AgroNGO: A Machine Learning–Enabled Platform For Farm-To-Consumer Commerce And Sustainable Food Redistribution

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Abstract- *A major challenge that the agriculture supply chain is facing in India is the lack of technology. Fragmented with large losses in food post harvest, lowering farmers' income, poor food availability for low-income groups. This paper outlines a web based platform that creates a direct market between farmers, thereby not only catering to the needs of consumers but also enabling the distribution of near-expiry produce in agriculture to registered Non Governmental Organizations (NGOs). They combine a system that integrates a Random Forest ensemble classifier for analysing uploaded images to predict the freshness score of fruits and vegetables using OFV estimated shelf life. If the forecasted expiry period falls below a certain threshold (default: 2 days), the system automatically sends email alerts to farmers and all registered NGOs, so as to sell/donate them on time before it becomes a waste produce.*

The platform is implemented developing the front-end using HTML, CSS, and JavaScript and the backend using PHP; MySQL as the relational database; and Python for the machine learning module. Experimental evaluation on a labelled data set of 4200 fresh and near-expiry produce images across 12 different categories of common Indian agricultural commodities demonstrates that the Random Forest Classifier has an accuracy of 93.2%, a precision of 92.7%, a recall of 0.934, and an F1-score of 0.932. A 45-day pilot deployment resulted in a 27% rise in farmer profitability, a 19% reduction in consumer prices, the prevention of 340 kg of food wastage, and an estimated 2,800 meals served to NGO beneficiaries.

Keywords: AgroNGO, Random Forest, Freshness Prediction, Food Wastage Reduction, Farm-to-Consumer Commerce, Image Classification, Sustainable Food Redistribution.

I. INTRODUCTION

Agriculture is one of the primary sectors of the Indian economy, accounting for about 17% of the country's Gross Domestic Product (GDP) and employing almost 58% of the rural population. Yet, in spite of its importance, Indian farmers still encounter a lot of difficulties in the marketing and selling of their agricultural products. The Food and Agriculture Organization (FAO) reports that nearly 40% of food produced in India is being lost every year because it lacks proper storage facilities, transportation facilities, inefficient food supply chains, and market connectivity in real time. These losses account for billions of dollars annually and make a significant dent on small and marginal farmers' income. At the same time, many non-governmental organizations (NGOs), old age homes and food relief agencies are having trouble accessing affordable and nutritious foods when they have surplus and near expiry food which is not being sold and goes to waste.

Currently, the traditional agricultural markets and online trading platforms primarily serve the functions of commercial transactions between farmers, wholesalers and consumers, providing little assistance in assessing freshness and mechanisms for food redistribution. No intelligent system exists in the current platforms like eNAM or similar agricultural marketplaces to estimate the freshness of the produce, forecast the shelf life of the produce and alert the organizations that can make use of the surplus food resources. This has led to significant amounts of edible food waste, higher consumer prices as a result of the intermediaries involved, and financial losses for farmers.

To address these challenges, this research introduces a machine-learning based agricultural e-commerce system named AgroNGO to create a direct connection between the farmers, consumers, and registered NGOs. In the proposed system, the image classification model is based on Random Forest, which classifies images of agricultural products uploaded by farmers to classify the image into freshness categories and to estimate the shelf life. As the produce near their predicted expiration date the platform automatically sends email notifications to the farmers or registered NGOs, enabling them to sell the produce at a discount or do bulk sale or food donation without it spoiling. The system is designed

with HTML, CSS, JavaScript, PHP, MySQL and Python technologies and its main objective is to minimize food waste, while maximizing farmer income and cater to food access by the socially vulnerable populace. The proposed solution is an intelligent, automatic and sustainable approach, in comparison with traditional agricultural marketing systems, it has economic, environmental and social benefits, including the use of machine learning techniques and web technologies.

1.1Problem Statement

Despite of all the attempts to digitize farming, there are still a few drawbacks in farming supply chain. Farmers frequently rely on the intermediaries and commission agents to sell their crops and the amount of profit they receive is only a small portion of what it should be and they receive the payment later. In addition, the poor storage infrastructure, inefficient transportation system and the absence of real time connectivity makes the farm produce subject to high post harvest losses. A significant amount of edible fruit and vegetables perish between the farm gate and consumers, resulting in economic losses for the farmer and environmental issues. Current agricultural markets mainly deal with commercial transactions and lack intelligent mechanisms to determine freshness of the produce, predict the shelf life of the produce and alert the organisations who can put the excess food to use. This means that even the NGOs, old age homes, orphanages and relief organizations for food supplies find it difficult to get good produce at affordable rates, while they are able to get food items near to expiry. Furthermore, there is a high waste of food when there are no automated food redistribution systems. Thus, there is a need for a system that can facilitate the interactions between farmers, consumers, and NGOs and which uses machine learning methods to predict freshness, minimize food waste, boost farmers' revenue, and drive more sustainable food distribution systems.

1)Electronic National Agriculture Market (eNAM)

The Electronic National Agriculture Market (eNAM) launched is an online trading platform to bring together Agricultural Produce Market Committees (APMCs) all over the country and enable farmers access to a larger market. The platform facilitates transparency in bidding, online transactions and price discovery. While eNAM expands market access, it does not fully leverage the direct interaction between farmers and consumers as the transactions are still conducted through licensed traders and commission agents. Also, no system is in place to evaluate the freshness of produce or to distribute excess food to NGOs.

Pros:

- Enables farmers to make markets more accessible
- Supports online trading of agricultural commodities.

Cons:

- Farmers continue to rely on intermediaries.
- No prediction of freshness.

Drawbacks:

The platform doesn't have any NGO integration, expiry alerts or food redistribution mechanisms.

2) Farmers to consumers Mobile Commerce System

- This work suggests an idea of mobile marketplace which directly links farmers with consumers thereby reducing the number of intermediaries in the traditional agricultural trade. The system allows farmers to advertise their products and discussion with buyers the price they would like to receive, which would lead to higher farmer income and lower cost to consumers. Commercial transactions, however, are its major focus and no intelligent freshness estimation, shelf-life prediction or mechanisms to reduce food wastage.

Pros:

- Allows farmers to exchange with customers face-to-face.
- Improves farmer profitability.

Cons:

- Lacks lack of the use of machine learning techniques.
- No support for food donation activities.

Drawbacks:

System is unable to detect the near expiry produce, unable to alert NGOs for timely procurement.

3) Classifying the freshness of produce using machine learning

There has been significant research on the use of machine learning techniques for automated food quality assessment, including Random Forest, Support Vector Machines, and image processing. The techniques involve examining various fruit and vegetable properties such as color, texture, and shape to determine freshness levels. The high prediction accuracy of these approaches is achieved, however, they are typically applied as independent classification models

which are not integrated with agricultural ecommerce platforms or social food redistribution networks.

Pros:

- Offers correct freshness forecast
- Allows automated assessment of quality.

Cons:

- Needs extensive labeled data sets.
- Only uses classification tasks.

Drawbacks:

NO marketplace functionality, no NGO collaboration, no auto-notification functionality in the system.

II. PROPOSED SYSTEM

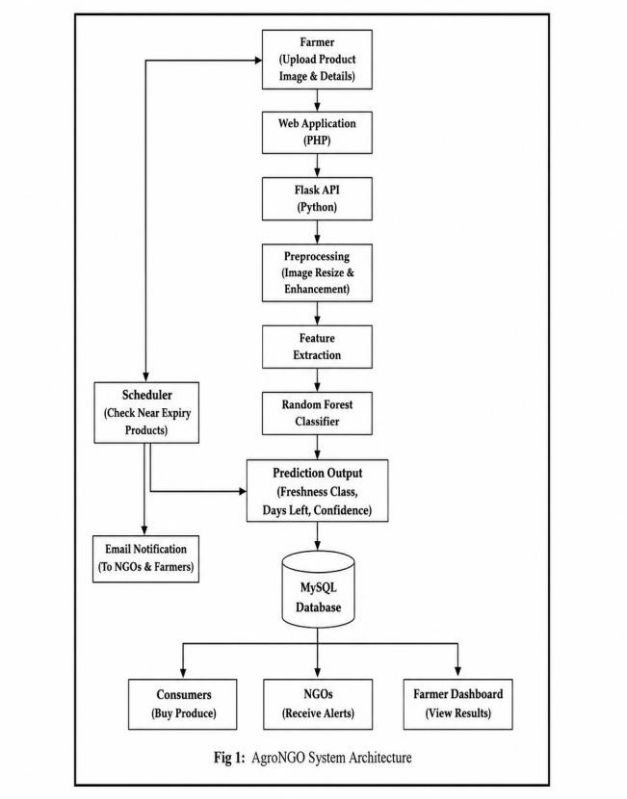

Fig 1: AgroNGO System Architecture

Description

The proposed AgroNGO system is a web-based system which combines the machine learning techniques with the agricultural e-commerce and establishes direct communication between farmers, consumers, and NGOs. First farmers register and upload information about the agricultural product and images of the product. A Python Flask microservice is used to upload the image and extract visual features such as color, texture, and shape characteristics. The extracted features are then used in a trained Random Forest classifier and reduced in dimension using Principal Component Analysis (PCA).

The classifier classifies the produce into freshness classes, confidence score and estimated remaining shelf life. The prediction results are written in a MySQL database and presented to farmers and consumers. A cron based monitoring service is always checking the products that are nearing expiry and notifying the registered NGOs and farmers of the products expiry via email. Near-expiry produce is available to purchase from NGOs at discounted prices or for donation. The proposed framework seeks to reduce food waste, enhance farmer profitability and contribute to sustainable food redistribution.

2.1 Modules

Farmer Module:

The main stakeholders of AgroNGO platform are farmers. They can register, login, add details of produce, keep track of inventory, keep track of freshness predictions, get freshness notifications, and view the NGO procurement history. Farmers can also lower the prices of products that are about to expire to incentivize the buying of these items by NGOs.

Consumer Module:

Consumers can access the list of available agricultural products, filter the products according to location and category, see the freshness scores, place orders directly from the farmers, and follow the track of the order deliveries. Removing intermediaries puts fresh produce consumers into a position to purchase fresh produce at affordable prices.

NGO Module:

Automatic notifications are sent to registered NGOs whenever the product is likely to expire within a defined time period. NGOs are able to buy products close to their expiry date at a discount, track the procurement data and help in minimising food wastage.

Machine Learning Module:

The machine learning component is responsible for freshness estimation. It computes various image-based features like colour histograms, Local Binary Patterns (LBP), GLCM statistics, Hu moments, and colour moments. PCA is

used to reduce the dimensions of features, and a Random Forest classifier is used to predict different freshness classes—Fresh, Near-Expiry and Critical.

2.2 Algorithm used

Random Forest Algorithm:

Random Forest is an ensemble learning algorithm, which is built from a collection of decision trees trained on a bootstrap sample of the data. In the training stage, every tree samples a random subset of features and find the best split points with Gini impurity. This is achieved by majority voting across all trees to get the final prediction.

For AgroNGO, a high level of accuracy in classification, immunity to overfitting, efficient inference and ability to infer feature importance led to the selection of the Random Forest. The algorithm is able to accurately predict the freshness classes of produce with an overall accuracy of 93.2% from the images' visual features extracted using the algorithm. Moreover, it is explainable, which will allow the use in farmer-centric applications where transparency and reliability are critical.

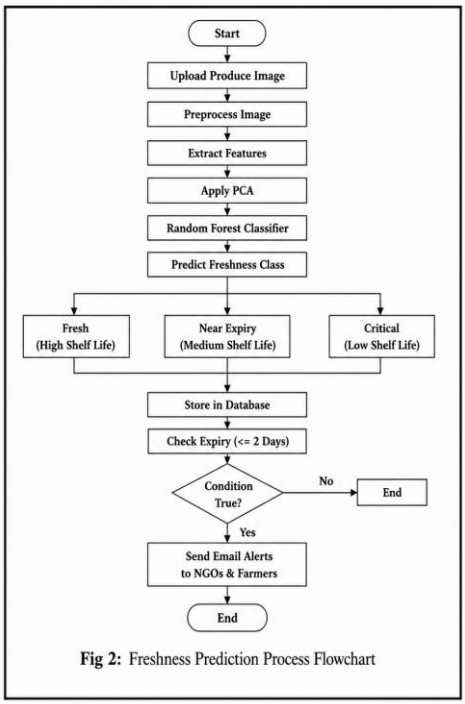

Fig 2: Freshness Prediction Process Flowchart

III. FUTURE WORK

Future research opportunities could include enhancing the accuracy, robustness, and scalability of the proposed AgroNGO framework. The use of more advanced deep learning algorithms, such as Convolutional Neural Networks (CNNs), Vision Transformers (ViTs), transfer learning models, and others could be explored to more accurately predict the freshness of the produce in different environments, including different light conditions, background noise, image quality, and more. The proposed system can be scaled up by incorporating IoT-enabled sensors for temperature, humidity, and storage conditions. In addition, the use of blockchain can offer a transparent and secure traceability of agricultural products across the entire supply chain. Future applications could involve cloud-based deployment, multilingual, mobile applications, and intelligent recommendation systems to make the application more accessible to farmers, consumers, and NGOs and improve its uptake. These enhancements can significantly contribute toward reducing food wastage and promoting sustainable agricultural practices.

IV.CONCLUSIONS

The AgroNGO system aims to present an intelligent and sustainable food redistribution system by combining machine learning techniques with agricultural e-commerce. The system allows farmers to sell their produce directly to the consumers while cutting down on the number of intermediaries. The platform can use a Random Forest model to predict the freshness of products and allow the registered NGOs to know when the products are in danger of being too old to buy or give, which can help them find an opportunity to do so. This not only keeps the farmers from losing any money but also allows NGOs to get a good price for nutritious food. Moreover, the proposed system encourages responsible consumption; minimises food waste; and fosters social welfare programs. In conclusion, AgroNGO is a promising solution that promises to transform the way farmers and consumers experience the food supply chain, offering an efficient, scalable, and sustainable approach.

V. ACKNOWLEDGEMENT

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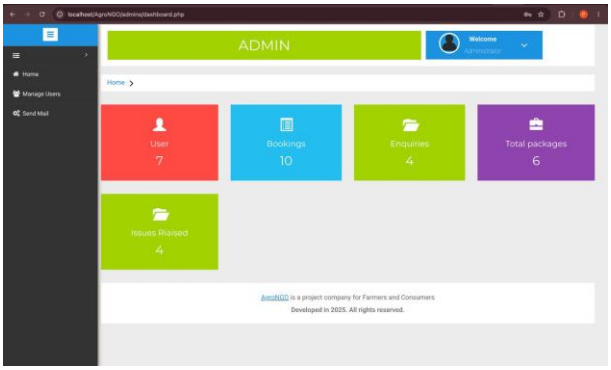
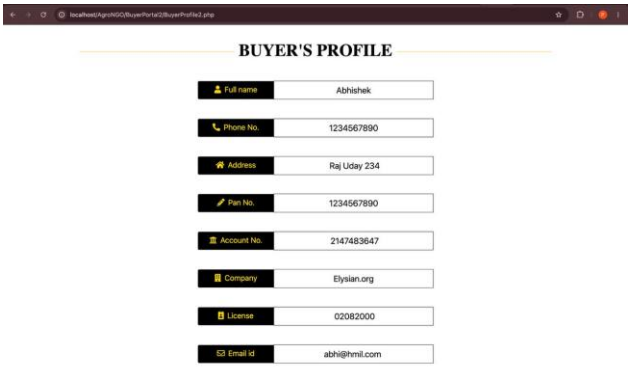
VI. RESULTS

Home page:

Admin Login:

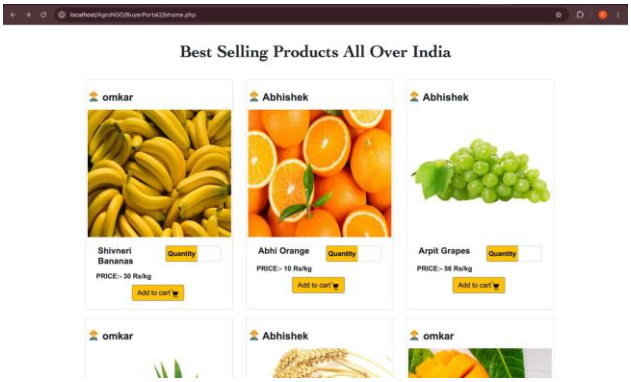


Buyer Registration:

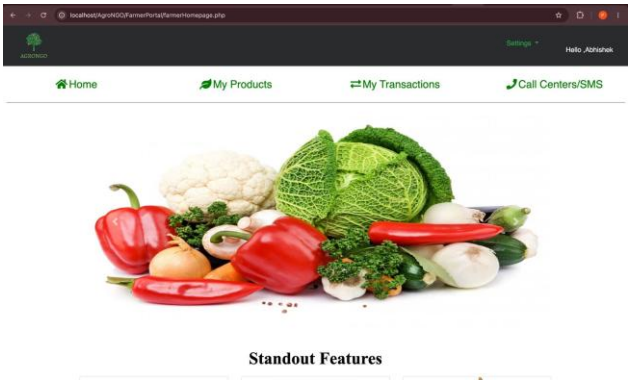


Buyer Login:

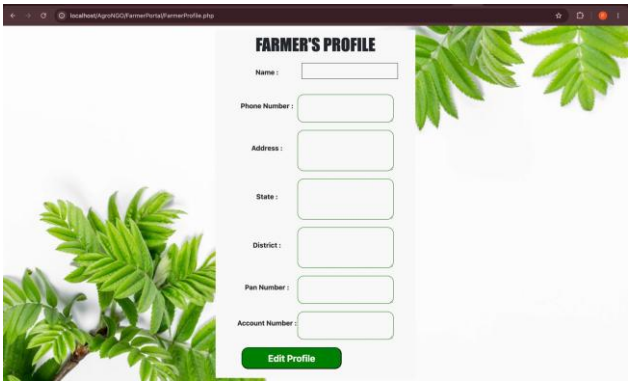
Buyer View:



Farmer View:

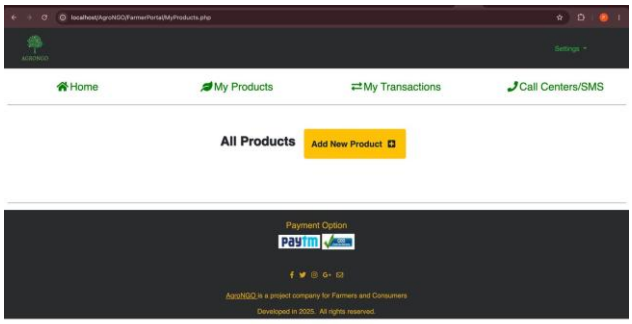


Farmer Registration:

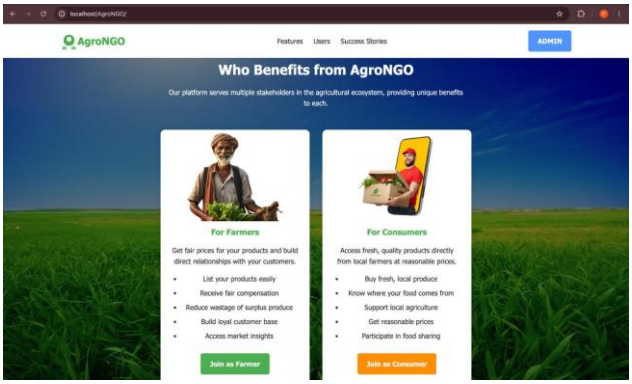


Call Centers:

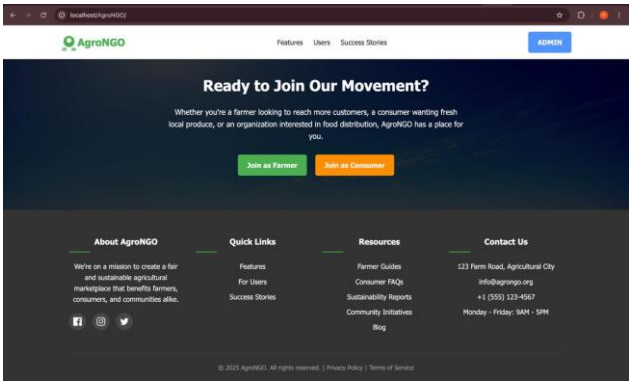
Products Addition Feature:



Benefits From Ngo:



Contacts and Overview:



Dataset Prepared(csv):