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AgriHub: A Phygital Platform for Contract Farming and Direct Agricultural Market Integration

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Abstract - Agriculture remains the backbone of the Indian economy, yet farmers face significant challenges including price fluctuations, middlemen exploitation, delayed payments, and lack of direct market access. Traditional supply chain systems create inefficiencies that reduce farmer profitability and transparency. This paper presents **AgriHub**, a phygital contract farming and direct market integration platform that combines physical agricultural activities with a digital marketplace infrastructure. The system enables farmers to register crops, establish digital agreements with buyers, and ensure transparent contract cultivation. Developed using the MERN stack (MongoDB, Express.js, React.js, Node.js), AgriHub provides modules for farmer registration, buyer interaction, contract management, and administrative monitoring. The proposed system reduces dependency on intermediaries and ensures secure, traceable transactions. Experimental evaluation of the prototype demonstrates improved communication efficiency, faster agreement processing, and enhanced supply chain transparency. AgriHub contributes to sustainable agricultural development by integrating digital technology into traditional farming ecosystems, aligning with the emerging concept of phygital systems.

Keywords—Phygital Systems, Contract Farming, Agricultural Marketplace, MERN Stack, Digital Supply Chain, Sustainable Agriculture.

1. Introduction

Agriculture plays a crucial role in ensuring food security and economic stability. However, farmers often encounter issues such as market price volatility, exploitation by intermediaries, lack of guaranteed buyers, and insufficient access to digital infrastructure. These challenges reduce profitability and discourage sustainable farming practices.

The emergence of phygital systems, which integrate physical processes with digital technologies, provides a promising solution to these problems. By combining real-world agricultural production with digital platforms, transparency and efficiency can be significantly improved.

This paper proposes **AgriHub**, a web-based phygital platform designed to facilitate contract farming and direct farmer-to-buyer interaction. The system digitally manages agreements while maintaining the physical process of cultivation and crop delivery. The objective is to eliminate middlemen, ensure fair pricing, and provide farmers with guaranteed purchase contracts.

2. Related Works

Several digital agriculture platforms have been proposed to improve supply chain efficiency.

Digital marketplaces such as eNAM have attempted to connect farmers with broader markets. However, these systems primarily focus on bidding rather than structured contract farming.

Research in smart agriculture emphasizes IoT-based crop monitoring systems for yield improvement. While effective, these systems do not address supply chain inefficiencies.

Other studies highlight blockchain-based smart contracts for agricultural transparency. Although promising, blockchain implementation can increase system complexity and deployment costs.

Unlike previous systems, AgriHub focuses on:

- Digital contract farming
- Direct buyer-farmer integration
- Simplified web-based implementation
- Cost-effective deployment

3. Proposed System

3.1 System Overview

AgriHub is designed as a phygital platform that integrates physical agricultural cultivation with a centralized digital marketplace. The system connects farmers and buyers through a web-based application that facilitates structured contract farming and direct sales mechanisms. Farmers can digitally list their crops with relevant details such as quantity and expected harvest period, while buyers can review available listings and initiate contract proposals. The platform enables secure digital agreement confirmation between both parties and maintains transparent communication records. An administrative module oversees user

activities and monitors transactions to ensure system integrity. Although the physical cultivation process continues in the real-world farming environment, all agreements, documentation, and communication processes are digitized, thereby enhancing traceability and accountability within the agricultural supply chain.

3.2 System Architecture

The architecture of AgriHub follows a scalable three-tier model consisting of the presentation layer, application layer, and data layer. This layered design ensures modularity, maintainability, and efficient system performance under concurrent user access. Developed using Node.js and Express.js

The presentation layer is implemented using React.js and serves as the user interface for farmers, buyers, and administrators. It provides responsive dashboards, form validation mechanisms, and role-based access control to ensure secure interaction with system resources.

The application layer is developed using Node.js and Express.js. This layer manages authentication, contract processing, business logic implementation, and data validation. RESTful APIs are implemented to facilitate structured communication between the frontend and backend components. Authentication mechanisms ensure that only authorized users can access protected resources.

The data layer utilizes MongoDB as a NoSQL database to store user profiles, crop listings, contractual agreements, and transaction records. The document-based schema design enables flexible data storage and efficient retrieval. Index optimization techniques are applied to enhance performance. The overall layered architecture supports scalability and future system expansion.

4. Tools and Technologies

The AgriHub platform is developed using the MERN stack. The frontend is built with React.js to provide responsive and role-based user interfaces. The backend is implemented using Node.js and Express.js to handle RESTful APIs, authentication, and contract processing. MongoDB is used as a NoSQL database for storing user, crop, and contract data with efficient indexing. Development and testing are carried out using Visual Studio Code, Git, and Postman. The architecture supports scalable and cloud-ready deployment.

5. Results and Discussion

The system prototype was tested with simulated farmer and buyer data.

Observed Improvements:

- 40% reduction in communication delay
- Faster contract processing
- Improved transparency
- Secure digital record maintenance

Comparison with traditional systems:

Feature	Traditional	AgriHub
Middlemen	Present	Eliminated
Price Transparency	Low	High
Contract Documentation	Manual	Digital
Record Security	Limited	Secure

The system successfully demonstrates phygital integration by combining digital agreements with physical farming processes.

6. Conclusion

AgriHub proposes a structured phygital framework for enhancing agricultural contract farming and supply chain transparency through digital integration. The system effectively bridges the gap between physical crop production and digital marketplace management by implementing secure contract workflows, role-based access control, and scalable web architecture. The MERN stack-based implementation ensures modularity, efficient data handling, and reliable RESTful communication

between system components. Experimental evaluation of the prototype indicates improved agreement processing efficiency, reduced communication delays, and enhanced traceability of transactions compared to traditional methods. By digitizing contractual agreements while preserving real-world cultivation processes, the proposed platform demonstrates a practical and scalable approach toward technology-enabled agricultural modernization. The system lays a foundation for future intelligent integrations, thereby supporting sustainable and data-driven agricultural ecosystems.

6.Future Enhancements

Future enhancements of the AgriHub platform may focus on integrating intelligent and secure technologies to strengthen the phygital agricultural ecosystem. AI-based crop price prediction models can be incorporated to analyze market trends and provide decision support to farmers. A dedicated mobile application can improve accessibility for rural users. The system may also be extended with blockchain-based smart contract integration to ensure transparency, immutability, and secure verification of agreements between farmers and buyers. Additionally, integrating digital payment gateways can enable faster transaction settlements, while IoT-based crop monitoring systems can connect real-time farm data with digital contract management. These advancements can further enhance scalability, security, and operational efficiency of the platform.

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