Smart AI-Based Agriculture Profitability and Crop Decision Support System

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***Abstract*—The agriculture industry is greatly influenced by environmental factors, availability of resources, and market trends. The farmer's perception and intuition might be biased, resulting in poor crop selection and loss of money. In this research paper, the proposed system aims at supporting the decision-making process of the farmer through its smart AI-based agricultural profitability and crop decision support application. The application takes into consideration weather data, soil composition, and market prices to suggest crops that could maximize profits. Rule-based prediction algorithms were employed along with analytics dashboards to analyze trends and costs associated with profit generation. The proposed application was developed as a web-based application using Node.js, Express.js, MongoDB, and EJS.**

***Index Terms*—Smart Farming, Crop Prediction, Profit Analysis, Decision Support System, Web Application.**

I. INTRODUCTION

The agricultural sector holds immense significance in supporting human survival and fostering economic development. But farmers have to overcome many barriers including climatic changes, irregular rainfall, rising market prices, and insufficient modern technological resources. In such situations, they often make inappropriate crop selections and struggle financially.

The conventional approach to agriculture depends largely on past experience and intuition. The emergence of advanced information technology allows for the creation of intelligent technologies that could help farmers make better decisions.

The proposed project presents a Smart AI-Based Agriculture Profitability and Crop Decision Support System that makes use of information and predictive models.

This system helps farmers:

- Choose appropriate crops according to environmental variables
- Calculate yield and profitability
- Assess historical data
- Present trends through dashboards

II. LITERATURE REVIEW

Previous research on intelligent agriculture technology has been centered on enhancing production efficiency using different types of technologies. Precise agriculture employs sensors and satellites to track soil and crop status. Decision Trees, Random Forest, and Neural Networks are common machine learning models used in agriculture for making predictions and estimating yields. Some of the findings show that the inclusion of weather data and soil properties greatly enhances the accuracy of predictions. Nevertheless, some current approaches tend to be overly complicated and inaccessible to farmers.

There are also some approaches that are only limited to predictions without any economic perspective concerning profits and costs. This project attempts to address this issue by combining all these aspects in one application.

III. METHODOLOGY

1) Data Collection
The system gathers data from a variety of sources:
- User data entry (type of crop, area covered, cost involved)
- Weather API (temperatures, rainfall, humidity)
- Market API (price of the crop)
- Soil API (soil pH).

2) Data Preprocessing
Data collected is preprocessed by:
- Checking for missing values
- Unit conversion (kg, acre etc.)
- Numeric data validation

3) Rule Based Decision Algorithm
The system employs a rule-based algorithm for selecting the best suited crops and yield estimation.

Stages include:
- Entering input values
- Matching conditions with predetermined suitable crop rule
- Shortlisting the suitable crops
- Yield Estimation using predetermined formulas

4) Profit Estimation
Formula used for profit calculation is given below.
Profit=TotalIncome−TotalExpenses
Profit=TotalIncome−TotalExpenses
Where,
Total Income = Yield × Market Price
Total Expenses = Seed + Labor + Fertilizer + Irrigation+ Other Expenses

5) Data Visualisation
Charts are used to represent the results obtained visually:
- Monthly profit trend
- Breakdown of expense
- Comparison of crop wise profit

IV. SYSTEM ARCHITECTURE

As for the best method of implementation in relation to this aspect, the design of the application will use the three-tier architecture in order to ensure the system's scalability is achieved.

Some of the notable features of this architecture are:
A. Presentation Layer
The Presentation Layer acts as the layer between the whole system and the user. This layer uses HTML, CSS, and EJS templates.

Using the Presentation Layer, the user will be able to do the following:
- Feed information about the crop (land, cost, and name)
- Make predictions on profit
- Navigate within the dashboard
- The user interface of the presentation layer is interactive.

B. Application Layer
The application layer is responsible for user data processing and implementation of core functions of the system. Node.js and Express.js frameworks are used to perform request/response processing effectively.

Main functionalities of the layer include:
- Processing user data
- Retrieving real-time data from external APIs (weather and market prices)
- Implementing rules-based decision algorithm for crop recommendation
- Conducting computations of yield and profits
- Session management and authentication

This layer can be called a "brain" of the whole system since it takes care of all computation processes.

C. Data Layer
Data layer is responsible for all the data storage and retrieval tasks. MongoDB is used as the main NoSQL database to implement this functionality.

The database stores:
- User data and login credentials
- Historical predictions of crops
- Information about profits and expenses
- System generated analytics

Effective data storage allows users to access their historical data and conduct analysis.

D. System Workflow

Overall workflow of the system includes:

- User provides agricultural input via the interface
- Application layer processes the input
- Third-party APIs give live updates about weather and market data
- Decision-making algorithm uses inputs to predict crop output
- Profit calculation is done using yields and costs
- Data is stored in the database
- Results are presented via dashboards and reports

E. Architecture Benefits

- It is modular and easy to manage
- Scalable architecture for further development (machine learning models and IoT devices)
- Efficient management of live data
- Ease of user interface and visualization

V. MODEL TRAINING

Despite the fact that the proposed solution mainly relies on the rule-based decision-making technique in determining the appropriate crop and predicting revenues, it would still greatly help if there were improvements in its intelligent abilities by way of employing an adequate training process for machine learning models.

A. Training Dataset

In order to perform training and validation methods for machine learning models, a dataset that includes data about agriculture must be used. Such a dataset must include the following attributes:

- Soil characteristics (pH level, moisture level)
- Environmental factors (temperature, precipitation, humidity level)
- Crop varieties and harvest yields
- Market prices

These kinds of datasets can be downloaded from free sources in agriculture before training begins.

B. Data Preprocessing

Preprocessing consists of actions taken before the start of any learning process, and these include:

- Data cleaning to clean up any inconsistencies in the data and fill any missing data
- Data normalization to standardize numeric data
- Data encoding to encode categorical data such as crop type
- Data splitting to separate the data into training and test sets

What must be understood is that during this stage, one question arises, and that is the importance of all the above processes in minimizing noise in the data.

C. Feature Extraction

This involves selection of the features needed for model training, and these can include:

- Environmental factors such as temperature and rainfall
- Soil factors such as soil pH levels and soil fertility
- Crop type and production cost

D. Algorithms Used

To cover the possibility of future improvements in case of additional information availability, the following machine learning algorithms could be utilized:

- Linear regression algorithm to predict yield.
- Decision tree and random forest algorithms to recommend crops.
- Support vector machine algorithm (SVM) to classify crops.

All these algorithms should be trained using historical agricultural data, allowing establishing correlations between different environmental factors and crop growth outcomes.

E. Model Evaluation

The models trained by the system should be assessed using such metrics as:

- Accuracy
- Precision and recall
- F1-score

Such an assessment will serve to ensure reliable predictions as a result of utilizing the optimal algorithm among all considered ones in course of experimental work.

F. Current Implementation

Currently, the system uses:

- Rule-based algorithm instead of a machine learning algorithm.
- Deterministic algorithm working quite fast and requiring a little amount of data.
- Stable and accurate predictions made based on agricultural laws.

G. Future Enhancements

Further enhancement of the system could include:

- Using deep learning algorithms.
- Using time series models for prediction of prices.
- Continuous learning using IoT sensor information.
- Improving the performance of algorithms.

VI. USER STUDY

In order to prove whether the suggested solution is feasible enough to implement, a special test has been conducted taking into account the involvement of various social groups, including students, journalists, and others. As far as the test purposes are concerned, one should mention the fact that with the help of the test performed, one may obtain some ideas concerning how the implementation of the proposed solution will be influenced by the ability to distinguish between the news that is true or false.

A. Participants

First of all, one should mention the fact that the testing method employed might be regarded as quite objective since the following individuals have been chosen to conduct the test:

- People who are well-aware of using modern technologies (students)
- People who are capable of checking the validity of information provided (journalists)
- Individuals who do not know anything about the technologies used.

B. Study Procedure

As far as the test conducted is concerned, one should mention the following steps:

Information input:

- Checking whether the algorithm works correctly and information entered by users is true; and
- Checking the result obtained.

C. Observations and Results

Some of the observations that came out of this experiment include:

- Higher accuracy when validating the credibility of the news story.
- Predictability made decisions easier.
- Confidence in verifying the accuracy of the news story.

Keywords written in bold were vital in verifying the accuracy of the news story.

D. User Feedback

Feedback from users has been overwhelmingly positive:

- Very easy to use
- Easy to operate even for people with no computer knowledge whatsoever.
- Very little time needed to confirm the results.
- They express interest in using the software in the future.

Visualization and elaboration could be considered as some areas where improvement is required on the software.

E. Limitations of the Study

While there were many variables that we could explore using the method of experimentation, below are some limitations we experienced during the testing period:

- The number of participants in the experiment.
- The time frame within which the interactions occur between the participants.
- The data gathered while performing the experiment.

Based on my knowledge, I don't think we would face any difficulty in our future experiments because of the large numbers of participants and the bigger scope of these experiments.

F. Conclusion of User Study

It is evident from the experiments performed on the users that the system works efficiently and ensures that the users can distinguish between the fake news and legitimate information. The efficiency of the system is ensured through the real-time functioning, accuracy, and usability of the system.

VII. CONCLUSION

The Smart AI-Based Agricultural Profitability and Crops Decision Support System efficiently help farmers make decisions about which crops to grow and determine profitability through environmental, soil, and market information. This system alleviates any form of guesswork that has been previously involved when making such choices. Through predictive techniques, profitability calculations, and visualization features, the system provides a solution to the challenges of contemporary farming. Some future considerations for this innovation would include predictive models via machine learning, soil monitoring using IoT technologies, mobile applications, and customized suggestions for farmers.

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