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An AI and Blockchain Enabled Platform for Transparent Contract Farming in India

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Abstract: *The agricultural sector in India is dominated by small and marginal farmers, who are vulnerable to income uncertainty, delayed payments, a lack of price transparency, and dependence on middlemen. Contract farming has been recognized as a means to reduce market uncertainty by ensuring assured markets and prices; however, the current implementations of contract farming are plagued with one-sided contracts, lack of enforcement, low trust levels, and poor awareness among farmers. These issues are further exacerbated in rural and developing environments, where access to timely information, legal certainty, and digital literacy are poor. This paper presents Kisan Bandhu, a digital platform enabled by AI and blockchain technology, to facilitate transparent, secure, and inclusive contract farming. The proposed platform combines district-level AI-powered crop advisory services, blockchain-secured smart contracts, and multilingual conversational interfaces to enable direct engagement between farmers and agri-businesses. The proposed solution is centered on low-cost implementation, legal soundness, and usability for small farmers. The system design, architecture, methodology, and application validity are presented to establish the viability of the proposed platform in real-world agricultural supply chains.*

Key Words: *Contract farming, digital agriculture, blockchain, artificial intelligence, agricultural supply chain, smart contracts*

I. INTRODUCTION

Agriculture is an important sector of the Indian economy, as it provides employment to a large number of people. However, farmers in India continue to face problems like price volatility, uncertainty of demand, delayed payments, and a lack of information. According to a survey, the majority of agricultural households in India have small landholdings, which make them highly susceptible to market risks. Contract farming is expected to resolve these problems by setting up a pre-agreed framework between the farmers and the buyers with respect to the type of crop, quantity, quality, price, and time of delivery. Although the regulatory framework for contract farming is present in India, its implementation has been hampered by a lack of transparency, trust deficits, and poor monitoring systems. Lack of awareness among farmers regarding the terms of the contract, and challenges faced by the companies to identify good contract farmers and ensure timely delivery of produce, are some of the issues associated with contract farming. Recent developments in digital technologies such as artificial intelligence, blockchain, and mobile communication platforms offer a chance to re-engineer the contract farming system. AI can be used for data-driven crop planning, and blockchain can be used for secure and tamper-proof contracts and settlements. But most of the current work focuses on these technologies in a standalone manner and does not consider the issue of accessibility in low-resource settings. This paper proposes Kisan Bandhu, a comprehensive digital platform that combines AI-based advisory systems, blockchain-based smart contracts, and multi-lingual voice interfaces to facilitate transparent and inclusive contract farming. The proposed system is designed to function with minimal infrastructure requirements, making it suitable for rural and low-resource settings.

II.RELATED WORK

Digital interventions in agriculture have mainly targeted market linkage platforms, price discovery systems, and advisory services. E-market platforms and corporate-driven procurement platforms have increased access to buyers but are often dependent on centralized control and middlemen, thereby lacking transparency. Various research studies have also examined the use of blockchain technology in agriculture for traceability and secure transactions, thereby establishing its potential in minimizing conflicts and maximizing trust among stakeholders. [1]

Artificial intelligence has been extensively used in agriculture for crop suggestion, yield estimation, pest identification, and weather- based advisory services. AI-driven decision support systems have been found to be highly effective; however, their use among small- scale farmers is limited due to usability issues, language constraints, and fragmented delivery systems. Moreover, most blockchain and AI-based agricultural solutions are dependent on high-end infrastructure, cloud connectivity, or complex user interfaces.

The current state of research suggests that there is a need for comprehensive systems that can integrate legal contract enforcement, intelligent advisory, and farmer-friendly access in a unified platform. The proposed Kisan Bandhu platform fills this research void by offering an end-to-end contract farming solution that is specifically designed to meet the socio-economic and infrastructural needs of rural India. [2]

III.CONTRACT FARMING BACKGROUND AND REGULATORY STANDARDS

Contract farming requires a pre-production agreement between farmers and consumers regarding characteristics of the produce, pricing mechanisms, quality, and delivery terms. In India, the Model Contract Farming Act focuses on protecting farmers, ensuring price, land ownership, and resolving disputes. However, the lack of transparency and enforcement in practical implementation remains a challenge.

From an agricultural point of view, successful contract farming requires proper crop planning, agricultural practices, and proper coordination between parties. Climate, soil, and regional differences require district-specific advice rather than general advice. Moreover, oral contracts between farmers and consumers make them vulnerable to exploitation and late payments. [3, 4]

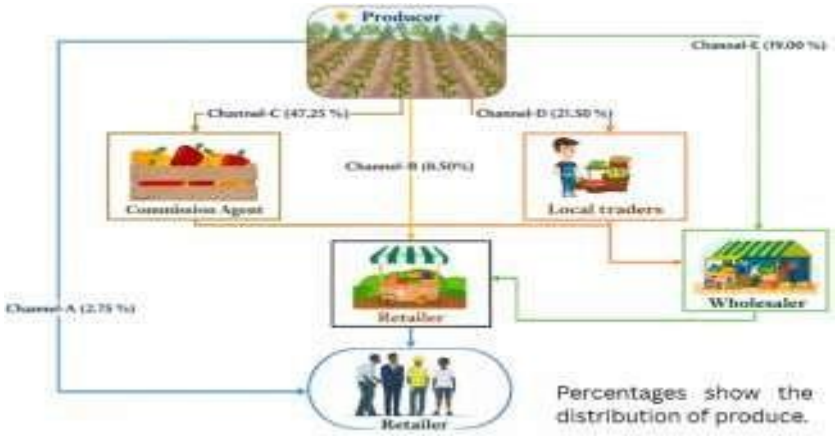

Fig. 1. Traditional agricultural supply chain showing intermediary-driven distribution of produce.

An electronic system that meets regulatory requirements can help in enforcing contracts, maintaining records, and accountability. Encoding contract details in an electronic system and ensuring immutability can reduce disputes and increase trust between farmers and corporations.

IV.SYSTEM DESIGN AND ARCHITECTURE

The Kisan Bandhu framework is designed as a modular system comprising four key components: user interaction, application services, intelligence and trust, and data integration. Each module functions independently, working together to achieve a single processing pipeline.

A. User Interaction Module

This module offers access interfaces for farmers and businesses. Farmers can access the system using a multilingual WhatsApp chatbot and voice interface, which is user-friendly for those with limited digital knowledge. Businesses can access the system using a web-based dashboard for demand generation, contract management, and monitoring.

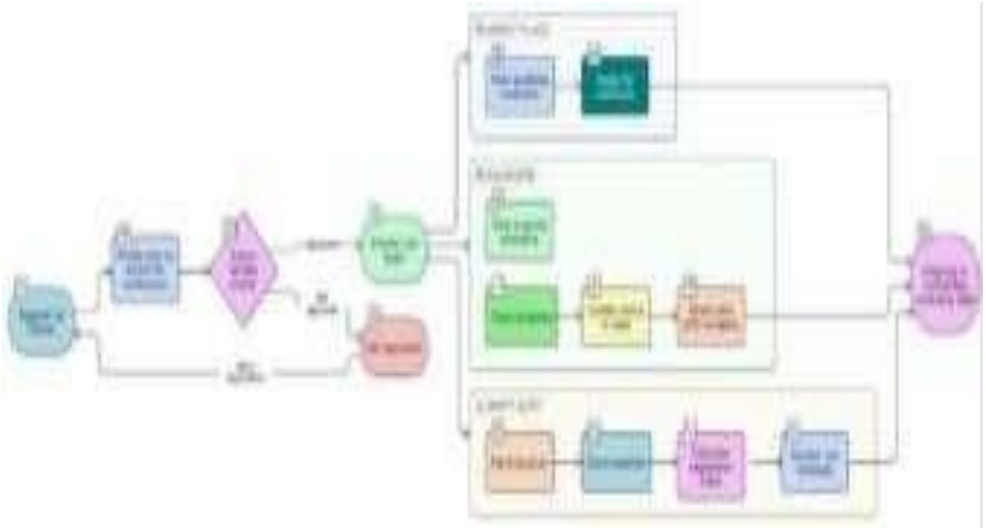

Fig. 2. Farmer-side workflow in the proposed Kisan Bandhu contract farming framework.

B. Application Services Module

The key services offered include registration and verification, contract marketplace, contract management, monitoring, and payment processing. Verification services ensure that only real farmers and legitimate businesses are allowed to participate. The marketplace enables the discovery of contract opportunities based on the type of crop, geographical location, and time.

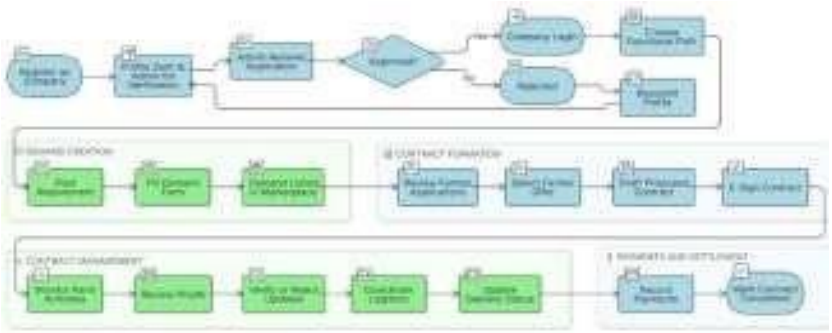

Fig. 3. Company-side workflow for demand creation, contract management, and settlement.

C. Intelligence and Trust Module

The intelligence part uses AI models to create crop calendars, sowing, and harvesting suggestions for each district, as well as alert notifications, based on historical and real-time data. The trust part uses blockchain smart contracts to formalize agreement terms like price, quantity, quality, and delivery milestones. The smart contracts automate the execution of these agreements, thus minimizing human involvement and delays in payments. [5]

D. Data and Integration Module

This module involves the integration of external data sources like weather, mandi prices, and government data. Secure APIs are used to facilitate real-time data updates while ensuring data integrity and privacy. [6]

V.METHODOLOGY

This section describes the methodology adopted in the proposed Kisan Bandhu framework in detail. The methodology is analogous to the rule-based evaluation in the health domain, where the agricultural contract farming process is divided into well-defined computational steps.

A. Contract Lifecycle Definition

Each contract in the farming domain has its own lifecycle, and the states in the contract are as follows:

1. **Contract Proposal:** The Company decides on the type of crop, quantity, quality, price (fixed or range), delivery period, and location for the contract.
2. **Farmer Enrolment:** The farmers who are eligible for the contract either enroll individually or in clusters, depending on their land and the suitability of the crop for the region.
3. **Contract Finalization:** The terms are mutually agreed upon, and the contract is digitally signed and implemented as a smart contract.
4. **Active Monitoring:** The updates are tracked during the cultivation period in the crop growth phase.
5. **Delivery Verification:** The quantity and quality are verified upon delivery.
6. **Settlement and Closure:** The payment execution and the contract are archived.

B. Smart Contract State Model

The smart contracts are based on a permissioned blockchain with deterministic state transitions. The transitions are based on verified events such as farmer acceptance, crop state updates, or delivery confirmation.

C. AI-Based Crop Advisory Pipeline

Advisory pipeline includes data ingestion, data preprocessing, model inference, and delivery. The data includes district-wise historical yield data, weather forecast, and seasonal crop calendars. The output of the AI model includes sowing windows, risk alerts, and harvest time, which is communicated through a conversation interface.

D. Monitoring and Exception Handling

Deviations, which may include late sowing, bad weather, or failure to comply with the agreed schedule, are identified during the cultivation process. The system alerts the farmers and the companies accordingly.

E. Automated Payment Trigger Mechanism

Upon verifying the delivery, the smart contract will check whether the parameters have been met. Upon satisfying this, the payment will be made directly to the farmer's account.

VI.COMPARATIVE ANALYSIS

Traditional contractual arrangements of contract farming in India primarily rely upon a 'paper-based' system, negotiations, and a number of intermediaries. The system, in general, lacks transparency in terms of pricing, quality, and payment settlements. Moreover, monitoring of cultivation is not systematic, which creates difficulties for companies in planning procurement strategies and increases risks for farmers. The level of awareness of contractual obligations and market conditions for farmers is also low, as advisory support is either not available or is provided by different sources. [7]

However, in contrast, the proposed Kisan Bandhu model will provide a digitally formalized system of contract farming, where contracts will be formally represented through blockchain-based smart contracts. The proposed system will eliminate any disputes or difficulties in terms of payment, as smart contracts will automatically enforce payment terms. Unlike traditional models, monitoring of cultivation will be consistent, as AI-based advisory support will be provided to farmers throughout the cultivation period. The proposed system will be a highly structured model, as it will overcome all the shortcomings of traditional contractual models of contract farming.

VII.SYSTEM EVALUATION AND PRACTICAL IMPLICATIONS

This section examines the proposed framework from an operational and economic point of view. By digitizing the terms of a contract and executing it via a smart contract, the framework eliminates confusion related to price, quality, and delivery time. Settlement mechanisms minimize delays in payments, thus providing a stable source of income for farmers. In the case of agri-businesses, structured monitoring and data-driven analysis improve forecasted demand and procurement planning.

The application of conversational interfaces and lack of infrastructure requirements make the framework suitable for implementation in rural areas. More importantly, the framework is designed to be integrated with existing agricultural processes, thus allowing for its adoption without disrupting conventional processes.

VIII.APPLICATION SCENARIO AND OPERATIONAL FLOW

To prove the applicability of the system, let us consider a soybean procurement contract where the contract parameters are established by an agri-processing firm in the state of Maharashtra. The contract parameters include the type of crop, quantity of the crop, quality of the crop, etc., while the farmers are registered based on the suitability of the region and the landholding capacity of the farmers.
[8] [9]

At the cultivation stage of the contract, the farmers are advised on the cultivation of the crop through AI-based advisories. The progress of the contract is regularly updated, which helps in the early detection of potential risks. Once the delivery conditions are met, the smart contract automatically settles the payment, thus establishing the coordination, transparency, and trust between the parties.

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