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Blockchain-Based Agriculture Supply Chain System

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ABSTRACT: The agriculture sector plays a crucial role in sustaining livelihoods worldwide, necessitating continuous advancements to enhance its efficiency and resilience. Blockchain technology (BCT) has emerged as a transformative tool with the potential to streamline and secure agriculture supply chains by enabling transparent, traceable, and tamper-resistant transactions. This study investigates the adoption of BCT in agriculture supply chains, focusing on a comparative analysis across both developed and developing economies. Data collected from The Netherlands, the United States, Saudi Arabia, and India provides insights into the factors driving and impeding BCT adoption in these regions. Utilizing Interpretive Structural Modeling and the Decision Making Trial and Evaluation Laboratory approach, the study identifies and ranks factors based on their influence on BCT adoption. Findings reveal that while enabling factors vary among the economies, policy support emerges as the most significant enabler across all regions. This research highlights the importance of policy frameworks in promoting BCT adoption and underscores the need for tailored strategies to address regional barriers in the agriculture supply chain

KEYWORDS: Blockchain Technology (BCT), Agriculture Supply Chain, Data Immutability, Smart Contracts, Traceability, Transparency, Regulatory Compliance, Inventory Management, Analytics and Decision Support System (DSS), Transaction Automation, Stakeholder Trust, Real-Time Updates, Quality Standards etc.

I. INTRODUCTION

Blockchain technology (BCT) has gained recognition as a powerful tool in modernizing agriculture, particularly by addressing inefficiencies and transparency issues within the supply chain. In agriculture, where product quality, traceability, and supply chain reliability are paramount, BCT offers a decentralized and tamper-resistant system for securely tracking the journey of agri-produce from farm to consumer. This technology records transactions on an immutable ledger, making it possible to trace each step a product takes, which strengthens trust among suppliers, distributors, and consumers. Additionally, BCT helps to reduce fraud, optimize inventory management, and streamline processes through automated smart contracts that improve coordination and reduce reliance on intermediaries.

The significance of BCT in agriculture supply chains is evident in its capacity to provide a single, shared source of truth among stakeholders, which is especially beneficial for ensuring food safety and regulatory compliance. By creating a transparent record of each transaction, BCT can help developing and developed economies alike tackle challenges such as counterfeit products, supply chain delays, and inconsistencies in product quality. However, the adoption of BCT in agriculture faces unique barriers, including technological infrastructure, policy limitations, and varying levels of digital literacy among farmers. This study delves into these enablers and challenges by examining data from four distinct economies—The Netherlands, the United States, Saudi Arabia, and India—revealing that while specific factors differ, strong policy support is universally critical to BCT adoption in agriculture supply chains.

II. LITERATURE SURVEY

Title: A Framework for Secure Food Supply Chain Management
Author: Ramesh A. & Padhy R. (2021)
Description: The authors propose a secure framework aimed at enhancing food safety and quality insupply chains. The paper includes a case study demonstrating the effectiveness of the proposed system.
Title: Reducing Food Waste in Supply Chains with Innovative Technologies
Authors: Wiggins S. & Frost D.(2022)

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Description: This study analyzes how innovative technologies can enhance coordination among supply chain actors , minimizing food waste and increasing operational efficiency.

Title: Enhancing Food Safety through Improved Traceability Systems
Authors: Liu X. & Wang Q. (2019)
Description: This study highlights the role of enhanced traceability systems in improving food safety, providing empirical data that demonstrates increased consumer trust and satisfaction..

III. PROBLEM STATEMENT

The agriculture supply chain is often characterized by inefficiencies, lack of transparency, and vulnerability to fraud. Traditional supply chain systems suffer from issues such as delays in information flow, limited traceability of goods, and the inability to verify the authenticity of agricultural products, especially in complex global supply chains. Farmers, distributors, and consumers face challenges due to these issues, leading to food waste, economic losses, and a lack of trust in the quality and origin of agricultural products.

Blockchain technology offers a decentralized and transparent solution to address these challenges. By enabling immutable record-keeping and real-time traceability, a blockchain-based agriculture supply chain system could enhance transparency, reduce fraud, and improve overall efficiency. This system could allow stakeholders to track products from farm to table, ensuring authenticity, safety, and quality at every stage.

IV. OBJECTIVES

The primary objectives are to:

1. **To assess** current challenges in the agricultural supply chain, identifying inefficiencies, transparency issues, and sustainability concerns.
2. **To evaluate** innovative technological solutions such as distributed ledger systems and smart contracts, analyzing their potential impact on supply chain operations.
3. **To develop** comprehensive implementation frameworks for effectively integrating these technologies into the agricultural supply chain, addressing barriers to adoption.
4. **To enhance** traceability and transparency in the supply chain, ensuring consumers have reliable information about the origins and safety of their food products.
5. **To improve** food safety standards by investigating how innovative technologies can provide real-time monitoring and compliance tracking throughout the supply chain.
6. **To reduce** food waste by exploring methods that utilize technology for better coordination and information sharing among supply chain stakeholders.

V. PROPOSED SYSTEM

This study employs a mixed-methods approach, combining qualitative and quantitative techniques to analyze the adoption of Blockchain Technology (BCT) in agriculture supply chains across developed and developing economies. Data collection begins with qualitative surveys and in-depth interviews with stakeholders from the agriculture sectors of The Netherlands, the United States, Saudi Arabia, and India. This allows for a comprehensive understanding of the varying levels of BCT awareness, perceived benefits, and challenges among these countries. To ensure a representative sample, participants are selected from diverse roles, including farmers, logistics providers, policy-makers, and tech companies involved in BCT. Following data collection, responses are categorized to establish common themes and unique insights that reflect the socioeconomic contexts and adoption levels of BCT in both developed and developing economies.

Once the initial qualitative data is gathered, this study leverages Interpretive Structural Modeling (ISM) and the Decision Making Trial and Evaluation Laboratory (DEMATEL) approach to identify and rank key enablers and barriers to BCT adoption. The ISM process begins by developing a hierarchical structure that captures the interrelationships among factors influencing BCT adoption, from regulatory support and infrastructure readiness to

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awareness and perceived benefits. DEMATEL is subsequently applied to quantify the degree of influence each factor exerts on the others, helping to distinguish the critical drivers from secondary elements. This combined ISM-DEMATEL method is particularly useful for examining complex, interdependent factors, as it allows researchers to determine the intensity and direction of influence across various enablers and barriers.

The study then performs a comparative analysis of the ISM-DEMATEL findings from each country to assess regional variations in BCT adoption enablers and barriers. By comparing results across developed (The Netherlands and the United States) and developing (Saudi Arabia and India) economies, this analysis reveals patterns in regulatory and technological support, infrastructure, and sector-specific challenges. Through this structured methodology, the study identifies the pivotal role of policy support as a universal enabler and highlights other factors that may be more regionally specific. Ultimately, the findings aim to inform tailored strategies and policy recommendations to enhance BCT adoption in agriculture supply chains globally, facilitating the creation of transparent, resilient, and efficient systems adaptable to diverse economic contexts.

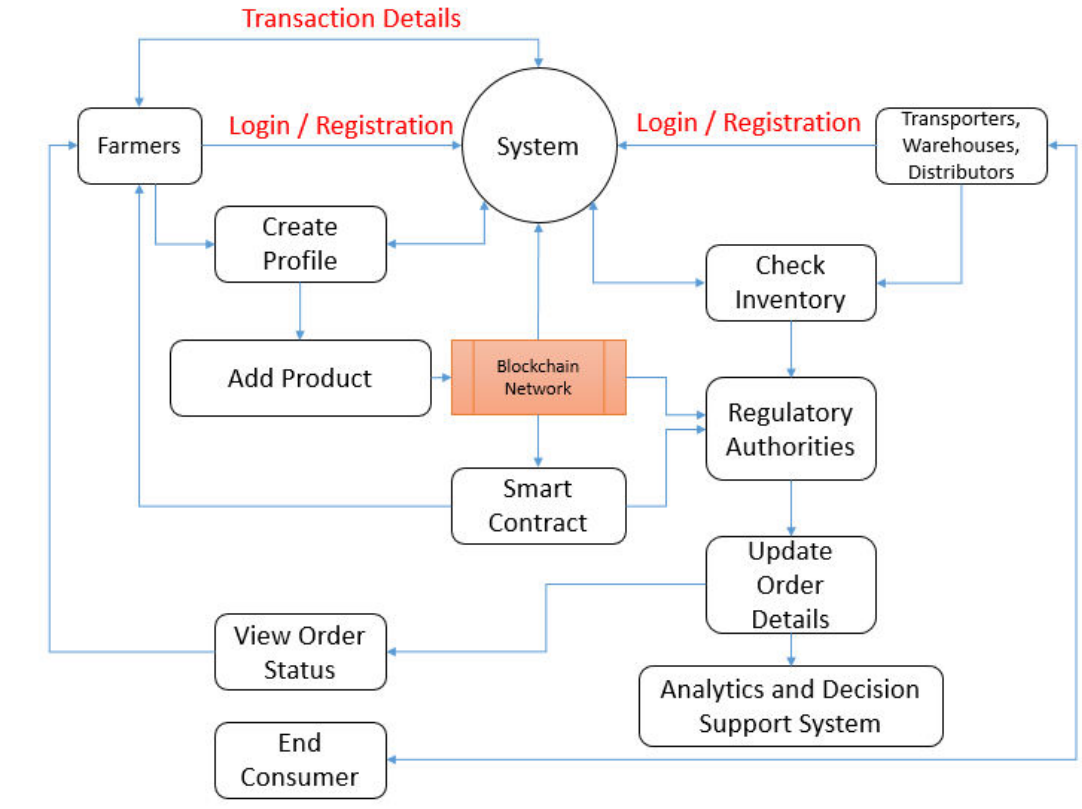

Fig.1: Proposed System Architecture

VI. EXISTING SYSTEM

The existing agricultural supply chain operates through a series of interconnected stages, including production, processing, distribution, retail, and consumption. However, this system often suffers from significant limitations. Information is fragmented across stakeholders—farmers, distributors, and retailers—leading to a lack of visibility and inefficient traceability. Tracking the origin and journey of products relies heavily on manual records, making it cumbersome and prone to errors. Additionally, transparency is limited, resulting in consumers having little knowledge about the sourcing and safety of their food. Communication among stakeholders is often ineffective, causing delays and inefficiencies. Food safety concerns are exacerbated by the absence of real-time monitoring, making it difficult to

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respond swiftly to issues. Overall, the existing system hinders effective decision-making and fosters distrust among consumers, highlighting the urgent need for innovative technological solutions to enhance efficiency, traceability, and transparency throughout the agricultural supply chain.

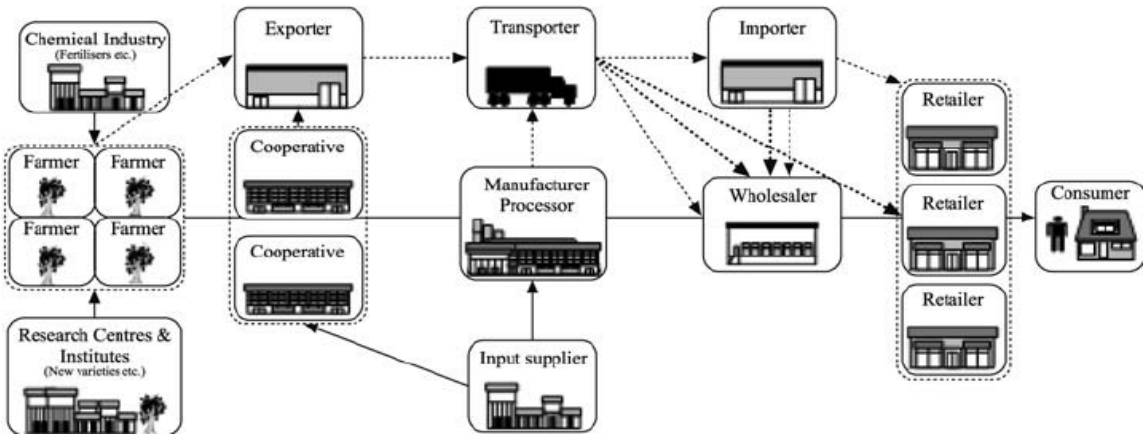

Fig.2: Existing System Architecture

VII. CONCLUSION & FUTURE WORK

we try to design a system name as the blockchain-based agriculture supply chain system that can be provides a secure, transparent, and efficient platform for managing agricultural transactions by integrating all key stakeholders farmers, transporters, warehouses, distributors, regulatory authorities, and end consumers through a centralized system enhanced by blockchain technology. By utilizing smart contracts, the system automates processes, ensures data integrity, and fosters trust among participants. Regulatory oversight further enhances quality assurance, while the Analytics and Decision Support System (DSS) offers actionable insights to optimize logistics and inventory management. This solution effectively addresses critical challenges in the agriculture sector, such as traceability and transparency, ultimately strengthening the supply chain and building consumer confidence in agricultural products.

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