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Review on agriculture 4.0: Exploring the digital transformation of the agriculture supply chain

¹Yagya Kumari Lodhi and ²Dr. Amisha Shah

¹Ph.D., Research Scholar, Center for Studies in Rural Management, Gujarat Vidyapith, Nr. Income Tax Office, Ashram Road, Ahmedabad, Gujarat, India

²Assistant Professor, Center for Studies in Rural Management, Gujarat Vidyapith, Nr. Income Tax Office, Ashram Road, Ahmedabad, Gujarat, India

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Corresponding Author: Yagya Kumari Lodhi

Abstract

The advent of Industry 4.0, marked by integrating advanced technologies and data-driven processes, has brought about various transformative changes in various sectors of the economy, one such area is agriculture. Agriculture 4.0, this approach combines cutting-edge technologies with traditional farming practices which address challenges in agricultural industry. This paper delves into the current initiatives and technologies like the use of remote sensing, precision agriculture, block chain, artificial intelligence, etc. under the umbrella of Digital Agriculture across the world and nation while analysing their impact on crop yield, resource optimization, market access, and farmer welfare.

Keywords: Agriculture technology, agriculture, farm mechanization, ICT

Introduction

Different authors have defined Digitalization in Agriculture differently, according to Sonali Ganguly and S. Patra, 2017, it meant ICT and data enabled ecosystem which support advancement and timely delivery of information and services which makes farming profitable and sustainable. This digitalization of agriculture supply chains, often referred to as Agri 4.0. This transformation encompasses the seamless integration of digital technologies, harmonizing the intertwined principles of precision farming and smart agriculture (Rasputina, 2022) ^[46]. Blockchain technology, can be used to solve the problem of traceability and visibility of agri-food products (Kurucz, 2021) ^[31]. The buyer could get the details of producer along with the farm details etc through this blockchain technology. However, the implementation of Agri 4.0 faces several challenges, including the need for sustainable solutions and the role of technology in decision-making (Panetto, 2020) ^[44]. Digital technologies such as the Internet of Things (IoT), artificial intelligence and big data are key drivers towards innovation in agri-food sector, leading to reduced food wastage and improved supply chain operations (Dadi, 2021) ^[12]. In Indian context, the adoption of Agriculture 4.0 is hindered by barriers such as lack of government approach towards sensitization for adoption of new technology/services along with proper incentives to Agriculture stakeholders in using these technologies/services (Kumar, 2021) ^[30].

Current status of Digitalization of Agri Supply Chain

The adoption of digital technology like IoT, AI and big data

in the agri-supply chain has the potential to revolutionize the way farmers connect with markets and improve overall efficiency and effectiveness. In recent years, there is a surge in digitalization of the agri-supply chain. Several initiatives have been already taken to promote the integration of digital technology into agri-supply chain. The utilization of analytics, connected sensors, and arising technologies could further boost works, amend the water efficiency and other resources, and promote sustainability and adaptability across agriculture civilization and livestock management (R. Naresh, 2021) ^[38]. Also, Indian Government has undertaken significant measure to revolutionize agriculture in different parts/regions though e-marketing of agro based products. Despite these efforts, 58 per cent of total population in India still rely upon agriculture, agri-based products or related activities for their livelihood. Indian government has also taken various action to streamline and enhance the marketing effectiveness for farmers (Unknown author, 2019). For instances, various initiatives have been taken across the world and in nation, are as follows:

1) Electronic Market Platforms

It is a digital platform that revolutionizes the agri-supply chain by connecting farmers directly with buyers, ensuring fair prices, and providing agricultural education and training. E-NAM (Electronic National Agriculture Market) is one of a collaborative effort by the governments of India and the private sector to bring about a revolutionary change in agrarian marketing through digitalization and varied enterprise (D. Chadha, 2020; M. Garg & Shelly Singhal,

2022)^[8, 21].

2) Access to consumer sales data

Farmers in China's agriculture industries leverage Alibaba's "Juhuasuan" and "Jutudi" to access consumer sales data, precise planning of crops based on recent patterns and enabling customers to pre order agricultural products before harvest. It allows consumers to classify agrarian products in advance of crop (Mr. Gaurav Chaudhari & Dr. Nilesh Anute, 2022)^[9].

3) Digital Payments

The adoption of digital payment methods like UPI, mobile wallets, and internet banking has increased among farmers and various stakeholders in agriculture sector, making transactions faster and more transparent. The Indian Government's Digital India Campaign focuses on digitizing the agriculture sector, undertaking various initiatives in enhancing agriculture productivity including mobile operation. (D. Chadha, 2020)^[8]. Additional, Agri-Fintech Solutions from startups are providing digital lending and insurance solutions which are customized for the agricultural sector. This helps in smoothing cash flows and mitigating risks in the agriculture supply chain.

4) AI in Pest Management

AI-based application like Plantix, Fieldin, AgroPestAlert etc. are being used for early detection and management of pests and diseases, reducing crop losses and ensuring a steady supply of quality produce.

5) Traceability Solutions

Blockchain-based solutions are being widely adopted to ensure traceability, transparency and security, thereby maintaining quality and building trust among consumers (Ibtisam Ehsan, 2022)^[19]. The model fosters trust among suppliers, collaborators, other stakeholders and consumers. Walmart exemplifies the integration of blockchain in the agriculture industry to enhance transparency, quality and trust in the agri-supply chain (A. Sharma, 2020)^[53].

6) IoT Based Soil Testing

Utilizing Internet of Things (IoT) with wireless sensor networks and a cloud platform, farmers can effectively monitor various soil attributes such as moisture, temperature, humidity, and NPK value through mobile application, simplifying and optimizing the soil testing process (Siddalinga Nuchhi, 2020)^[42].

7) Mobile Applications for Agriculture

These days, a variety of mobile apps and technologies designed in local languages are being used in agriculture, to bridge knowledge gaps, offering services like rainfall prediction, crop advisory, and pricing information. The use of mobile applications, such as M- farm in Kenya and Uzhavan in Tamil Nadu, aids in reducing market distortions by providing price data and facilitating sales collaborations among growers (S. Sindhu & D. Sindhu, 2018 Mr. Gaurav Chaudhari & Dr. Nilesh Anute, 2022)^[9, 54].

8) Use of GPS and sensors

GPS and sensor-based technologies are being used to collect crop data, produce digital charts, geo- fencing, and give rainfall and pest information for precision agriculture, encompassing controlled traffic farming, point specific fertilization, and plant protection measures (S. Sindhu & D. Sindhu, 2017)^[54]. In India, emergence of Smart farming integrates large data with advanced crop and climate models through GPS guidance systems, utilizing cloud-based

connectivity to make on- farm decisions for enhanced productivity (Dr. Susil Kumar Sarangi, 2018)^[30].

9) Smart Cold Storage and Inventory Monitoring System

It is a system utilizing sensor-based IoT technology with various sensors and a Wi-Fi-enabled microcontroller which enables remote monitoring and tracking of produce, ensuring end to end visibility and minimizing losses for business.

Challenges and Considerations of Digitalization of Agriculture Supply Chain in India

Challenges among agri supply chain in Agri 4.0 are multifaceted. Despoudi (2021)^[15] identifies sector diversity, farm size, safety and security, investment costs, and compatibility as crucial challenges. Kumar (2021)^[30] further highlights the lack of government brace and impulses, as well as the absence of programs and protocols, as significant barricades to the adoption of Industry4.0 and indirect economy in the husbandry force chain. Derakhti (2023)^[14] adds to this by illuminating the specialized, functional, economic, social, and structure difficulties, involving innovation, food security and big data, and cloud based infrastructure/storage. Despite these difficulties, Despoudi (2021)^[15] also points out the openings of Agri 4.0, similar as real- time data dissection, dropped functional charges, swelled profit and product inflexibility, bettered sustainability, enhanced trust ability and uptime, self-optimization, and bettered structure." In India, farmers still lack real time information about consumers, demand requests and prices, leaving them vulnerable to exploitation as intermediaries in the conventional supply chain (Tanmoy Ray, 2020). These challenges are listed below:

- a) **Lack of information about Government resources, institutions, and extension services:** Indian farmers face limitation in maximizing their farm incomes due to lack of information on government Scheme, institutions, extension services and poor market connections.
- b) **Poor access to quality farm inputs, services, and technology:** Farmers often struggle with insufficient access to reliable seeds, fertilizers and modern agricultural technologies, this hinders their ability to adopt efficient and sustainable farming practices impacting overall productivity and socio-economic development. It also results in increased reliance on traditional methods in the face of evolving agricultural challenges.
- c) **Improper supply chain infrastructure, cold storage and preservation facilities:** The logistic infrastructure in India is presently deficient, leading to significant wastage. It's 134.5 MT production of fruits and vegetables, emphasizes the urgent need for enhances cold storages and preservation facilities with all modern AI tool enabled. Given globalisation, evolving information needs, population pressure on the food security etc, there is a compelling call to explore diverse alternatives and digitalize the agri-supply chain. Though, last mile connectivity by Ministry of Road and Highway Transport has led to construction of roads but along with connectivity India also needs storage equipped with modern tools.

d) Poor market linkages for farmers: Farmers from small villages have to travel longer distances due to lack of market, lower their bargaining power which in return affects them in obtaining fair prices for their produce. A strategic hub and spoke model should be adopted in creation of markets to strengthen the farmers economically.

Future aspects of digitalization of Agri Supply chain

Despite various challenges, the potential benefits of digitalization, such as increased profitability and cost reduction are evident with blockchain technology. It also promises of enhancing farmers' income leading to the economic growth of the country through concepts like Smart farming and robotics (Amentae, 2021; Starykh, 2022; Kurucz, 2021; Panetto, 2020; Nirmala Chavan, 2019; Yash Bhojwani, 2020) ^[1, 31, 57, 31, 44]. The role of ICT along with AI tool can play a vital in fostering sustainable connections and urging e-service adoption for online trading in the agriculture sector, along with the evolution of agribusiness through digital banking and improved storage and transportation, underscores the transformative impact of digitalization in agriculture (S.K. Mudda, 2017; S. Dharanidharan, 2018; R. Goswami, 2023; Dr. Susil Kumar Sarangi, 2018; Ratnakar Jaiswal, 2022; Shraddha G Srivatsa, 2021) ^[17, 30, 56].

Conclusion

Agriculture 4.0 represents a significant shift in the agricultural sector, fostering sustainability, efficiency, and improved productivity. By embracing digitalization, IoT, robotics, AI, and blockchain, farmers can make precise decisions based on big data, optimize resource allocation, and ensure traceability throughout the agri supply chain.

However, there is still barriers in adoption of Agriculture 4.0, such as lack finance with farmers, poor access to quality farm inputs, services, and technology, lack information about Government schemes/policies etc. Still, the potential of advanced technologies and data-driven processes in farming holds immense promise for crop yield, resource optimization and farmers welfare. The future of agriculture appears promising with the potential positive impacts of digital innovations.

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