. N. H., Khamparia, A., Pande, S., Malik, R., & Gupta, D. (2021). Recognition and classification of pomegranate leaves diseases by image processing and machine learning techniques. Computers, Materials & Continua, 66(3), 2939-2955.
6. Mehmood, A.; Ahmad, M.; Ilyas, Q.M. (2023). On Precision Agriculture: Enhanced Automated Fruit Disease Identification and Classification Using a New Ensemble Classification Method. Agriculture, 13, 500. https://doi.org/10.3390/agriculture13020500
7. Rathore, S.S.; Shekhawat, K.; Singh, R.K.; Babu, S.; Singh, V.K. (2022). Diversification for Restoration of Ecosystems and Sustainable Livelihood. Sustain. Agric. Syst. Technol., 21–36. [Google Scholar] [CrossRef]
8. Manavalan, R. (2020). Automatic identification of diseases in grains crops through computational approaches: A review. Comput. Electron. Agric. 2020, 178, 105802. [Google Scholar] [CrossRef]
9. Ngugi, L.C.; Abelwahab, M.; Abo-Zahhad, M. (2020). Recent advances in image processing techniques for automated leaf pest and disease recognition–A review. Inf. Process. Agric. 2020, 8, 27–51. [Google Scholar] [CrossRef]
10. Benos, L., Tagarakis, A. C., Dolias, G., Berruto, R., Kateris, D., & Bochtis, D. (2021). Machine learning in agriculture: A comprehensive updated review. Sensors, 21(11), 3758.
11. Ruzzante, S., Labarta, R., & Bilton, A. (2021). Adoption of agricultural technology in the developing world: A meta-analysis of the empirical literature. World Development, 146, 105599.
12. Yengoh, G. T., Armah, F. A., & Svensson, M. G. (2010). Technology adoption in small-scale

agriculture.
13. Kaur, J., Hazrati Fard, S. M., Amiri-Zarandi, M., & Dara, R. (2022). Protecting farmers' data privacy and confidentiality: Recommendations and considerations. Frontiers in Sustainable Food Systems, 6, 903230.
14. Zhang, Z., Qiao, Y., Guo, Y., & He, D. (2022). Deep learning based automatic grape downy mildew detection. Frontiers in Plant Science, 13, 872107.
15. A. Sharma, U. S. Aswal, A. Rana, V. D. Vani, A. Sankhyan and Shekhar, "Real Time Plant Disease Detection Model using Deep Learning," 2023 6th International Conference on Contemporary Computing and Informatics (IC3I), Gautam Buddha Nagar, India, 2023, pp. 2695-2699, doi: 10.1109/IC3I59117.2023.10398070.
16. Kulkarni, A. H., & Patil, A. (2012). Applying image processing technique to detect plant diseases. International Journal of Modern Engineering Research, 2(5), 3661-3664.
17. B. Haveri and K. Shashi Raj, "Review on Plant Disease Detection using Deep Learning," 2022 Second International Conference on Artificial Intelligence and Smart Energy (ICAIS), Coimbatore, India, 2022, pp. 359-365, doi: 10.1109/ICAIS53314.2022.9742921.
18. Xu, M., Park, J. E., Lee, J., Yang, J., & Yoon, S. (2023). Plant Disease Recognition Datasets in the Age of Deep Learning: Challenges and Opportunities. arXiv preprint arXiv:2312.07905.