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AgriChainAI – Blockchain and AI Enhanced Agricultural Supply Chain Management

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Abstract: *Agriculture is a critical domain that directly influences food production, rural employment, and national economic stability. Farmers frequently encounter challenges such as unpredictable weather conditions, improper crop selection, fluctuating mandi prices, plant diseases, and lack of transparency in supply chain processes. Traditional farming decisions are often based on previous experience rather than analytical data, which may lead to lower productivity and financial uncertainty [1], [2].*

AgriChainAI is proposed as an integrated Artificial Intelligence and Blockchain based smart agriculture platform that assists farmers in making informed decisions. The system provides crop recommendation using environmental parameters such as rainfall, soil nutrients, humidity, and temperature. The mandi price prediction module estimates future crop price trends using historical datasets and seasonal demand patterns [3]. Disease detection module identifies crop health conditions using image-based analysis. The blockchain-based supply chain module stores crop batch transactions securely, ensuring transparency and preventing data manipulation [4], [5].

Machine learning algorithms analyse relationships between environmental factors and crop productivity to recommend suitable crops [6]. Regression models identify patterns in historical mandi datasets to estimate price trends for selected months [7]. Blockchain structure ensures secure and verifiable storage of agricultural transactions [5]. Experimental observations indicate that the system improves decision-making accuracy and enhances transparency in agricultural trade [8].

The proposed system aims to promote sustainable farming practices by enabling data-driven decision making, improving productivity, and reducing uncertainty in agricultural operations..

Keywords: Artificial Intelligence, Smart Farming, Crop Recommendation, Price Prediction, Blockchain Technology, Agricultural Analytics, Decision Support System, Precision Agriculture, Supply Chain Transparency

I. INTRODUCTION

Agriculture plays a vital role in sustaining human life and supporting economic development. Farmers continuously face multiple uncertainties such as irregular rainfall patterns, soil fertility variation, pest infections, and unpredictable market prices [1]. Selecting appropriate crops and deciding the correct selling time requires understanding of environmental conditions and price trends. Lack of reliable analytical tools often results in reduced profit and inefficient crop planning. Artificial Intelligence has emerged as an effective solution for analysing agricultural datasets and identifying patterns useful for decision making [2]. Machine learning techniques can evaluate relationships between soil nutrients, rainfall patterns, and crop productivity. These predictive models help farmers determine suitable crops for cultivation based on environmental conditions [6].

In addition to prediction challenges, agricultural supply chains often suffer from lack of transparency and trust. Crop transactions pass through multiple intermediaries including distributors, wholesalers, and retailers. Maintaining reliable records of crop movement is difficult using traditional methods [4]. Blockchain technology provides a decentralized storage structure that maintains immutable transaction records, ensuring transparency and traceability [5].

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AgriChainAI integrates prediction algorithms and blockchain-based storage into a unified smart farming platform. The system assists farmers in crop selection, price prediction, disease detection, and secure supply chain management [7]. The objective of this system is to improve agricultural productivity and enable data-driven farming decisions.

II. TECHNIQUES

Requirement Analysis

Requirement engineering is the process of identifying system functionality, user expectations, and operational constraints required for developing reliable software solutions [3]. For AgriChainAI, system requirements include prediction accuracy, secure transaction storage, user-friendly interface, and efficient data processing capability.

Software Requirement Specification

Software Requirement Specification (SRS) describes system objectives, functional components, and operational limitations [2]. The SRS for AgriChainAI includes crop recommendation module, mandi price prediction module, disease detection module, and blockchain supply chain module.

A. Interface Conditions Login Interface

Users create accounts using email identification to access personalized dashboard. Authentication ensures privacy of stored agricultural data and transaction records [4].

Crop Recommendation Interface

Users provide environmental parameters such as soil nutrients, rainfall level, temperature, humidity, and location details. The system processes these inputs to generate suitable crop suggestions [6].

Price Prediction Interface

Users select crop type, state, and preferred month to estimate future mandi price trends [7]. Supply Chain Interface Farmers store crop batch information including quantity, location, and transaction details. Blockchain structure ensures secure storage [5].

Disease Detection Interface

Users upload crop images to identify disease type and suggested treatment methods [8].

B. Design of System

1. User Interface Layer

The user interface provides dashboards for crop prediction, price estimation, disease detection, and supply chain tracking. The interface ensures easy navigation and accessibility for farmers [3].

2. Database Layer

Database stores agricultural datasets including mandi price records, crop environmental parameters, and blockchain transaction logs [7].

3. Machine Learning Layer

Machine learning algorithms analyse environmental data and historical price datasets to generate prediction outputs [6].

4. Blockchain Layer

Blockchain stores crop transaction records using hash-based linking mechanism ensuring data integrity [5].

C. Classification

Classification methods categorize agricultural conditions according to soil nutrients, rainfall, temperature, and seasonal characteristics [6]. Crop suitability is determined using predefined environmental thresholds.

D. Forecasting

Forecasting techniques analyse historical mandi price trends to estimate expected price for selected future month [7]. Seasonal demand and supply variations influence crop price patterns [1].

E. Objectives

- To develop AI-based crop recommendation system using environmental parameters [6].
- To predict future mandi price trends using machine learning techniques [7].
- To ensure transparency in agricultural supply chain using blockchain storage [5]. To detect plant diseases using image-based analysis [8].
- To improve farmer decision-making using data-driven insights [2].

III. ARCHITECTURE

This section presents the detailed architecture of the AgriChainAI system, describing how different technological components interact to provide intelligent agricultural decision support. The objective of the architecture is to combine Artificial Intelligence, Machine Learning, and Blockchain technology into a unified smart farming platform capable of assisting farmers in crop selection, price prediction, disease identification, and transparent supply chain tracking.

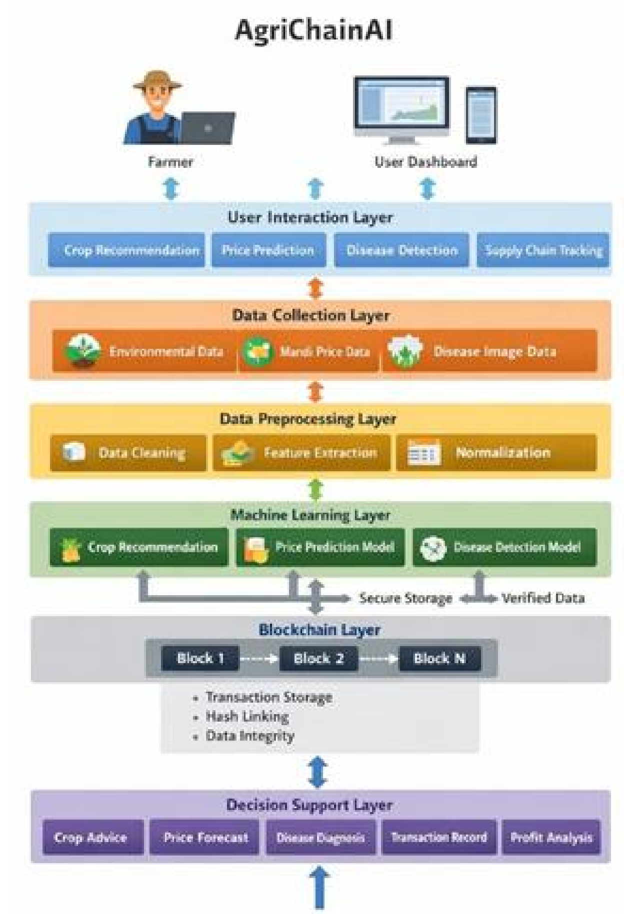

Fig 1 Architecture of the AgriChainAI

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The architecture is designed using a modular approach, allowing independent development and scalability of each component. The system integrates multiple data sources including environmental parameters, historical mandi price datasets, crop disease datasets, and blockchain transaction records. These components work together to provide accurate predictions and secure storage of agricultural information.

The proposed architecture consists of the following major layers:

A. User Interaction Layer

The User Interaction Layer acts as the interface between farmers and the intelligent agricultural system. This layer is responsible for collecting user input and displaying prediction results in an understandable format.

The interface is designed as a web-based dashboard where farmers can easily access different modules such as crop recommendation, price prediction, disease detection, and supply chain tracking.

Key functionalities of this layer include:

User Registration and Authentication

Farmers create an account using email identification. Authentication ensures that personal data and previous transaction history remain secure [3].

Input Collection Interface

Farmers provide input parameters such as soil nutrients (Nitrogen, Phosphorus, Potassium), rainfall level, temperature, humidity, location, crop type, and quantity.

Visualization of Results

Prediction results are displayed in simplified format including recommended crop, expected price trend, disease diagnosis, and supply chain transaction details.

Navigation Dashboard

Provides access to different modules such as Crop Advisory, Market Prediction, Disease Detection, Blockchain Tracking, and Profit Analysis.

This layer ensures accessibility for farmers with minimal technical knowledge.

B. Data Collection Layer

The Data Collection Layer gathers structured agricultural datasets required for training and prediction processes. Types of datasets used:

Crop Dataset

Contains environmental parameters such as rainfall, soil nutrients, humidity, and temperature along with crop suitability labels [6].

Mandi Price Dataset

Contains historical mandi price records including state, district, market name, commodity, and modal price [7]. Disease Dataset

Contains crop leaf image samples used for disease identification using pattern recognition techniques [8]. Supply Chain Dataset

Stores crop transaction records such as farmer name, crop batch ID, quantity, price, and timestamp.

The collected datasets are cleaned and standardized before processing.

C. Data Preprocessing Layer

Before training machine learning models, the collected data undergoes preprocessing to improve prediction accuracy.

Data Cleaning

Missing values and incorrect entries are removed from dataset [7]. Normalization

Numerical features such as rainfall and price are scaled into uniform range.

Feature Extraction
Important features such as month, seasonal variation, supply index, and environmental patterns are derived from dataset [1]. Categorical Encoding
Crop name, state, and market labels are converted into machine readable format. This layer improves consistency and reliability of input data.

D. Machine Learning Layer

The Machine Learning Layer forms the core intelligence component of the AgriChainAI system.
1. Crop Recommendation Model
Crop recommendation is performed using classification-based logic trained on agricultural environmental datasets. The model analyses relationships between environmental parameters and crop productivity [6].
Output: Recommended crop Confidence score
Expected productivity level
2. Price Prediction Model
The price prediction module estimates expected mandi price for selected crop and month using regression-based machine learning algorithms.
Features used for prediction:
Historical price trend Seasonal demand variation Supply approximation index Month-based trend pattern
Location-based mandi dataset
Linear Regression model identifies relationship between historical prices and seasonal factors [7]. Output:
Current mandi price Predicted future price Expected price trend Best performing mandis
3. Disease Detection Model
Disease detection module uses image-based classification logic to identify crop disease type. Input:
Crop leaf image Processing:
Image feature extraction Pattern matching
Classification of disease category Output:
Detected disease name Confidence score
Suggested treatment
This module helps farmers identify crop health problems early [8].

E. Blockchain Layer

Blockchain layer ensures transparency and security in agricultural supply chain transactions. Each crop transaction is stored as a block containing:
Farmer identification Crop batch ID
Quantity Price
Location Timestamp
Each block contains a cryptographic hash linking it to previous block, ensuring immutability [5]. Advantages:
Prevents data tampering
Ensures transparent crop tracking
Maintains trust among supply chain participants
Blockchain structure improves reliability of agricultural trade records.

F. Decision Support Layer

Decision Support Layer integrates outputs from machine learning models and blockchain data to generate useful recommendations.

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Examples:
Suggesting most profitable crop Predicting best time to sell crop Identifying best mandi location
Providing disease treatment suggestions
The system converts raw predictions into actionable insights for farmers [2].

G. Output Layer
Output layer displays final results to user in simplified format. Outputs include:
Recommended crop Predicted mandi price
Disease identification result
Supply chain transaction details Profit estimation
Results are presented in user-friendly dashboard interface.
Architecture Workflow Step 1
User provides input parameters such as soil nutrients, rainfall, crop type, and location.
Step 2
System preprocesses dataset and extracts relevant features. Step 3
Machine learning models analyse data to generate predictions.
Step 4
Blockchain module stores crop transaction records securely. Step 5
System displays final results and recommendations to farmer.

Advantages of Proposed Architecture
• Modular design allows easy expansion of system features.
• Combines Artificial Intelligence and Blockchain in single platform.
• Provides transparent and secure storage of agricultural transactions.
• Supports real-time prediction using historical dataset.
• Improves farmer decision-making accuracy.

IV. OVERVIEW OF THE SYSTEM

A. Information Gathering
Agricultural datasets containing mandi price records and crop environmental requirements are collected from government sources and research repositories [1].
B. Identifying Key Factors
Important agricultural factors influencing crop productivity include rainfall level, temperature variation, soil nutrients, seasonal demand, and transportation conditions [6].
C. Predictive Modelling
Machine learning algorithms analyse dataset to estimate crop suitability and future price trends [7].
D. Decision Support
The system provides recommendations that help farmers select profitable crops and determine optimal selling time [2].

V. RESULTS OF EXPERIMENTS

Machine learning models were tested using agricultural datasets containing mandi price records across multiple states and districts [7].
A. Objective of Experiments
Evaluate prediction accuracy of crop recommendation model [6].
Measure performance of price prediction algorithm using historical mandi datasets [7]. Verify transparency of blockchain storage mechanism [5].

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Assess system usability for agricultural decision support [3].

B. Data Preprocessing

Dataset preprocessing includes cleaning missing values, converting categorical variables, and normalizing price values [7].

Feature engineering includes month extraction, seasonal classification, and supply-demand approximation [1].

C. Models Used Regression Model

Used to estimate future crop price trend based on historical dataset [7]. Classification Model

Used to determine suitable crop based on environmental conditions [6]. Blockchain Structure

Used to store crop transaction information securely [5].

D. Interpretation

Experimental results show that price prediction model captures seasonal price variation trends [7].

Crop recommendation model provides suitable crop suggestions based on environmental input values [6]. Blockchain module successfully stores transaction data without modification [5].

Results indicate improved decision accuracy for crop planning and selling strategy [8].

VI. CRITICAL ANALYSIS

Prediction accuracy depends on availability and quality of agricultural datasets [7]. Unexpected climate changes may affect crop suitability prediction [1].

Blockchain implementation requires internet connectivity and technical awareness [5]. Continuous dataset updates are required to maintain prediction accuracy [2].

VII. SUGGESTIONS FOR FURTHER RESEARCH

Integration with real-time weather API for automatic rainfall detection [1].

Integration with IoT-based soil sensors for accurate soil nutrient measurement [6]. Mobile application development for wider accessibility [3].

Improved disease detection accuracy using deep learning models [8].

Integration with government agricultural databases for improved prediction reliability [7].

VIII. CONCLUSION

AgriChainAI demonstrates how Artificial Intelligence and Blockchain technology can improve agricultural decision making [2].Machine learning models analyse environmental parameters and historical mandi price datasets to generate prediction results [7].Blockchain storage ensures transparency and security of crop transactions [5].

The system assists farmers in selecting suitable crops, predicting market price trends, and maintaining secure supply chain records [6].AgriChainAI contributes toward development of intelligent agriculture solutions that promote sustainable farming practices and improve farmer profitability [1].

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