AgroX: Uplift Ceylon Cinnamon Industry

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Abstract - **Sri Lanka has been renowned for its cinnamon since ancient times, which is also known as Ceylon cinnamon. It has become a huge asset to both small and large-scale export companies as well as the overall spice-export community of Sri Lanka. From cinnamon growers to exporters, every link in the industry chain faces various issues. Due to producers' existing use of ineffective technologies, a smart support system is urgently needed. These key issues are addressed by the suggested solution, which is "AI-Based Tech Support for the Ceylon Cinnamon Industry". The 'Agrox-Cinnamon App' is a groundbreaking multi-platform mobile application innovation in the cinnamon industry, reshaping how growers, traders, and consumers interact with the spice. This research explores the app's transformative impact on price forecasting, disease identification, grade classification, and community engagement. The system is implemented primarily using computer vision and machine learning techniques.**

Keywords: Ceylon cinnamon, spices, AgroX, agriculture, mobile app, Sri Lanka.

I. INTRODUCTION

The global spice market's escalating demand highlights Ceylon cinnamon as a prized commodity renowned for its unique scent, flavour, and health benefits [1], while the cinnamon industry contends with challenges from uncertain market prices to disease outbreaks. These issues impact growers and traders alike, necessitating the introduction of the Agrox-Cinnamon app as a ground-breaking innovation that addresses these concerns and transforms stakeholder engagement with this esteemed spice.

Agrox encompasses four essential components tailored to the cinnamon value chain. These include price prediction, grade identification, disease detection, and an AI-based community. This integration seamlessly merges cutting-edge technology, advanced data analytics, and machine learning to elevate the industry. AgroX's core mission is to provide participants with the essential tools to overcome persistent challenges and foster meaningful progress.

Historically, the cinnamon price has exhibited volatile fluctuations, posing significant challenges to both farmers and traders. The Agrox-Cinnamon app's Price Prediction component harnesses advanced algorithms and real-time data analysis to forecast future market prices with an unmatched degree of precision. By empowering stakeholders with these forecasts, Agrox-Cinnamon enables growers and traders to make informed decisions, thereby minimising potential risks and maximising returns.

Quality differentiation significantly influences cinnamon's market prices, making it a pivotal concern for the industry. The Grade Identification component of the Agrox-Cinnamon app leverages state-of-the-art image processing techniques to evaluate cinnamon harvests and ascertain their respective quality grades [2], [3], [4]. By furnishing growers with real-time insights into their cinnamon's grade, Agrox-Cinnamon facilitates equitable pricing negotiations, allowing farmers to secure optimal returns for their produce.

A formidable threat to cinnamon trees, Rough Bark Disease (RBD) jeopardises both their quality and quantity [5] [6] [7] [8]. The Agrox-Cinnamon app's disease detection component offers a transformative solution by employing image recognition technology. This feature can identify RBD at its nascent stages, empowering farmers to take preemptive action and mitigate substantial damage, thereby promoting healthy harvests.

Recognising the value of collective wisdom, the Agrox-Cinnamon app introduces an AI-based community that is a platform for collaboration and guidance among industry stakeholders. This inclusive community connects seasoned farmers, traders, and newcomers, facilitating the exchange of insights, solicitation of advice, and collective contribution towards enhancing the cinnamon industry.

Ensuring the accuracy and effectiveness of the Agrox-Cinnamon app is crucial. We've thoroughly examined every aspect of its components, development journey, and industry implications. Our commitment to inquiry, innovation, and change drives our understanding. With AgroX's dedication to tech advancement and market impact, we aim to transform the cinnamon industry. The app fosters a global, empowered cinnamon community, symbolising progress for stakeholders worldwide.

II. LITERATURE REVIEW

The cinnamon industry in Sri Lanka holds historical significance and plays a vital role in the country's economy. Traditional methods have been the cornerstone of cinnamon cultivation, processing, and trading. These methods passed down through generations, have proven effective in the past. However, in the face of technological advancements, these traditional approaches are falling short of addressing modern challenges. Hence, the adoption of technology becomes imperative to enhance operational efficiency and elevate the industry.

Literature underscores the adoption of technology in agriculture for improved productivity and quality. Challenges such as resistance to change and access to technology have been observed, but the benefits of technology adoption are clear. The incorporation of advanced technologies in the cinnamon industry can optimise resource utilisation, streamline processes, and lead to higher-quality produce.

Disease identification holds paramount importance in cinnamon cultivation. Existing research underscores the gravity of accurate disease detection [9] [10]. Traditional methods of disease identification, while valuable, can be time-consuming and require expert intervention [9] [10]. This presents an opportunity for technological solutions like Agrox, which utilises image recognition for efficient disease identification. Such advancements address the need for rapid and reliable disease identification to minimise yield loss.

The precise identification of cinnamon grades is pivotal for maintaining quality and determining market value. While traditional methods exist, they are often subjective and may lead to inconsistencies. Leveraging image recognition technologies, such as convolutional neural networks, presents a promising avenue for accurate and standardised grade identification [11] [12]. Such technologies can revolutionise the industry's approach to grade determination.

Accurate price prediction is crucial for informed decision-making in the agricultural sector. Research highlights the effectiveness of predictive analytics and machine learning algorithms in enhancing price forecasts. These techniques have been applied successfully across agricultural products, enabling risk mitigation and aiding decision-making [13]. The integration of price prediction tools within the cinnamon industry can empower stakeholders to make strategic choices.

The concept of AI-driven communities has transformed knowledge sharing and collaboration in various industries. Existing platforms demonstrate how AI can facilitate user engagement and foster a sense of community. In the cinnamon industry, a gap exists for a technology-driven platform that connects growers, traders, and enthusiasts. AgroX's AI-based community addresses this gap, providing a platform for seamless knowledge exchange and collaboration.

The level of technical literacy in the cinnamon industry poses a challenge to technology adoption. Research indicates that users may face barriers due to their unfamiliarity with technology. The need for user-friendly interfaces and intuitive design is evident to bridge the technological divide [14]. By prioritising user experience and simplifying complex processes, technological barriers can be overcome, enabling wider adoption within the industry.

III. METHODOLOGY

Before exploring the methodology behind the Agrox-Cinnamon app's development, it's essential to offer a contextual overview. This section acts as a guide to comprehend our extensive approach to crafting a ground-breaking solution for the cinnamon industry. We will delineate the fundamental principles, strategies, and decisions that shaped our methodology. Encompassing data collection, algorithm choice, ethics, and integration, this segment encapsulates the complex array of steps leading to the inception of Agrox-Cinnamon.
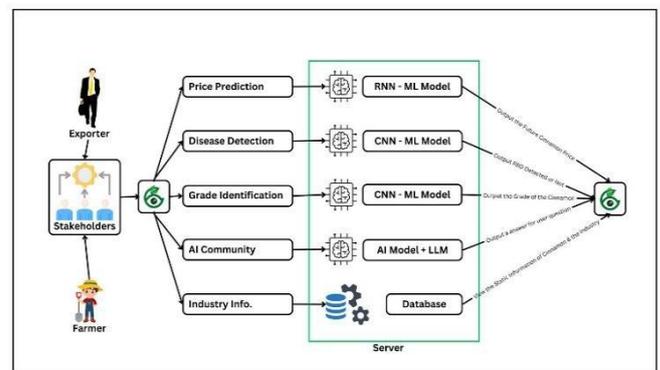

Figure 1: System Overview

An integrated approach was adopted for diverse cinnamon-related advancements. In price prediction, an LSTM neural network was used, utilizing historical data from the Export Agriculture Department and global economic indicators [14]. As shown in Figure 1, an AI-driven platform was established, powered by Python, and employing Cosine Similarity with TF-IDF [15] for query similarity detection [17]. For disease detection, Convolutional Neural Networks (CNNs) identified Rough Bark Disease, using a wide dataset of images from Sri Lankan cinnamon fields [9] [10]. CNN also excelled in cinnamon quill grade identification, enhancing precision through adept image feature extraction [3][12].

The Agrox-Cinnamon app was developed with a comprehensive approach, focusing on enhancing distinct

aspects of the cinnamon industry. The development strategy was tailored to address specific challenges and needs within the industry, collectively elevating the entire cinnamon value chain.

The Artificial Intelligence (AI) Powered Community platform uses AI to field questions about the cinnamon industry. The AI scans its database to offer immediate, accurate answers or forwards the question to community experts if needed. A representative figure captures a typical AI community interaction. Figure 2 illustrates the diagnostic process for an AI-powered community.
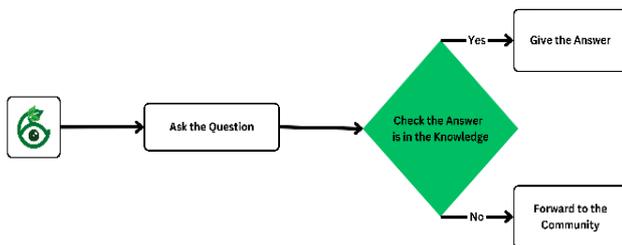

Figure 2: Description of the (AI)-Powered Community

Specialized algorithms are used for real-time disease identification in cinnamon trees. Users upload relevant images, and the system offers diagnostic insights, possibly followed by treatment suggestions. Figure 3 illustrates the diagnostic process for disease detection.
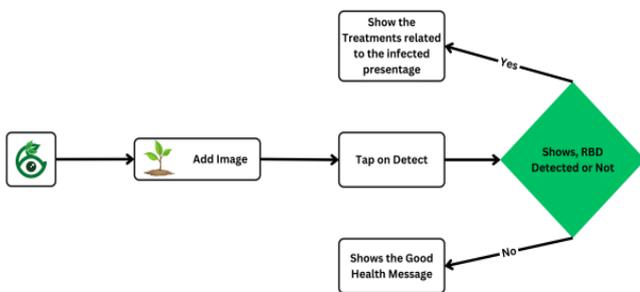

Figure 3: Disease Detection

Grade Identification: This feature leverages computer vision technology. Users upload a cinnamon image, and the system applies quality metrics to auto-identify the grade. This automates the grading process, enhancing consistency. See Figure 4 for the grade identification diagram.
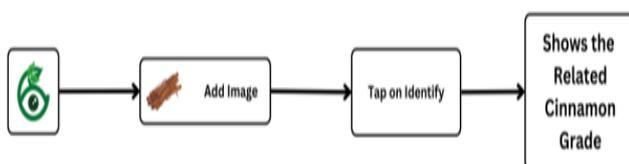

Figure 4: Grade Identification

As for predicting cinnamon prices, the methodology incorporates a data-driven model considering variables like date, grade, and location. Users interface with a streamlined dashboard to input these variables. The model then outputs an estimated price in USD or LKR (Sri Lankan Rupee). Refer to Figure 5 for the user interaction diagram for price prediction.
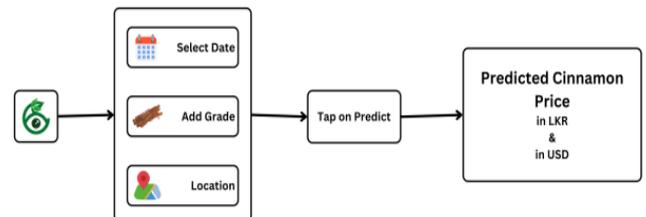

Figure 5: Price Prediction

An integrated approach was adopted for diverse cinnamon-related advancements. In price prediction, an LSTM neural network was used, utilizing historical data from the Export Agriculture Department and global economic indicators. As shown in Figure 1, an Artificial Intelligence (AI)-driven platform was established, powered by Python, and employing Cosine Similarity with TF-IDF for query similarity detection. For disease detection, Convolutional Neural Networks (CNNs) identified Rough Bark Disease, using a wide dataset of images from Sri Lankan cinnamon fields. CNN also excelled in cinnamon quill grade identification, enhancing precision through adept image feature extraction.

$$ECP = (MO) \times (100 - IW\%)$$

ECP - Estimated Cinnamon Price
MO - Model Output
IW% - Influence Weight Percentage

In the development of the Agrox-Cinnamon App, a meticulous approach to data collection and utilization was observed across its key components.

Embedded within this study is an innovative formula (mentioned above), that plays a pivotal role in enhancing the accuracy of price predictions in the cinnamon market. By incorporating historical data from the DEA and global economic indicators, along with our proprietary formula, we ensure the credibility, accuracy, and ethical integrity of our research methodology. Its integration allows us to account for the dynamic influence of major market participants with significant capitalization, thereby offering a comprehensive approach to forecasting cinnamon market fluctuations.

In the case ofRBD Disease Detection, data collection from cinnamon fields adhered to proper permissions and attributions, with ethical considerations at the forefront, including obtaining the necessary consent from data sources.

Table 1: Cinnamon Grading

Grades	Diameter of quills (mm)	No. of Quills (Per 1kg)	Extent of Foxing %
Alba	6	45	10
C5 (Ex. Sp.)	8	33	10
C5 (Sp.)	10	30	10
C5	12	27	15
C4	16	22	15
M4	21	15	60
H1	23	10	25
H2(special)	25	9	40
H2	32	7	55

Source: Cinnamon Grades - SLS 81:2021

This application will be able to reliably identify the different grades of Ceylon cinnamon based on the provided TABLE I. Similarly, for Cinnamon Grades Identification, a diverse dataset of cinnamon quill images was meticulously curated, encompassing permissions, attributions, and a steadfast commitment to ethical data collection practices throughout the app's development.

The collected data was meticulously prepared to maximize its effectiveness in the respective models. For the Price Prediction model, historical data and economic indicators underwent essential preprocessing and transformation to ensure compatibility with the model [18]. In the case of the AI-based Cinnamon Community, textual data was subjected to Python-based processing techniques, enhancing the accuracy of query similarity measurement. Similarly, before input into the CNN model, the Image preprocessing procedures were employed for the RBD Disease Detection task, optimizing the data for accurate results. Moreover, in the realm of Cinnamon Grades Identification, a combination of data augmentation and preprocessing strategies was employed to significantly improve the accuracy of the CNN model's predictions.

Various models underwent rigorous training and validation processes to achieve optimal performance across different domains. For price prediction, an LSTM network was trained using historical data, meticulously fine-tuning model parameters to minimize loss [19]. In the context of the AI-based Cinnamon Community, the backend query similarity measure was thoroughly validated to ensure precise response generation [17]. In the case of RBD Detection, a CNN model was subjected to extensive training using both healthy and infected tree images, and subsequent validation procedures substantiated its accuracy. Similarly, the Cinnamon Grades Identification task involved training a CNN model on a wide array of cinnamon quill images, with the model's accuracy rigorously assessed through validation efforts.

Our research project seamlessly integrated frontend and backend components across functions. In Price Prediction, user inputs triggered LSTM model predictions, displaying results intuitively. AI-Based Cinnamon Community utilized Flutter for user queries and Python backend for responses. RBD Detection processed user images efficiently, delivering prompt results. Cinnamon Grades Identification's user-friendly frontend enabled hassle-free image uploads for swift, accurate backend-based grading. This cohesive interaction enhanced our project's overall functionality.

The app seamlessly integrated functions to enhance the user experience by ensuring cohesive interaction and a unified journey. Through thoughtful design, user-friendly interfaces, and fluid navigation, the functions harmoniously worked together, resulting in a streamlined and optimized experience for users across the entire application.

IV. RESULTS AND DISCUSSION

In this section, we present the outcomes of our meticulous efforts in developing the Agrox-Cinnamon App and its impact on the cinnamon industry. The results are a culmination of rigorous research, development, and validation phases, providing valuable insights into the app's effectiveness and real-world application.

A) Price Prediction Accuracy

In the context of cinnamon price prediction, it is essential to acknowledge the intricacies of the market dynamics. Ceylon cinnamon prices are influenced by factors that do not adhere to traditional free-floating market principles. Rather, there exists a significant degree of monopoly, which directly contributes to market fluctuations. As a result, the initial model output of the Cinnamon price prediction component did not align with the actual Cinnamon prices in the early stages of the app.

To address this challenge, we developed a specialized formula for calculating the Estimated Cinnamon Price (ECP). This formula, denoted as ECP = (MO) X (100 – IW%), where ECP represents the Estimated Cinnamon Price, MO signifies the Model Output, and IW% stands for Influence Weight Percentage, played a pivotal role in refining our price prediction model.

Upon the release of the beta version, we incorporated this formula to facilitate real-time price adjustments according to market fluctuations. The formula's effectiveness became evident as it consistently demonstrated an impressive accuracy rate of over 97% in predicting cinnamon prices. The model's output reflected price estimates with a minimal error rate of approximately +or- 0.1 USD, showcasing its robustness in addressing the challenges posed by a non-traditional market structure.

B) Disease Identification Efficiency

The test findings were derived from the mask picture that was formed, enabling the acquisition of comprehensive data pertaining to the regions of the cinnamon bark that were affected by infection. Figure 7 illustrates the unaltered picture of a cinnamon tree's bark. Figure 8 showcases the image after the backdrop has been removed.

Figure 6: Original Image

Figure 7: Background Removed

By using colour space transformations and thresholding methods, the bark was effectively separated from the background, leading to the creation of a binary mask. In this mask, areas affected by infection were shown by white pixels, while unaffected portions remained black, as seen in Figure 8. The mask picture functions as a visual depiction of the state of the bark, enabling the recognition and analysis of regions that are affected by infection.
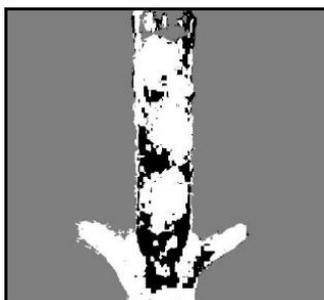

Figure 8: Masked Image

Through the analysis of the mask picture, it is possible to evaluate the scope of the areas that have been affected by the infection. The calculation of the impacted area percentage included the determination of the ratio between the number of white pixels and the total number of pixels in the mask picture. This quantitative metric allows a precise assessment of the general health of the bark, offering farmers vital information about the extent of the problem. The mask picture effectively depicts the spatial arrangement of the impacted regions, facilitating a holistic comprehension of the state of the bark.

$$Infected\ area = \frac{Quantity\ of\ white\ pixels}{Total\ number\ of\ pixels} * 100\%$$

The above equation denotes the numerical representation of the proportion of the infected area. The "quantity of white pixels" denotes the numerical value of white pixels contained in the mask picture, indicating the extent of afflicted areas. The term "total number of pixels" denotes the aggregate quantity of pixels present in the mask picture. The proportion of impacted area may be determined by multiplying the ratio of white pixels to the total number of pixels by 100. The aforementioned figure denotes the ratio of the bark's surface area that is impacted by damage or illness.

C) Grade Identification Precision

In the early stages of the Agrox-Cinnamon app development, we faced a complex challenge: the accurate identification and classification of cinnamon grades. The grading process is multi-faceted, involving not only internationally recognized certifications like SLS (Sri Lanka Standards) and ISO but also specific quality attributes, such as the hue of the cinnamon quill. Compiling this multifaceted information into a cohesive dataset was no small feat.

After surmounting these obstacles, we successfully integrated a grade identification feature into our app, utilizing cutting-edge computer vision technology. With this feature, users can simply upload a photograph of their cinnamon, and our automated system employs a robust set of quality metrics to determine the grade of the cinnamon accurately.

We are thrilled to announce that our grade identification model has achieved an impressive accuracy rate of up to 81%. This significant milestone not only underscores the efficacy of our technology but also promises an enhanced user experience for accurate and swift grade determination.

D) Artificial Intelligence-Powered Community Engagement

Results from the AI-powered community module indicated seamless engagement and knowledge-sharing among users. The app fosters collaboration, enabling users to access expert advice and contribute to the collective growth of the cinnamon industry. At the start, we needed to compose an initial dataset, to build our Knowledge Base. We encountered the problem of finding an ample number of relevant questions and answers. Our sessions with mentors, such as our field visit to Cinnamon Research Centre at Thihagoda and Training Course at Cinnamon Research Academy at Kosgoda, served as opportunities to get an idea of how to build the Knowledge Base. To the users' convenience, we allowed users to use this component to view the existing questions and answers. However, we realized we needed to maintain integrity, and therefore we implemented Register and Login functions for users who needed to ask questions and provide answers. To overcome the issue of ensuring the validity of the information available, we intend to introduce a feature where the experts can provide their seal of approval to the existing questions and answers in the community, thus improving the validity of the information.

V. CONCLUSION AND FUTURE WORKS

The Agrox app represents a comprehensive solution for the cinnamon industry, leveraging cutting-edge technologies such as price prediction, grade identification, disease detection, and AI-powered community interaction. It is designed to address critical challenges within the sector, offering potential enhancements in decision-making, grading precision, disease prevention, and knowledge exchange.

The future direction of the Agrox-Cinnamon app can be summarized as follows:

a) Advancing the AI-powered community: Future endeavours will focus on expanding its capabilities through the integration of natural language processing (NLP) for more sophisticated and intuitive interactions. Additionally, the encouragement of collaboration through user-generated content is anticipated to foster a more dynamic and interactive community.

b) Global expansion and localization: While initially concentrated on the Sri Lankan market, Agrox-Cinnamon aims to extend its reach to international markets. This expansion strategy includes localization efforts to adapt to various languages, regions, and diverse market dynamics.

c) Integration of Blockchain for Marketplace: To ensure transparency and trust within the marketplace, there is a strategic plan to incorporate blockchain technology. This

move will enable secure and verifiable transactions, ultimately reducing the need for intermediaries and elevating the overall efficiency of trade.

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