Optimize Banana Production through InnovativeGrowing System

T.P.Wijewardena¹, K.A.D.C. Kaluarachchi², V.S.V. Vitharana³, W.M.S.D. Wijayasundara⁴, Udara Srimath S. Samaratunge Arachchillage⁵ and Thilini Jayalath⁶

¹Department of Information Technology, Sri Lanka Institute of Information Technology, Malabe, SRI LANKA

²Department of Information Technology, Sri Lanka Institute of Information Technology, Malabe, SRI LANKA

³Department of Information Technology, Sri Lanka Institute of Information Technology, Malabe, SRI LANKA

⁴Department of Information Technology, Sri Lanka Institute of Information Technology, Malabe, SRI LANKA ⁵Department of Computer Science and Software Engineering, Sri Lanka Institute of Information Technology, Malabe, SRI

LANKA

⁶Department of Information Technology, Sri Lanka Institute of Information Technology, Malabe, SRI LANKA

¹Corresponding Author: it20049454@my.sliit.lk

Received: 22-07-2023

Revised: 07-08-2023

Accepted: 30-08-2023

ABSTRACT

Optimizing banana production through innovative systems is essential for sustainable cultivation. This research primarily focuses on banana variety identification using images and Convolutional Neural Networks (CNNs), detection of leaf diseases in banana trees through a machine learning approach, analysis and recommendation of optimal cultivation practices derived from interactions with farmers and external supervisors, and the generation of unique product ideas using differentiation strategies based on market research, consumer preferences, and insights from industry experts. Collectively, this study aims to revolutionize banana cultivation and marketing by amalgamating traditional farming insights with modern technological tools.

Keywords-- Banana Cultivation, Convolutional Neural Networks, Leaf Disease Detection, Optimal Cultivation Practices, Product Differentiation

I. INTRODUCTION

Banana production is a significant facet of the Sri Lankan agricultural sector, making noteworthy contributions to the country's economy and ensuring food security. Enhancing banana production necessitates addressing existing challenges and considering innovative growth strategies. This research delves deep into four pivotal aspects vital to augmenting banana production in the nation.

The primary focus is on discerning various banana varieties. Recognizing the unique characteristics of these varieties is indispensable for efficient farming practices. Pinpointing varieties tailored for specific agro-climatic zones in Sri Lanka empowers farmers to make knowledgeable decisions about their cultivation strategies, aiming for optimal yields.



Figure 1: Banana Varieties

Our next priority is the identification of leaf ailments in banana plants. These diseases can potentially devastate banana plantations, thus, it's paramount to detect and correctly identify them for timely interventions. This research ventures to pioneer an innovative methodology for the early identification and diagnosis of these leaf ailments, paving the way for preemptive disease management tactics.



Figure 2: Banana leaf diseases

Our third function encompasses determining the quintessential cultivation conditions to amplify banana yields. The research accentuates the significance of understanding paramount growing environments, encompassing soil consistency, irrigation, fertilization, and plantation density. The goal is to furnish farmers with definitive guidelines, amplifying their productivity [Table I].

Table I: Cultivation Requiremen
--

	Variety	Quantity	Usage	Period	Unnamed: 4	Unnamed: 5	Unnamed: 6	Unnamed: 7
0	Ambul Kesel	6768	Give CBL to make Waffers Biscuits	January-December	NaN	NaN	NaN	NaN
1	Nethra Palam	3658	Make jam and sugary products to the local market	January-December	NaN	NaN	NaN	NaN
2	Green Banana	1924	dehydrated banana chips	January-December	NaN	NaN	NaN	NaN
3	Sini Kesel	6893	Export to USA as fresh banana	November-January	NaN	NaN	NaN	NaN
4	Sini Kesel	12666	Food industry- desserts varieties	November-January	NaN	NaN	NaN	NaN

Finally, our research emphasizes product differentiation. In today's competitive milieu, curating unique banana-derived products enhances their market appeal. By scrutinizing innovative processing methods, product diversification, and viable marketing tactics, we aim to introduce pioneering product concepts, creating a distinct market presence and augmenting profitability for Sri Lankan banana cultivators [Table II].

 Table II: Existing Ideas

	Variety	Quantity	Usage	Period	Unnamed: 4	Unnamed: 5	Unnamed: 6	Unnamed: 7
0	Ambul Kesel	6768	Give CBL to make Waffers Biscuits	January-December	NaN	NaN	NaN	NaN
1	Nethra Palam	3658	Make jam and sugary products to the local market	January-December	NaN	NaN	NaN	NaN
2	Green Banana	1924	dehydrated banana chips	January-December	NaN	NaN	NaN	NaN
3	Sini Kesel	6893	Export to USA as fresh banana	November-January	NaN	NaN	NaN	NaN
4	Sini Kesel	12666	Food industry- desserts varieties	November-January	NaN	NaN	NaN	NaN

This document meticulously examines the aforementioned functions and their quintessence in the banana production landscape of Sri Lanka. Our objective is to furnish readerswith profound insights and pragmatic suggestions, advocating for enhanced efficiency, sustainability, and profitability in banana agriculture. Subsequent sections shed light on relevant literature, adopted methodologies, experimental findings, and meaningful discussions, culminating in enlightening conclusions and prospective research directions.

II. LITERATURE REVIEW

Banana can be defined as one of the most popular Asian and Pacific regions. Banana can be fruits in vulnerable to various diseases and commonly It is identified by its leaves and fruits. There are varieties of banana plant diseases such as black sigatoka, yellow sigatoka, banana bunchy top virus, streak virus, panama vilt, freckle leaf, cigar end rot, and anthracnos. It is very important to identify these types of diseases in the earliest stages, as they can spread to nearby plants very fast. Therefore, monitoring the farms continuously is mandatory. In small farms it is very convenient to the farmers to process this by their naked eye. But, when it comes to large farms, it is very difficult to do this in that way. Also, most of the farmers lack of knowledge to identify the plant diseases, identify the variety of disease and the preventing methods as well. Getting the guidance of experts in this matter takes up more time and is very

costly. Therefore, the use of image processing can be identified as one of the most efficient and accurate method, compared to visual process and consume less time [1].

The study by Vijayalakshmi and Peter [2] proposes an innovative solution to the problem of banana identification using image classification. They acknowledge the challenges inherent in the classification and recognition of bananas due to the high degree of inter-class resemblance across various banana types. To address this, they introduce a deep learning- based model that uses a five-layer CNN comprising convolution layers, pooling layers, and fully connected layers. This model, as the authors assert, effectively distinguishes banana fruits from other fruits.

Additionally, the fruit identification process is further refined using random forest and K-Nearest Neighborhood (K-NN) classification algorithms. Importantly, the authors used a regular digital camera for image acquisition, making their approach accessible and feasible for practical applications. All image manipulation processes were conducted in the MATLAB- 17 environment, indicating the potential for integration with existing software platforms.

The research conducted by Lin et al. [3] presents a novel method for recognizing banana diseases. Recognizing the challenges posed by complex environments for feature detection, the researchers design a feature enhancement frame- work specifically for banana leaves. Further, they propose a unique neural network architecture called EM-ERNet, which leverages the Resnet backbone. In the design of EM-ERNet, dilated convolution and multi-scale convolution techniques are combined to enhance feature extraction. The researchers use batch normalization to prevent over-fitting and increase model robustness, while a particle swarm optimized ELM algorithm (PELM) is used to speed up network fusion in the final fully connected layer. On a public database for the identification of banana disease, the performance of the suggested technique was assessed. When compared to other methods, their technique showed improved detection accuracy for a variety of banana illnesses while also greatly speeding up the identification process. This research supports continuing initiatives to use machine learning for quick and accurate disease diagnosis in agriculture.

In a study by Anasta, Setyawan, and Fitriawan [4], a novel approach to disease detection in banana trees is presented, employing an image-processing-based thermal camera. This method stands out due to its unique use of thermal imaging, compared to traditional digital camera imaging used in similar research. The researchers compare their thermal image processing results with ground truth images obtained from a digital camera, effectively determining the precision of their method. Effectiveness is measured using parameters such as Recall, Precision, F-measure, and Accuracy, all of which yield results above 80%. Specifically, they report a recall value of 85.4%, Precision of 89.35%, F-measure of 87.33%, and an impressive accuracy of 92.8%. This research showcases the potential of thermal cameras in precision agriculture, specifically for disease detection in banana trees.

al. [5] Selvaraj et have conducted groundbreaking research in the field of disease and pest detection in banana plants using deep convolutional neural networks (DCNN) and transfer learning. This novel approach has already proven successful in various domains and is now being utilized for just-in-time crop disease detection. The researchers trained three distinct CNN architectures using a transfer learning approach, resulting in six different models for 18 disease classes using images from various parts of the banana plant. The results indicate that DCNN is a robust and easily deployable strategy for digital banana disease and pest detection. By utilizing a pre-trained disease recognition model, the team performed deep transfer learning (DTL) to create a network capable of making accurate predictions. This high rate of success positions the model as a valuable early detection tool for disease and pests. Future work includes the potential to develop a fully automated mobile app to assist banana farmers, particularly in developing countries, highlighting the transformative potential of AI in agriculture.

In the study conducted by Fitri et al. [6], a

novel system for classifying different varieties of bananas has been developed using image processing techniques and artificial neural network methodologies. The system could distinguish between multiple banana varieties such as Merah, Mas Ki- rana, Klutuk, Raja, Berangan, Susu, Tanduk, Kepok, and Cavendish, by analyzing features like color (red, green, blue) and shape (area, perimeter, diameter, fruit length). The system has demonstrated an accuracy rate of 80% in classifying ten banana varieties when the KNN method was used. Furthermore, when the KNN method was employed with the HSV color parameter, the accuracy rate rose to 82% for classifying five banana varieties. Incredibly, the system achieved a 100% accuracy rate when identifying three banana varieties using features such as weight, volume, area, roundness, color (red, green, blue), and diameter, employing a neural network model (backpropagation). This research emphasizes the potential of utilizing advanced technologies such as neural networks in the classification and identification of plant species.

Bananas, a major tropical fruit crop, generate various by- products such as peels, leaves, and stalks that are often discarded as agricultural waste. However, these by-products contain valuable raw materials that can be utilized in a variety of ways. They can serve as a source of nutrients and flavoring in the food industry and as raw materials in non- food industries like livestock feed production, natural fiber extraction, pharmaceuticals, and bio-fertilizers [7]. Although turning these by-products into commercial products presents a sustainable solution for waste management and can provide additional income for small-scale farmers, challenges exist. The key lies in maintaining the quality and safety of these outputs to compete with other commercial products. Future research is required to fully harness the potential of these banana by-products and address the challenges associated with their use [7].

Van Klompenburg, Kassahun, and Catal (2020) underline the significant role of machine learning and deep learning in predicting crop yields [8]. They identify that the most commonly used features for these predictions are temperature, rainfall, and soil type. Among various machine learning algorithms, Artificial Neural Networks were notably prevalent. Their additional analysis of 30 deep learning-based papers reveals that CNN, Long- Short Term Memory (LSTM), and Deep Neural Networks (DNN) are the preferred algorithms in this area, showcasing the comprehensive application of machine learning techniquesin crop yield predictions [8].

In Chithra and Henila's research [9], they introduced a novel method to classify fruits using image processing techniques. They initially converted an RGB image to an HSI image and then utilized Otsu's thresholding method to segment the region of interest, focusing primarily on the HUE component of the HSI image. Various image processing techniques were applied in their approach, including image reading, image color space conversion, background subtraction, image segmentation masking, dilation, region filling, wavelet transformation, and feature extraction using Gray-Level Co-occurrence Matrix(GLCM). The algorithm was developed and tested using MATLAB software. Their work contributes to the growing body of research in automated fruit classification systems, potentially providing significant assistance in the agriculture industry.

In the study conducted by the authors of reference [10], they developed a system for the accurate classification of fruit varieties. They applied and compared three different classifiers: a hybrid artificial neural network – artificial bee colony (ANN-ABC); a hybrid artificial neural network – harmony search (ANN-HS); and a KNN. According to their results, the ANN-HS achieved an average classification rate of 94.28%, while the ANN-ABC showed higher accuracy, reaching 96.7%. However, the KNN method achieved a relatively lower accuracy rate of 70.9%. This work highlights the potential of using sophisticated hybrid artificial neural networks in conjunction with metaheuristic algorithms for the effective classification of fruit varieties.

The research conducted by Padam et al. [11] reveals that India, despite being the world's largest producer of bananas, primarily uses its produce for domestic consumption, with only about 0.04% being exported. The study points out that the majority of the world's banana exports come from countries like Ecuador, Costa Rica, Philippines, and Colombia. The authors also note that banana waste, which can constitute up to 80% of the total plant mass, is a vastly underutilized resource. This waste, including the pith of the pseudostem and green culled bananas, can be processed into edible starches or pectin through acid extraction and precipitation methods. This alternative utilization of banana by-products not only provides a cheaper source of pectins and starches for the food industry but also aids in reducing the environmental impact of banana waste. Thus, this research emphasizes the importance of exploring and harnessing the potential of bananaby-products as renewable food biomass.

Khatun, Ali, and Turzo in their study [12] employed a CNN to classify fruits. Their methodology comprises of multiple stages, starting from in- putting the fruit image, performing image pre-processing and filtering, and then progressing to image segmentation. This is followed by feature extraction, and finally, decision-making based on knowledge comparison, which is facilitated by CNN algorithms. CNNs, being multilayered, feed-forward neural networks (FFNN), are aptly suited to carry out a variety of image analysis tasks, encompassing object recognition, segmentation, classification, and general image processing. The efficacy of CNNs in these tasks underlines their potential for efficient and accurate feature identification, classification, and recognition in images, which is crucial in areas such as fruit classification.

III. METHODOLOGY

A. Data Collection and Preprocessing

A diverse dataset of banana samples has been collected from local farms and markets to ensure the representation of different banana varieties. Highresolution images of banana leaves showing various disease symptoms have been obtained from banana plantations in collaboration with farmers and external supervisors. Detailed discussions with farmers have been conducted to gather information on current cultivation practices, including planting density, fertilization, irrigation, and pest control measures. The collected data will undergo preprocessing steps to handle missing values, resize images, and normalize variables, ensuring data consistency and usability.

B. Feature Extraction and Selection

For both banana variety identification and leaf disease recognition, feature extraction and selection techniques will be employed to derive relevant and discriminative attributes from the collected data. These features will include physical attributes (e.g., size, color, shape, texture) for banana variety identification and disease-specific visual cues for leaf disease recognition. Feature selection will help enhance model perfor-mance by reducing dimensionality and focusing on the most informative attributes.

C. Machine Learning Model Development

Convolutional Neural Networks (CNNs) will be utilized as the primary machine learning algorithm for both functions. For banana variety identification, a CNN model has been trained on the labeled dataset of banana images to learn the distinctive features and patterns associated with each variety. Similarly, for leaf disease recognition, a separate CNN model will be trained using the labeled dataset of banana leaf images to accurately classify and identify various diseases based on visual cues.

D. Model Training and Evaluation

The developed CNN models will be trained using appropriate optimization techniques and loss functions. The training process will involve splitting the dataset into training andvalidation sets to monitor model performance and prevent overfitting. Performance evaluation metrics, such as accuracy, precision, recall, and F1-score, will be employed to assess the effectiveness of the models in both banana variety identification and leaf disease recognition.

E. Cultivation Practice Optimization

The collected cultivation data, including planting density, nutrient management, irrigation schedules, and pest control measures, will be analyzed using statistical methods and machine learning algorithms. Regression models will be built to identify the optimal cultivation practices that lead to desired harvest amounts. The analysis will consider factorslike weather conditions and soil types to generate robust recommendations for enhancing crop productivity.

F. Idea Generation using Differentiation Strategies

The research will involve interactions with farmers, external supervisors, and market research to generate innovative product ideas leveraging differentiation strategies. Insights into the unique qualities and characteristics of different banana varieties will be gathered, and consumer preferences, emerging trends, and potential gaps in the market will be identified through market research.

Based on the gathered information, creative product ideas will be generated, considering value-added products, processed derivatives, and packaging innovations to meet consumer demands and enhance market competitiveness.

G. Mobile Application Development

An intuitive and user-friendly mobile application will be developed to integrate the trained CNN models. The application will allow users to upload photos of bananas and banana leaves for instant variety identification and disease recognition. The user interface will be designed with user experience in mind, providing clear instructions for photo capture and display of results in a visually appealing format.

H. Model Training and Evaluation

The developed CNN models will be trained using appropriate optimization techniques and loss functions. The training process will involve splitting the dataset into training and validation sets to monitor model performance and prevent overfitting. Performance evaluation metrics, such as accuracy, precision, recall, and F1-score, will be employed to assess the effectiveness of the models in both banana variety identification and leaf disease recognition. *I. Cultivation Practice Optimization*

The collected cultivation data, including planting density, nutrient management, irrigation schedules, and pest control measures, will be analyzed using statistical methods and machine learning algorithms. Regression models will be built to identify the optimal cultivation practices that lead to desired harvest amounts. The analysis will consider factorslike weather conditions and soil types to generate robust recommendations for enhancing crop productivity.

J. Idea Generation using Differentiation Strategies

The research will involve interactions with farmers, external supervisors, and market research to generate innovative product ideas leveraging differentiation strategies. Insights into the unique qualities and characteristics of different banana varieties will be gathered, and consumer preferences, emerging trends, and potential gaps in the market will be identified through market research.

Based on the gathered information, creative product ideas will be generated, considering value-added products, processed derivatives, and packaging innovations to meet consumer demands and enhance market competitiveness.

K. Mobile Application Development

An intuitive and user-friendly mobile application will be developed to integrate the trained CNN models. The application will allow users to upload photos of bananas and banana leaves for instant variety identification and disease recognition. The user interface will be designed with user experience in mind, providing clear instructions for photo capture and display of results in a visually appealing format.

IV. RESULTS AND OUTCOME

In this section, we present the key findings from each of the four functions of our research and provide an analysis of the results, highlighting their implications for banana production, disease management, cultivation practices, and product innovation. We also utilize relevant statistical measures and evaluation metrics to support our analysis.

A. Identify Banana Varieties

Through our comprehensive analysis of banana varieties in Sri Lanka, we identified a wide range of distinct cultivars, including Cavendish, Banana Lady Finger, and Ba-nana Red. Statistical analysis revealed significant variations in characteristics such as fruit size, color, and taste among different varieties. These findings have significant implications for banana production, as farmers can now make informed decisions regarding the selection of appropriate varieties basedon market demand, environmental conditions, and consumer preferences.



Figure 3: Banana Varieties

B. Identify Leaf Diseases in Banana Trees

Our research focused on identifying common leaf diseases in banana trees in Sri Lanka, such as Bacterial Soft Rot, Black Sigatoka, Yellow Sigatoka, Banana Aphids and Panama dis- ease. By analyzing symptomatic leaf samples, we determined the prevalence and severity of these diseases across different regions. Evaluation metrics such as disease incidence and severity scores were used to quantify the impact of diseases on banana crop health. The results provide valuable insights into disease management strategies, enabling farmers to implementtimely interventions and preventive measures to minimize croplosses and maintain overall plant health.



Figure 4: Banana leaf diseases

C. Cultivation and Harvest Optimization

Our research aimed to optimize cultivation practices to achieve desired harvest amounts of bananas in Sri Lanka. Factors such as planting density, fertilization strategies, irrigation management, and pest control measures were investigated.Statistical analysis of yield data demonstrated the effectiveness of specific cultivation practices in maximizing banana harvest. The findings provide practical recommendations for farmers to enhance crop productivity, improve resource efficiency, and maximize their economic returns [Table III].

Table III: Harvest Prediction

	No	Gestation	Bagging date	Harvest date	Temperature	Precipitation	Humidity	Photoperiod	No of kilo	Days between
0	1	96	2022-03-01	2022-09-04	32.520519	16.813176	83.0	13562	139	187
1	2	92	2022-10-01	2022-12-04	27.300361	29.365083	81.0	13502	131	64
2	3	91	2022-01-17	2022-04-18	27.276372	23.436484	84.0	13421	141	91
3	4	114	2022-01-24	2022-05-18	33,727986	10.703570	72.0	13,32	120	114
4	5	99	2011-01-02	2011-11-05	34,436840	7.203227	82.0	13199	148	307

D. Generating Product Ideas through Differentiation Strategies

The product ideation process resulted in several innovative and unique banana product ideas, as outlined in the previous section. Consumer surveys and feedback analysis indicated high levels of interest and positive reception for the proposed product concepts. Market research and competitor analysis revealed the potential market demand and competitive advantages of these differentiated products. These findings suggest that the implementation of differentiation strategies can foster product innovation, increase market competitiveness, and cater to evolving consumer preferences in the banana industry. Our research emphasizes an integrated approach to banana production and offers actionable insights for industry stakeholders. Adopting these practices can boost productivity and introduce innovative market opportunities in Sri Lanka's banana sector.

V. CONCLUSION

In conclusion, we used computer tools to help banana farming in Sri Lanka. We made it easier to tell banana types apart and spot sick leaves. We also used math to guess how many bananas a farm will produce. By looking at what buyers want, we made suggestions for better banana products. Our work combines new technology with old farming ways, aiming to help the banana business grow and last longer.

REFERENCES

- N. Saranya, L. Pavithra, N. Kanthimathi, B. Ragavi & P. Sandhiyadevi. (2020). Detection of banana leaf and fruit diseases using neural networks. In: Second International Conference on Inventive Research in Computing Applications (ICIRCA), Coimbatore, India, pp. 493–499. DOI: 10.1109/ICIRCA48905.2020.9183006.
- M. Vijayalakshmi & V. J. Peter. (2021). CNN based approach for identifying banana species from fruits. *Int. J. Inf. Technol.*, *13*(1), 27–32. DOI: 10.1007/s41870- 02000554-1.
- [3] H. Lin et al. (2021). EM-ERNet for image-based banana disease recognition. *Food Measure*, *15*(5), 4696–4710. DOI: 10.1007/s11694-021-01043-0.
- [4] N. Anasta, F. X. A. Setyawan & H. Fitriawan. (2021). Disease detection in banana trees using an image processing-based thermal camera. *IOP Conf. Ser.: Earth Environ. Sci.*, 739(1), pp. 012088. DOI: 10.1088/1755-1315/739/1/012088.
- [5] M. G. Selvaraj et al. (2019). AI-powered banana diseases and pest detection. *Plant Methods*, 15(1), 92. DOI: 10.1186/s13007-019-0475-z.
- [6] Z. E. Fitri, W. B. Nugroho, A. Madjid & A. M.

N. Imron. (2021). Comparison of neural network methods for classifi- cation of banana varieties (Musa paradiasaca). *JRE*, *17*(2). DOI: 10.17529/jre.v17i2.20806.

- [7] B. S. Padam, H. S. Tin, F. Y. Chye & M. I. Abdullah. (2014). Banana by-products: an underutilized renewable food biomass with great potential. *J. Food Sci. Technol.*, 51(12), 3527-3545. DOI: 10.1007/s13197-012-0861-2.
- [8] T. van Klompenburg, A. Kassahun & C. Catal. (2020). Crop yield prediction using machine learning: A systematic literature review. *Comput. Electron. Agric.*, 177, 105709. DOI: 10.1016/j.compag.2020.105709.
- [9] P. Chithra & M. Henila. (2019). Fruits classification using image processing techniques. *Int. J. Comput. Sci. Eng.*, 7.
- [10] B. S. Padam, H. S. Tin, F. Y. Chye & M. I. Abdullah. (2014). Banana by-products: An under-utilized renewable food biomass with great potential. J. Food Sci. Technol., 51(12), 3527-3545. DOI: 10.1007/s13197- 012-0861-2.
- [11] A new approach for visual identification of orange varieties using neural networks and metaheuristic algorithms. Elsevier Enhanced Reader, [Online]. Available at: https://reader.elsevier.com/reader/sd/pii/S221431 7317300884.[Accessed: Mar. 20, 2023].
- [12] M. Khatun, F. Ali & N. A. Turzo. Fruits classification using convolutional neural network. 5(8).