

AI- BASED FARM PROFITABILITY PREDICTION AND DECISION SUPPORT SYSTEM

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Abstract – Farming profitability depends on a number of factors such

as crops to grow, input cost, labor cost, transportation cost,

expected yield, market price, etc. Farmers usually make decisions without the knowledge of their estimated profits or losses. FORMPROFIT is an AI-based farm profitability prediction and decision support system which can help farmers assess different farms strategies prior to cultivation. This system enables users to provide crop information, cultivation cost, expected yield, market price and many others. Based on the inputs provided, this system will give information about total revenue, total cost, expected profit or loss, and profitability. It will enable farmers to choose between different crop strategies based on their profitability. The system is expected to reduce risks, provide better decision making, and help farmers farm in a profitable manner.

Keywords: Farm Profitability, Artificial Intelligence, Machine Learning, Crop Selection, Profit Prediction, Decision Support System, Agriculture Analytics.

SDG Goals:

* SDG 2 – Zero Hunger

* SDG 8 – Decent Work and Economic Growth
* SDG 12 – Responsible Consumption and Production

INTRODUCTION

Agriculture plays a key role in earning incomes and employment. However, uncertainties exist due to the fact that both production cost and market price can be affected. High yield doesn't guarantee high profit since there is cost associated with seed, fertilizer, pesticide, irrigation, transport, labor, and many other inputs.

Traditional farming involves using past experiences and beliefs. Farmers do not have any easy means to make comparisons and decisions regarding the profitability of various crops before making investments in cultivation.

FORMPROFIT provides farmers with an AI-based platform for assessing their profitability before making decisions. Farmers can provide relevant farming parameters like crop to grow, cost of cultivation, market price, and expected yield. The system will give the expected cost and revenue and predict the expected profit or loss from the chosen farming strategy.

This system offers an interactive and simple decision-making environment to farmers before starting cultivation.

1. LITERATURE SURVEY

A. MACHINE LEARNING ALGORITHMS FOR PREDICTION IN AGRICULTURE

Different agricultural systems have used the machine learning algorithms for prediction of the yield of crops or other agricultural performance. These systems use the historical data to predict and to identify the patterns. Such a system can be helpful for farmers to make better decisions regarding the crops.

B. Crop Yield Prediction

Crop yield prediction system predicts the crop yield depending on the type of crop, the soil, the weather conditions and historical data. However, crop yield prediction is not sufficient enough to evaluate whether the agricultural process will be profitable or not.

C. Agricultural Decision Support Systems

Agricultural decision support systems are being used by farmers for making decisions using the agricultural data and selection of the agricultural processes and strategy. Different decision support systems provide recommendations depending on the data, but mostly they provide only crop or yield predictions instead of profitability analysis.

D. Farm Cost Analysis

The farm cost analysis includes seeds costs, fertilizers cost, labor cost, irrigation cost, pesticides cost and transportation cost. It is important to know about the cost because some crops with high production can have low profits due to high cultivation costs.

E. Market Price Prediction

The market price is the second main factor determining the income from agricultural activity. The market price prediction can help to estimate the profitability of the crop. However, changing market prices complicate the estimation.

Research Gap

The existing agricultural systems usually provide recommendations related to crop recommendation, yield prediction or market-price analysis separately. It is important to develop the integrated system considering farm costs, yield, market price, revenue and profit

II. EXISTING SYSTEM AND DISADVANTAGES

Many farmers today use manual calculations or their previous experience in choosing a crop.

Manual Calculations

Farmers calculate manually cultivation costs and expected income which takes much time and may cause some calculation errors.

Dispersed Sources of Information

Crop information, prices, cultivation costs, and yield may come from various sources making the process of making a decision very complicated.

Absence of Comparing Options

The conventional methods don't have the opportunity to make comparison between several crops or farming options in terms of profitability.

Limited Forecasting of Financial Outcome

A lot of agricultural applications predict crops or yields, but they do not calculate the overall expected profit/loss of a farm.

Possibility of Bad Decision Making

Unexpected cultivation cost or change in market prices will influence the final income significantly.

III. PROPOSED WORK

Proposed FORMPROFIT system unites agriculture data analysis and AI-based forecasting for estimation of farming strategies' profitability.

The system will allow the farmer to set or adjust the following information:

- Crop selection
- Seed cost
- Fertilizer cost
- Pesticide cost
- Labor cost
- Irrigation cost
- Transportation cost
- Other expenses
- Expected yield
- Expected market price

The system will calculate the expected revenue, cultivation costs, and potential profit/loss.

System Overview

1. User Input

Farmer provides the required crop and financial information via the web interface.

2. Information Processing

Information is processed and prepared for further profitability analysis by the system.

3. Profitability Forecasting

The system analyzes the input parameters with an AI/ML model and predicts the profitability.

4. Calculation of Income and Expenses

The system calculates:

Income = Expected yield * market price
Expenses = Sum of all cultivation costs
Profit = Income – Expenses

5. Comparison of Farming Strategies

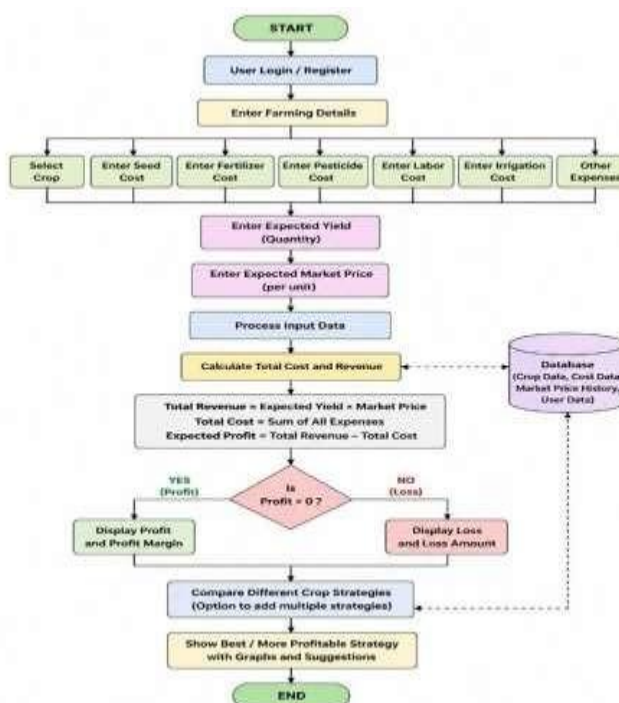
Farmers can input several crop strategies and compare them regarding:

- Expected revenue
- Total cost
- Expected profit
- Profit margin

6. Making Decisions

The system provides the results in terms of analytics and helps choose the more profitable strategy from the available option.

FLOWCHART



V IMPLEMENTATION

The FORMPROFIT system is implemented as a full-stack web application which includes front-end part, back-end, database, and AI/ML module.

5. Front-end

Front-end consists of forms and dashboards which allow users to input farming information and get the results of profitability analysis.

7. Back-end

Back-end collects user input, executes calculations, interacts with the prediction model and sends back the results.

9. Prediction Model

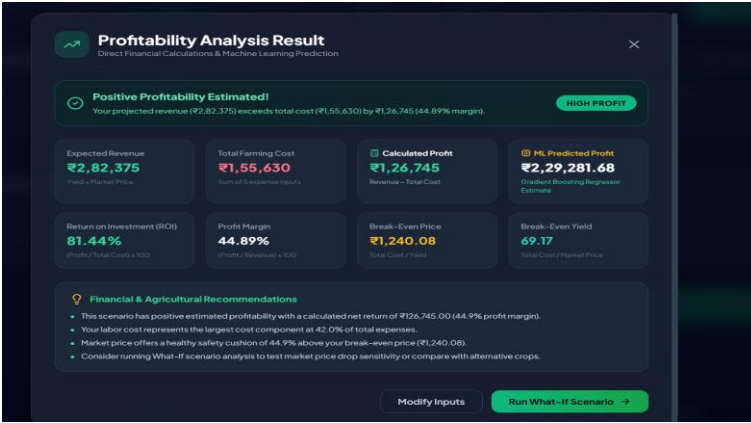
The prediction ML model is built using relevant information on agriculture and finances to detect patterns between farming parameters and profitability.

11. Databases

Databases contain crop information, information about costs, predictions, farming strategies defined by the user.

The screenshot shows the 'Farm Profitability Calculator & Predictor' web application. The top navigation bar includes links for Home, Farm Calculator, Dashboard, What-If Analysis, Crop Comparison, Model Performance, and About. The main header displays the title and a 'Calculate Profit' button. Below the header, there's a summary section showing 'EST. REVENUE ₹2,82,375', 'TOTAL EXPENSES ₹1,55,630', and 'EXPECTED PROFIT ₹1,26,745'. A 'QUICK CROP SELECTOR' allows users to click to load dataset averages for various crops like Chilli, Cotton, Groundnut, Maize, Onion, Potato, Rice, Sugarcane, Tomato, and Wheat. The '1. Farm Basic Information' section includes input fields for Crop Type (Rice), Location/State (Madhya Pradesh), Season (Kharif), Land Area (Acres) (5), Soil Type (Black Soil), and Irrigation Type (Drip). A '2. Crop Production & Expected Yield' section shows 'Expected Yield per Acre' (25.1) and 'Total Expected Yield' (125.5) in Quintal. The '3. Cost Breakdown (₹)' section lists 'Seed Cost (₹)' (10550), 'Fertilizer Cost (₹)' (43140), 'Labor Cost (₹)' (65340), 'Transportation (₹)' (17870), and 'Other Expenses (₹)' (18730), totaling ₹1,55,630. The '4. Market Price Information' section shows 'Market Price (₹)' (2250) and 'Price Unit' (INR per Quintal (₹/Qtl)). At the bottom, there are buttons for 'Calculate Profit' and 'Predict Profit (ML)'.

This screenshot shows the results of the profitability calculation. The '2. Crop Production & Expected Yield' section displays 'Expected Yield per Acre' (25.1) and 'Total Expected Yield' (125.5) in Quintal. The '3. Cost Breakdown (₹)' section shows the same cost breakdown as the previous screenshot, totaling ₹1,55,630. The '4. Market Price Information' section shows 'Market Price (₹)' (2250) and 'Price Unit' (INR per Quintal (₹/Qtl)). At the bottom, there are buttons for 'Calculate Profit' and 'Predict Profit (ML)'.



Algorithm

LINEAR REGRESSION

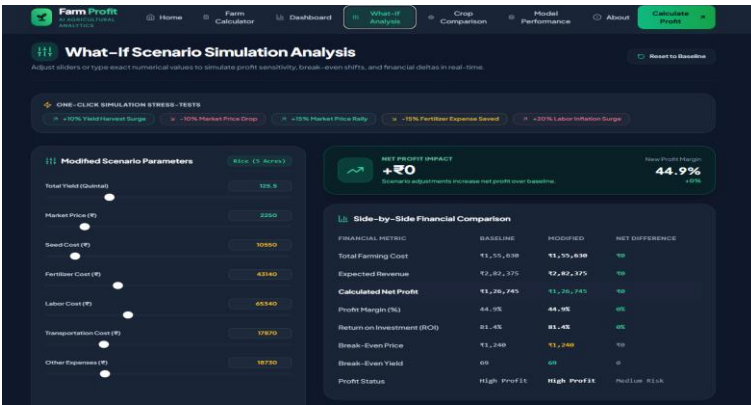
The model uses agricultural features such as crop selection, production cost, expected yield, selling price, and other relevant parameters. By combining predictions from multiple trees, Random Forest can capture nonlinear relationships between these variables and farm profitability.

The Random Forest model achieved an R^2 score of 0.9471, with an MAE of ₹66,316.23 and RMSE of ₹1,05,764.79 in the evaluated benchmark. This indicates that the Random Forest model provided better predictive performance than the Linear Regression baseline in the current evaluation.

Gradient Boosting Regressor

Gradient Boosting Regressor was considered as an additional ensemble regression technique for profitability prediction.

Unlike Random Forest, which builds trees independently, Gradient Boosting builds an additive sequence of weak decision-tree learners, where each new tree attempts to reduce the prediction error of the existing model.

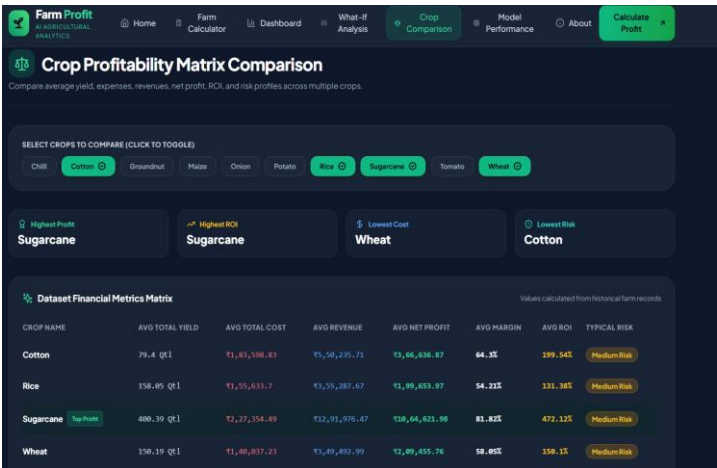


Linear Regression was used as a baseline regression algorithm in the FarmProfit system to establish a benchmark for predicting farm profitability. The model assumes a linear relationship between the input agricultural parameters and the expected profit.

The general equation of Linear Regression is:
$$\hat{y} = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_n x_n$$

where $\hat{y}$ represents the predicted farm profit, β_0 is the intercept, β_i represents the coefficient of the corresponding input feature, and x_i represents agricultural features such as crop type, cultivation cost, expected yield, and market price.

In FarmProfit, Linear Regression was mainly used as a benchmark model for comparison with more advanced ensemble-based regression algorithms



Random Forest Regressor

Random Forest Regressor was used as the primary machine learning algorithm in the FarmProfit platform for farm profitability prediction. It is an ensemble learning technique that combines multiple decision trees to produce a more robust prediction.

predictive performance than the Linear Regression baseline in the current evaluation.

Gradient Boosting Regressor

Gradient Boosting Regressor was considered as an additional ensemble regression technique for profitability prediction.

The prediction can be represented as:

$$F_M(x) = \sum_{m=1}^M h_m(x)$$

where M represents the number of boosting stages and $h_m(x)$ represents the prediction of the m^{th} regression tree.

The model updates the prediction iteratively using:

$$MAE = \frac{1}{n} \sum_{i=1}^n |y_i - \hat{y}_i|$$

$$RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^n (y_i - \hat{y}_i)^2}$$

$$R^2 = 1 - \frac{\sum_{i=1}^n (y_i - \bar{y})^2}{\sum_{i=1}^n (y_i - \hat{y}_i)^2}$$

VII RESULTS AND DISCUSSION

FORMPROFIT is an integrated tool that allows analysis of the profitability of the farm. Using the input of crop type, cost, yield and market prices, the system estimates the expected income, total cost, and profit or loss expected.

The system has an interactive comparison module which enables users to analyze various farming methods. For instance, a farmer may compare several crop types by

since the results are displayed using numerical calculations and visualizations. This helps farmers to detect farming methods that are associated with very high costs

Unlike Random Forest, which builds trees independently, Gradient Boosting builds an additive sequence of weak decision-tree learners, where each new tree attempts to reduce the prediction error of the existing model.

For a given input x , the Random Forest prediction can be represented as:

$$\hat{y} = - \sum_{t=1}^T f_t(x)$$

where T is the total number of decision trees, $f_t(x)$ is the prediction produced by the t^{th} decision tree, and $\hat{y}$ is the final predicted profit

VIII FUTUREWORK

Several improvements could be applied to FORMPROFIT system in the future, such as:

- Integrated real-time market price
- Analysis of risks due to the weather
- Information about crop diseases and pests
- Recommendations on regional crops
- Prediction of profitability for a season
- Profitability tracking throughout the year
- Mobile application
- Multilingual for farmer
- AI-based crop recommendations
- integration with government agriculture data sets

In the future, personalized advice can be given to farmers taking into account their location, budget, field size, and preferences regarding crops.

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