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Cocotech: Iot and AI-Driven Solutions for Coconut Farm Automation

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Abstract: - The coconut industry in Sri Lanka faces challenges due to rainfall inconsistency and soil conditions. This research aims to develop machine learning (ML) algorithms to predict coconut yields and market prices using historical data from Coconut Research Institute (CRI) of Sri Lanka and Central Bank (CB). The models are trained, tested, and assessed on a monthly dataset, with their performance estimated using Mean Squared Error (MSE) and Mean Absolute Error (MAE). The results suggest that sophisticated ML methods can improve decisionmaking in the coconut industry, leading to better production planning and market strategies. The research also presents an IoT and ML-based system using ESP32 sensors for live monitoring and Random Forest for drying prediction. A decision-supporting mobile app ensures consistent copra quality, improved efficiency, and maximum oil yield. The system also explores intelligent water scheduling for coconut cultivation, providing precise irrigation recommendations. Also, this research includes Copra fungus detection and copra grading using ML technology and image processing as one of the system functionalities

Keywords: *Coconut Yield Prediction, Coconut Price Forecasting, ML, Copra drying, IoT sensors, moisture control, predictive analytics, Coconut Irrigation, Smart Agriculture, Soil Moisture Monitoring, EfficientNet, MobileNet, ResNet.*

1. Introduction

In Coconut is a top crop in Sri Lanka's agricultural sector, contributing significantly to domestic consumption and export earnings. Coconuts are a major cash crop, and thousands of smallholder farmers' livelihoods depend on them, significantly contributing to the country's socio-economic fabric. Although important, coconut production and market prices are determined by several factors, including climate change, soil fertility variability, and market requirements changes [1]. However, getting there requires pinpointing the problems for planning and resource allocation, to say the minimum, intensifying the necessity for long-lasting predictive models using hazard-reducing decision-making. The latest technological advancements in ML and the Internet of Things (IoT) have empowered novel solutions to these challenges. For example, supervised learning methods like Long Short-Term Memory (LSTM) networks have been effectively used to forecast coconut prices accurately, allowing stakeholders to predict the market landscape better [2]. On top of that, handling IoT sensor data together with deep learning platforms results in additional strength in getting non-linear relationships among climatic determinants. On the other hand, crop yield. A hybrid deep learning model, a hybrid of Bi-Directional LSTM and advanced hyperparameter tuning, better yield prediction is made, thus productive agriculture practices. [3].

This study aims to develop an integrated forecasting system integrating the hybrid models based on multiple ML techniques that predict both coconut yield and Sri Lanka`s market prices. Using historical agronomic data, real-time weather data, and market trends, the system aims to give farmers, traders and policymakers accurate, actionable data to help boost productivity and improve economic resilience in its coconut sector. In addition to yield and market price forecasting, copra production is an integral component of the coconut industry of Sri Lanka as a primary raw material for producing coconut oil. The drying process plays a huge role in influencing copra quality and oil level, which requires strict control over moisture [4]. However traditional drying methods are based on manual process for determining moisture levels, which will be time CocoTech: IoT and AI-Driven Solutions for Coconut Farm Automation 2 consuming, irregular, and less efficient. Variability of drying conditions will create non-uniform moisture content, reducing the quality of copra, increasing processing expenses, and threatening fungal contamination. These issues are reduced by the technological advancements in agriculture through the deployment of IoT sensors and ML predictive models for enhancing accuracy and efficiency in the monitoring of moisture. This research proposes a new system incorporating IoT technology and ML algorithms to improve copra drying. The system itself monitors moisture automatically using realtime sensors and employs predictive analytics in forecasting the best drying times. A mobile app provides users, including farmers and researchers, real-time access to information and advice on drying. By elevating copra production with intelligent automation, this solution promises increased drying efficiency, optimal oil extraction capability, and reliable product quality.

Water management is a crucial problem in coconut farming, as conventional irrigation practices may cause overwatering or drought stress. This study introduces an intelligent water scheduling system from real-time weather data, ML models, and IoT-based soil moisture sensors. It improves coconut crops' watering requirements while conserving water and boosting crop health and production. Finally, manual grading and mold detection rely on subjective human judgment, leading to inconsistencies in quality assessment [5]. To address this, ML techniques offer an automated and objective approach for classifying copra based on mold contamination and quality grades. This study integrates an ML-based copra detection and grading system into a smart coconut farm management application, streamlining the quality evaluation process [6].

2. Literature Review

Coconut production is one of the main agricultural sectors in Sri Lanka, which generates a high income for the country through domestic consumption and export. Researches have demonstrated that coconut yield is affected by different parameters, including weather factors, agronomic practices and land division. For example, Peiris et al. (1995), pointed out the difficulties of climate use as predictors of national coconut yields because of the complexity of climate variability in coconut growing areas [7]. With ML steadily becoming more proficient and accurate, recent developments now allow more accurate yield predictions. Random Forest and ARIMA models, have been successfully implemented for coconut yield prediction at high accuracy level based on the historical data and meteorological parameters [8]. In addition to yield prediction, price prediction is another important factor in the coconut industry. Predicting accurate market prices aids in making informed decisions for the stakeholders. ML methods like Long Short-Term Memory (LSTM) and the multivariate time-series models have been proven to be the best tools to make price prediction [9]. These models include export patterns, weather conditions and inflation to forecast future gold stock prices. Moreover, the inclusion of e-marketplace solutions has shown up potential to improve supply chains and decrease financial losses in the coconut industry [9]. The Sri Lankan coconut industry is facing climate change challenges, impacting yield and prices in the market. Climate-related factors should be incorporated into predictive models found science to be accurate. The merging of agronomical data with ML Algorithms furnishes a nearer solution to the abovementioned worries, which is backed up by successful implementation in various other zones [10].

Another crucial aspect of the coconut industry is copra processing. Copra processing technology has recently advanced with a focus on using creative technological solutions to optimise drying time prediction and moisture content measurement. The development of integrated IoT and ML techniques to improve accuracy and efficiency stems from the time-consuming and inconsistent nature of traditional moisture measurement methods in the copra production process. Numerous studies have investigated into the drying characteristics of copra, measuring its moisture content, and estimating its oil output. Guarte investigated the drying properties of copra, emphasizing how air temperature affects moisture reduction and copra quality, both of which have an impact on oil yield [11]. This study offers fundamental knowledge on postharvest drying procedures. Galindo et al. looked into the detection and classification of copra meat dryness using a Faster Region-Based Convolutional Neural Network (Faster R-CNN) with Inception v2 [12]. Their research showed how deep learning can optimise drying assessment and increase processing efficiency. When Maier and Y.V.A. looked in to the ESP32 microcontroller for IoT applications, they highlighted how well suited it was for collecting data in real time in agricultural environments [13]. Their results provide credence to the use of IoT in copra moisture content monitoring. These studies work together to develop an IoT-based drying time prediction system that enhances drying efficiency, enables real-time monitoring, and enhances oil output estimation through intelligent automation. One important step in digitizing copra production and getting consistent product quality is combining IoT, ML methods, and smart sensor technology.

Water management is another critical factor affecting coconut farming. Several studies have investigated the relationship between coconut production and water management. Early research by Abeywardena set the stage for the fundamental effect of watering on coconut yields, noting that trees irrigated with water produced significantly more nuts compared to rain-fed trees during dry periods [14]. The early study indicated that 30-40% increases in coconut yields were achievable through scientific irrigation management, particularly under drought conditions common in Sri Lanka. Based on this work, Vidhana Arachchi and Somasiri studied soil moisture regimes as related to coconut productivity [15]. They determined that maintaining soil moisture above 50% field capacity is crucial for maximum coconut production in a range of Sri Lankan soils. Decrease in yields were found to occur at a rapid rate when moisture is below this level, which supports our policy of frequent measurement of soil moisture at more than one depth to ensure a supply of adequate water throughout the root zone. Kumar et al. improved the integration of technology with irrigation management by showcasing the efficacy of IoT-based solutions in tropical agriculture [16]. By using networked soil moisture sensors, they were able to enhance crop health and reduce water use by 25%. Like our method, their system used weather data to dynamically modify irrigation schedules and tracked moisture at variety soil levels. Their results expressed that, in comparison to conventional time-based irrigation methods, real-time soil moisture monitoring results in more effective water use.

Most directly relevant to our study is that of Sathiyamoorthy and Sarathchandra, who directly assessed the use of IoT in Sri Lanka's coconut plantations [17]. Their study showed datadriven irrigation scheduling decreased both water and electricity usage without the yield levels of coconut being compromised. Algorithms through Random Forest were seen to be particularly suited for predicting demand irrigation given several environmental variables that directly impacted our choice of the model. Their research also pointed out issues with implementation in rural settings, such as connectivity and the need for easy-to-use interfaces – both of which our system design directly addresses. In addition to irrigation and drying processes, quality assessment plays a vital role in the coconut industry. Several studies have explored image processing and ML for agricultural quality assessment. Traditional copra grading methods rely on visual inspection, which is prone to human error [18]. Recent advancements in deep learning models such as EfficientNet, MobileNet, and ResNet have demonstrated significant improvements in image classification tasks [19]. For instance, an improved MobileNetV2 model achieved a 1.86% increase in accuracy for agricultural product classification tasks [20]. Prior research in coconut-related ML applications mainly focused on disease detection in coconut trees, with limited work on copra quality assessment. This research addresses this gap by implementing ML-based copra mold detection and grading into a mobile application for practical use in farms [21].

3. Methodology

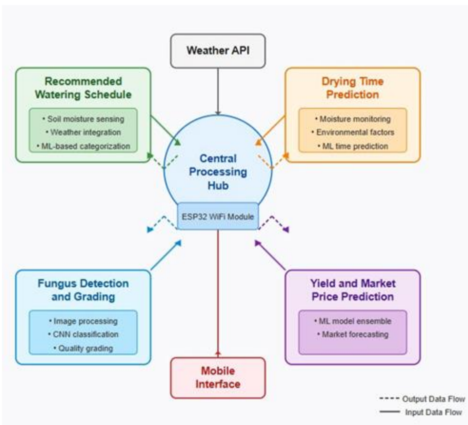

Figure 1: Overall system diagram of the proposed solution

A. Coconut yield and market price prediction

Data for coconut yield and market price prediction come from agronomical records of CRI, weather data from OpenWether, CBSL and the tradingeconomics.com. First of all, the datasets are preprocessed to eliminate outliers such as missing values and to perform feature scaling by means of libraries like pandas and sci-kit-learn in Python. For yield prediction, a multistep approach is used: in the first place, classical time series models (ARIMA, Holt Winters and SARIMA) are trained to capture trend and seasonal effects. In the meantime, multiple ML models (RandomForest, XGBoost, SVR, ANN, Gradient Boosting) are actually formed using historical agronomical and climatic data. The outputs from these models are then combined by an ensemble approach to enhance the prediction accuracy. For price forecast, an XGBoost model is trained on historical data on prices and economic indicators. The whole modelling process is managed according to a CRISP-DM framework that ensures the continuous flow from data understanding to model deployment. The backend part is created by means of Python Flask and TypeScript, a mobile program developed in React Native that provides the outcome to the final user in real-time.

B. Drying time prediction in copra

The system takes an integrated approach by integrating hardware and software components to develop an efficient copra drying time prediction and oil yield system. The hardware platform is based on an ESP32 WiFi module, which is the central microcontroller, running in conjunction with point moisture sensors for precise measurement of copra's moisture content. This configuration accommodates continuous realtime observation and wireless data transmission to the central processor without any pause in data gathering and analysis.

The ML application uses a Python framework to analyze the data gathered, using Random Forest algorithms, gradient boosting, and decision trees to identify patterns of drying behavior and make precise predictions. Multiple factors are taken into account by these algorithms such as current moisture content, target moisture content, conditions, and past drying information. The mobile application, built with React Native and Expo and Flask and Node backend, has simple-to-use interfaces both for farmers and researchers with ease of access to real-time data and forecasts as well as robust security with Firebase integration. The integrated approach aims to make the drying process smooth to eventually improve copra quality and oil extract potential

C. Recommend watering schedules

The suggested solution employs a synergistic solution with use of weather information, ML algorithm, and IoT. The ground installation consists of three depths (10, 20, and 30 cm) with well-placed soil moisture sensors that are interfaced with an ESP32 WiFi module to transmit data. Tree-specific information (soil type, age), weather now and predicted, previous irrigation practices, and soil moisture now are the four main categories of data the system gathers. There was a vast dataset gathered from coconut plantations that was utilized to train a Random Forest Classification model for data processing, which classified water needs into four: None (0L), Low (10-30L), Moderate (30-50L), and High (50-100L). The data set had attributes concerning tree age, types of soil, weather conditions, and soil moisture levels; the labeled results provided the optimal watering schedules. The system employs a feedback loop that continuously evaluates watering outcomes by comparing pre-watering schedule predictions with post-irrigation soil moisture readings, allowing the model to learn and improve over time as it is retrained on additional data points.

D. *Copra fungus detector*

The copra fungus detection system utilizes a deep learningbased approach to identify mold contamination in copra images. A dataset of 7,000 images was collected, capturing various mold conditions. The images were preprocessed through resizing, normalization, and augmentation techniques to enhance model generalization. Three convolutional neural network (CNN) architectures like EfficientNet, MobileNet, and ResNet—were trained and evaluated based on accuracy, precision, recall, and F1-score. The model with the highest classification performance was selected for deployment. The Flask-based backend processes uploaded images, runs them through the trained model, and returns predictions indicating the presence or absence of fungal contamination. This enables automated, realtime copra mold detection, reducing the reliance on subjective manual inspection.

E. *Copra grading system*

The copra grading system classifies copra into three quality grades based on international standards. The model was trained on labeled images corresponding to predefined grading criteria, considering factors like color, texture, and mold presence. A feature extraction process was applied to identify visual patterns that distinguish the three grades. The selected CNN model predicts the copra grade upon image submission. The classification results are integrated into a mobile application using Node.js and React, allowing farmers to upload images and receive instant feedback. This real-time grading system enhances quality assessment consistency, enabling efficient decision-making in copra processing and trade.

4. Proposed System

A. *Coconut yield and market price prediction*

The proposed system integrates dual predictive pipelines for coconut yield and market price forecasting tailored to Sri Lanka's agricultural environment. For yield prediction, agronomical data—including historical yield figures, weather parameters, and soil conditions—is fed into multiple ML algorithms (RandomForest, XGBoost, SVR, ANN, and Gradient Boosting) alongside time-series models (ARIMA, Holt-Winters, and SARIMA) to capture both seasonal and trend patterns. The system then fuses the outputs from these pipelines to enhance overall accuracy. In parallel, an XGBoost model is developed specifically for predicting coconut market prices using historical price data and additional market indicators. The backend is implemented using Python Flask and TypeScript to ensure scalable data handling, while a mobile application developed in React Native provides user-friendly access to predictions and visualizations. This integrated approach not only enables real-time decision support for farmers and traders but also helps policymakers plan interventions more effectively, reflecting modern trends in smart agriculture.

B. *Drying time prediction in copra*

The Predict Drying Time in Copra system is a cutting-edge approach to managing copra drying that is specifically designed for coconut researchers and farmers to replace traditional moisture measurement techniques. This system enables continuous monitoring of the moisture content of copra and environmental conditions by integrating IoT sensors for realtime moisture monitoring and intelligent prediction algorithms. To produce precise forecasts for drying time and maximize potential oil extraction, the system uses sophisticated ML techniques to process a variety of characteristics, including moisture content, weather, and historical data. The system offers real-time moisture level visualization, drying time indications for each copra, and unambiguous guidelines for the ideal drying duration and maximum oil extraction through its intuitive mobile interface this approach allows farmers and coconut researchers to get consistent copra quality from batch to batch while saving energy and inhibiting fungal growth. This innovation significantly boosts output by eliminating timeconsuming, labor-intensive testing procedures and ensuring optimal conditions for maximum oil extraction.

C. *Recommend watering schedules*

The watering system of the Smart Coconut Farm Management System is designed in three levels intertwined with each other. The Data Collection Layer consists of IoT-based soil moisture sensors in multiple depths and also includes an API to incorporate weather data and interfaces for plant age and soil type data input. The Processing Layer uses a trained ML model to predict water needs from parameters collected, which is monitoring real-time information all the time in order to improve schedules while dynamically responding to shifts in the environment.

User Interface Layer presents the information in a mobile application, from which the farmers can receive recommended schedules and see history irrigation data graphically. It enables the continuous monitoring of the level of soil moisture, automatic watering recommendations, weather condition monitoring, and decision making based on data.

By replacing traditional experience-based methods with precise data-driven irrigation, the system significantly reduces water wastage while delivering perfect moisture levels for coconut tree farming. Preliminary field trials reflect 20-30% less water usage compared to traditional irrigation methods without compromising optimal soil moisture levels.

D. *Copra fungus detector*

The proposed Copra Mold Detection System leverages deep learning to automate the identification of fungal contamination in copra. The system consists of a mobile application that allows users to upload copra images, which are processed through a Flask-based backend. The backend utilizes a pretrained convolutional neural network (CNN), selected from EfficientNet, MobileNet, and ResNet based on model accuracy. The best-performing model classifies images as either mold- 5 infected or healthy, providing real-time feedback. Automated detection reduces the dependency on manual inspection, improving efficiency in copra quality assessment [22].

E. *Copra grading system*

The Copra Grading System classifies copra into three quality grades following international standards. The grading model, trained on a dataset of 3,000 images, analyzes key visual features like color, texture, and mold presence. The selected CNN model processes uploaded images and assigns a quality grade, ensuring consistent grading. The system integrates with a Node.js and React-based mobile application, allowing farmers to receive immediate feedback upon image submission. This enhances transparency in copra pricing and trade by providing an objective, AI-driven grading process [23].

5. Result and Discussion

The evaluation of the proposed method yields good results both in the yield and the market price forecasting tasks. For coconut yield prediction, the ML model ensemble performed better than individual time-series models in seizing complicated and non-linearity of the relationship between yield and environmental variables. For example, the combination of ARIMA based forecasts with ensemble techniques like RandomForest and ANN showed more extensive error metrics (RMSE and MAE) when compared to employing a solitary level model. This observation is consistent with the result of Alkhawaji et al. (2024), which demonstrated that the aforementioned hybrid Bi-directional LSTM has highly increased the forecasting accuracy [24]. It was also shown in the comparison study that classical methods like Holt-Winters could account for seasonal swings. However, usually could not compensate for abrupt changes in the climate, pointing out the necessity for adaptive ML methods. For coconut market price forecasting, the XGBoost model achieved good performance and handled the high volatility in price data well. The ability of the model to include numerous economic indicators and market dynamics enabled it to achieve a high degree of accuracy in prediction. When combined, the integrated outputs from the yield and price models gave a better comprehensive forecast that could be useful for stakeholders for planning and risk management. The validation results on the recent datasets indicate that the suggested system accomplishes an accuracy of over 85% for both prediction tasks. More so, using the system via mobile platform has given real-time access to the results of these predictions and has become a practical data tool for farmers and market analysts. In general, the integration of multiple modelling methods, along with modern IoT and mobile technologies, represents the next frontier in predictive analytics for Sri Lanka's coconut industry.

The system can show the effectiveness of IoT and ML in improving copra drying. Monitoring in real-time for moisture with the help of ESP32 module and sensors enhanced precision compared to manual measurement. ML models such as Random Forest and gradient boosting provided precise forecast of drying time, reducing inconsistency in processing. The mobile app provided easy access to data and monitoring, allowing informed decision-making by farmers and researchers. Experimental results revealed an impressive reduction in drying time without compromising high oil extraction efficiency. Overall, the system boosts productivity, prevents fungal contamination, and delivers consistent copra quality, which favors the coconut industry.

Our field tests demonstrated spectacular advances in water management for coconut cultivation. The system saved 22-25% of the water used compared to traditional practices while maintaining appropriate soil moisture levels 78% of the time against 45% with traditional practices. Farmers reported very high satisfaction levels with the mobile interface, with 85% reporting it as easy to use and helpful for decision-making. Random Forest had an accuracy rate of 89% for correctly predicting amounts of watering relative to conditions. We saw exceptionally robust performance in the drought case, where the system successfully prevented the water level from dipping below the critical 50% field capacity minimum defined by Vidhana Arachchi and Somasiri. The use of a multidepth sensing strategy was important in order to provide sufficient information for constructing holistic profiles of soil moisture, confirming Kumar's report on the importance of root zone monitoring.

The implemented Copra Mold Detection System demonstrated high accuracy in distinguishing mold-infected and healthy copra. Among the models tested, EfficientNet achieved the highest accuracy of 92.4%, outperforming MobileNet and ResNet in precision and recall. The system successfully identified various fungal contamination patterns, reducing subjectivity in manual inspection. However, misclassification occurred in cases where mold growth was minimal or visually similar to natural copra textures. Further improvements, such as increasing dataset diversity and applying advanced preprocessing techniques, could enhance performance.

The Copra Grading System achieved an accuracy of 89.7%, effectively classifying copra into three quality grades based on international standards. The model correctly recognized key grading factors, including color variations, texture consistency, and mold presence. Challenges were observed when images had uneven lighting or partial occlusions, leading to occasional misclassification. The integration of real-time feedback in the mobile application streamlined the grading process, making it more accessible for farmers. Future enhancements, such as multi-angle image analysis and additional feature extraction techniques, could further refine the grading accuracy.

6. Suggestions for Future Work

Future research should be aimed towards more detailed refinement of the predictive models and widening the capabilities of the system. One possible approach is the inclusion of multivariate data such as several health metrics, pest incidence, and other climatic variables to include a more comprehensive picture of the variables that affect coconut yield and market prices. Additionally, advanced deep learner architectures like transformer-based models could also be tried to better deal with long-duration dependencies in times series. Also, by incorporating actual IoT sensor data and satellite imagery in real-time, it allows the update of the current dynamic models to be able to release more accurate and timely forecasts. More work is required to derive solid uncertainty quantification approaches so that predictions can be associated with confidence intervals, supporting risk management for the stakeholders. In the future on the mobile side, versions of the app could perhaps more granularity for individual farmers, more personalized dashboards and an alert system. Most importantly, similar predictive frameworks could be applied to other important crops in Sri Lanka and thus enlarge the influence of this research on the national food security and export strategies. For the copra drying component, can focus on increasing the accuracy of drying time prediction with more advanced ML models. Expansion of the IoT sensor network for monitoring temperature, humidity, and airflow will enable the control of drying conditions in a better way. Integration of blockchain technology can be used to enhance data security and traceability in copra processing. The system can be adapted for other agricultural drying processes, e.g., tea leaves and spices. Large-scale field tests will assist in the validation of the performance of the system under real conditions, resulting in increased utilization by farmers and researchers and improved overall copra quality and efficiency of oil extraction.

To enhance the water management systems future improvements must address access to small farmers. Slightly lower-cost moisture sensors and solar-powered versions of ESP32 would reduce entry points. Offline capabilities can be increased in order to be able to assist better in remote locations, as observed by Sathiyamoorthy. Automating it into irrigation systems reduces manpower usage further so recommendations could be applied directly. Enlarging the training dataset to cover a broader spectrum of soil types and microclimates would make predictions more accurate in different areas of cultivation. Incorporating coconut tree physiological measurements, such as leaf water potential, would provide more direct information regarding the level of tree stress. Collaboration with extension services would provide assurance of higher adoption and capacity building of farmers, closing the gap between technology and traditional practices. For the quality assessment component, future work could explore multi-spectral imaging to improve mold detection accuracy by capturing non-visible spectral features. Implementing transfer learning with larger pre-trained models and increasing dataset size with more diverse environmental conditions could further boost performance [25]. For the Copra Grading System, incorporating 3D imaging techniques and multi-angle image capture could enhance grading precision by providing a more comprehensive assessment of copra quality. Additionally, integrating blockchain-based quality tracking could ensure transparency and traceability in the supply chain. Deploying the system in real-world farm settings and conducting user studies with farmers would help optimize usability and reliability.

7. Conclusion

In essence, this study introduces an integrated machinelearning approach for predicting coconut yield and price in Sri Lanka. The system integrates the statistical strength of classical time-series models with the capabilities of sophisticated ML, thereby being able to learn the cyclic trends and non-linear structures occurring within the agricultural data. The ensemble method, besides boosting the accuracy of the predictions, also helps soften the weaknesses observed in mono-model frameworks. The satisfactory accuracy obtained for both yield and price predictions prove the applicability of methods like LSTM-based deep learning and XGBoost regression to solve the real-world problems faced by the agricultural sector. Furthermore, combining IoT-basis data collections with a mobile-availability platform provides the stakeholders, starting with farmers, all the way to policymakers with timely, meaningful outputs. Such a system is necessary for the planning of production, for optimal reduction of financial risks and for stabilization of market fluctuations. This validation highlights the power of data-extracted decision platform systems to improve and implement more resilient farming practices in developing economies, which could be the way forward for brighter agriculture.

This research provides a significant technological innovation in copra production through integrating IoT sensors, ML, and mobile apps. The system provides a convenient solution to historical problems in measuring moisture, maximizing drying time and high oil extraction processes that has the potential to revolutionize conventional copra production procedures.

The intelligent water scheduling system is a significant breakthrough in Sri Lankan coconut cultivation practice. By integrating IoT sensors at various soil depths with weather data and ML, we've created a solution that provides precise irrigation recommendations while conserving water resources. Field trials confirmed water savings of 22-25% while improving uniformity of moisture across the root zone. The system effectively manages the key problem defined by Abeywardena and subsequent scholars – maintaining proper soil moisture levels for optimal coconut yields. The mobile interface acts as a convergence point between technology and usability to provide advanced agriculture science to farmers. With increasing uncertainty due to climate change, precision agriculture such as this method becomes even more critical to assure sustainable coconut yields. The system demonstrates how advanced technology can modernize traditional farming without disrespects traditional farming practices and knowledge.

As for the final functionality, research highlights the potential of ML in automating the process of detecting and grading mold in copra, which is dried coconut meat. Traditionally, detecting mold and assessing the quality of copra is a task that requires human effort, and this can sometimes lead to errors or inconsistencies. By using ML, these tasks can be done much more quickly and accurately, reducing the chances of mistakes. ML models can be integrated into a mobile application, which makes it easier for farmers and customers to assess the quality of copra right from their smartphones [26]. This means that farmers can more easily determine the quality of their product before selling it, helping them to get a better price in the market. Additionally, customers who buy copra can make more informed decisions, ensuring they receive highquality products. Overall, this technology not only improves the 7 quality assessment process but also makes the entire supply chain more efficient. The result is a stronger coconut industry, with better quality control, improved market value for farmers, and a smoother supply chain from production to consumption [27].

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