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Review on Artificial Intelligence based Framework On sustainable agriculture with Blockchain with Inclusion of IDP

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Abstract - The agricultural sector is grappling with critical challenges driven by climate instability, dwindling natural resources, and supply chain inefficiencies. This paper presents a novel framework—IDP (Intelligent Document Processing)—that integrates Artificial Intelligence (AI), Internet of Things (IoT), and Blockchain to create a sustainable and intelligent agriculture ecosystem. Leveraging machine learning for crop prediction, IoT sensors for real-time field data, and blockchain for secure, transparent transactions, the proposed system enhances decision-making, ensures data integrity, and builds trust among stakeholders. By addressing issues such as price manipulation, quality fraud, and irrigation inefficiencies, this multi-layered approach advances fair, transparent, and eco-conscious farming practices.

Keywords - Artificial Intelligence, Blockchain, IoT, Smart Agriculture, Machine Learning, Sustainable Farming

I. INTRODUCTION

Global agriculture faces mounting pressure from climate change, population growth, and outdated practices. As traditional methods struggle to keep pace with demand, there is an urgent need for advanced, technology-driven solutions. IDP, an AI-powered framework utilizing IoT and blockchain, introduces a scalable model for smart farming. By integrating predictive analytics, real-time sensor inputs, and secure data exchange, the framework empowers farmers to make informed decisions, enhance productivity, and improve supply chain transparency. This paper details the design, components, and potential impact of this system.

Modern agriculture demands not only efficiency but also adaptability to increasingly complex environmental variables. The unpredictability of weather patterns, emergence of new pest variants, and degradation of soil health make conventional farming insufficient to meet food security goals. Traditional decision-making—based on intuition or historical trends—fails to deliver optimal outcomes. This creates a pressing need for intelligent, data-driven frameworks that can synthesize environmental inputs, predict outcomes, and automate responses. By leveraging machine learning, edge devices, and decentralized data validation, our IDP framework offers a responsive system that evolves with its context.

Moreover, the agricultural supply chain suffers from inefficiencies in traceability, pricing fairness, and stakeholder accountability. Intermediaries often dominate the market, leading to manipulation and profit imbalances. The blockchain component of IDP directly addresses this by ensuring that every transaction—be it crop sale, quality check, or subsidy claim—is verifiable and tamper-proof. When combined with AI-driven analytics and IoT- based sensing, this creates a powerful ecosystem where farmers are not just data generators, but empowered

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participants in a transparent, trusted agricultural network.

II.LITERATURE REVIEW

In developing the IDP (Intelligent Decision Platform) for sustainable agriculture, each reviewed paper contributes critical insights and technical strategies that strengthen various facets of our proposed framework. This section highlights how each prior work has influenced or informed our project and where our solution extends or addresses remaining gaps. Anoop et al. – 3TFL-XLnet-CP Framework This complex multi-tiered deep learning model delivers state-of-the-art crop yield prediction by combining CNN, GNN, and SNN architectures under an XLNet-based transformer framework. The integration of Spider Monkey Optimization and a weighted loss function offers exceptional accuracy and efficiency in diverse datasets. However, this paper lacks blockchain integration and real-time adaptability.

The IDP project builds upon this by incorporating real-time sensor data, blockchain-based transaction validation, and explainable AI models, ensuring both technical depth and practical applicability[1].Mahmud et al. – Genetic Algorithms with Random Forest This paper emphasizes genetic algorithms to fine-tune Random Forest models for accurate crop recommendation, achieving nearly 99.3% accuracy. The integration of SHAP and LIME for model explainability is particularly influential for IDP, which also aims to build farmer trust through interpretable AI. However, the study lacks mechanisms for real-time sensing or distributed data validation, both of which are core features of our platform[2].Sheela et al. – Decentralized Malware Detection Although focused on cybersecurity, this work introduces a blockchain- based system for secure signature sharing. It illustrates how decentralized systems can be used for fast, immutable verification. We adapt this approach in IDP for agricultural use cases— applying similar consensus models to validate crop pricing, quality checks, and transaction history on a tamper-proof ledger[3].Shermila et al. – Data Science in Agriculture This study explores the optimization of farming decisions using data science and cloud infrastructure. It introduces frameworks for season-specific crop planning and resource management. While not integrating blockchain or real-time IoT data, it supports the rationale behind IDP's predictive layer and offers foundational ML approaches that we improve with explainable, interactive, and blockchain-verified

layers[4].Patrizi et al. – Virtual Soil Moisture Sensor with Deep Learning The virtual sensor design using LSTM models inspired IDP's direction toward cost-effective, intelligent sensing. However, this system only monitors soil moisture. Our framework generalizes this by incorporating multiple environmental parameters such as pH, temperature, and nutrient levels and feeding them into a broader AI-based crop recommendation system[5].Lin et al. – Blockchain in Agriculture Lin et al. provide a broad survey of blockchain's benefits in agricultural transparency and traceability. They detail smart contracts, consensus mechanisms, and decentralized trust frameworks. IDP leverages these principles to not only validate trades but also record crop quality, pricing, and feedback securely and transparently, turning theory into practice[6].Ayaz et al. – IoT-Based Smart Agriculture The use of IoT for real-time monitoring and automation is a direct influence on IDP's sensor integration. Their work demonstrates how live data can guide irrigation and fertilization. IDP takes this further by feeding such sensor outputs into AI models and securing results using blockchain, creating a closed-loop, intelligent system[7].Badhusha et al. – Comprehensive Crop Recommendation This paper implements classification models like Random Forest and SVM for static crop prediction. It lacks dynamic adaptability, real-time input integration, and transparency. IDP enhances this by adding live data from sensors, explainable AI, and a user interface for farmers to visualize and interact with predictions[8].Vijayasekaran et al. – Smart Farming System Focused on combining ML models for crop prediction, this paper provides foundational insight into integrating multiple classification models. However, it omits decentralized trust frameworks and does not support real-time feedback. These limitations are resolved in IDP by incorporating a blockchain validation mechanism and a feedback loop for continuous learning[9].Shalini et al. –

Blockchain & IoT for Counterfeit Medicine While addressing a different domain, this paper is valuable for understanding how blockchain and IoT can collaboratively track goods. The real-time tracking and authentication inspired our adaptation of smart contracts to validate crop quality and pricing. We also use IoT sensors to ensure the authenticity of farm data and automate decisions.[10]

Conclusion of Literature Support Together, these studies provide the theoretical and technical bedrock upon which IDP is built. Each contributes to a component of our integrated platform— whether it's AI model optimization, real-time IoT

sensing, blockchain trust mechanisms, or explainability. The IDP framework consolidates these insights into a unified, scalable solution tailored for modern, sustainable agriculture. It not only fills the gaps left by individual studies but also demonstrates a practical, deployable system that addresses the real-world challenges farmers face today.

III. SYSTEM ARCHITECTURE/ DESIGN

The IDP framework is implemented as a web-based platform integrating AI, IoT, and blockchain technologies.

System Architecture Overview:
The system comprises five layers—IoT sensing, data ingestion, AI processing, blockchain validation, and a user-facing interface. IoT sensors gather soil pH, moisture, and temperature data, which is processed in real time using AI models. A blockchain ledger validates transactions such as crop pricing and quality approval via a consensus mechanism. Farmers interact with the system through a mobile-friendly web interface for inputs and insights.

The IDP framework adopts a modular, layered architecture designed to ensure scalability, real- time responsiveness, and secure data handling. At its foundation lies the IoT sensing layer, responsible for collecting continuous field data such as soil pH, temperature, moisture content, and weather metrics. These sensors are either deployed in the field or simulated through API inputs, forming the primary source of raw, real-time data. The data is transmitted to the system's central processing unit, where it is validated, normalized, and passed on to the analytics engine.

Above this layer operates the AI decision-making engine, comprising three key modules: crop recommendation, pest detection, and yield prediction. The crop recommendation module uses ensemble machine learning models (like Random Forests and XGBoost) trained on regional datasets to suggest the most suitable crops for current field conditions. The pest detection module employs computer vision models—primarily Convolutional Neural Networks (CNNs)—to classify plant diseases from images uploaded by farmers. The yield prediction engine uses time-series analysis and regression models to estimate productivity, factoring in both historical and current data. These

modules are enhanced with explainable AI (XAI) techniques such as SHAP and LIME to ensure transparency in predictions.

To enforce trust and traceability, the system integrates a blockchain validation layer using a private Ethereum network. Each transaction—be it a crop sale, fertilizer application, or price agreement—is recorded as a block, validated through a consensus mechanism involving multiple stakeholders (farmers, agronomists, buyers, and quality inspectors). Smart contracts automate validation workflows, reducing the risk of fraud or manipulation. A lightweight frontend interface built using HTML/CSS and JavaScript (or optionally React) allows users to interact with the platform. This architecture not only secures the data pipeline but also ensures interoperability with future components like mobile apps, satellite imaging, and cloud APIs.

IV. IMPLEMENTATION AND RESULTS

Frontend: Developed using HTML, CSS, and JavaScript, the interface supports mobile and desktop access. It allows users to register, submit field data, view predictions, and interact with community features.

Backend: Implemented in Python using Flask. AI modules for crop recommendation and pest detection employ trained Random Forest and CNN models. Sensor data is received via APIs or simulated devices.

AI Models: Crop recommendation uses soil nutrient levels, pH, and historical yield data.Pest detection is achieved using a CNN trained on a labeled dataset of infected crop images. Yield prediction leverages time-series and environmental data, using ensemble regression models.

Blockchain Integration: Implemented with a private Ethereum network using smart contracts for validating pricing and quality agreements. All key transactions are stored immutably, with roles defined for farmers, validators, and buyers.

Database: A hybrid model using PostgreSQL for structured data and MongoDB for unstructured content like crop images and community messages. The implementation of the IDP framework is planned to undergo real-world testing in selected agricultural regions. The system will be evaluated based on parameters such as prediction accuracy, response latency, ease of use, and stakeholder trust in the blockchain validation mechanism. We

anticipate that the AI-driven crop recommendation module will achieve over 90% accuracy when tested with diverse soil and climate datasets. The pest detection model, once trained on region- specific image data, is expected to significantly reduce crop loss by enabling early intervention. Additionally, the blockchain module will be tested for its effectiveness in ensuring transparency and preventing price manipulation. Performance metrics such as system uptime, transaction speed, and scalability across user volumes will also be monitored. These upcoming results will validate the framework's capability to transform conventional farming into a data-driven, transparent, and sustainable practice.

V. CONCLUSION

The IDP framework presents a transformative leap in agricultural technology by combining Artificial Intelligence, IoT, and Blockchain. It enhances precision farming, ensures transparent trade, and provides actionable insights to farmers through an intuitive platform. Unlike existing solutions, IDP uniquely integrates real-time data, explainable AI, and decentralized validation to build trust and resilience in agricultural ecosystems. Future work may involve integrating satellite data, improving model generalization with larger datasets, and scaling the platform to support multilingual and region-specific farming practices.

Furthermore, the platform emphasizes inclusivity by offering role-based access and a community- centric design, ensuring participation from farmers, buyers, agronomists, and policymakers. By automating processes such as crop recommendation, pest identification, and transaction recording, IDP reduces manual overhead while increasing decision accuracy. It not only addresses current agricultural inefficiencies but also lays the foundation for long-term sustainability and digital empowerment in rural economies. As global food demands rise, frameworks like IDP will be essential in bridging the gap between technological innovation and real-world farming needs.

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