USE OF ARTIFICIAL INTELLIGENCE IN THE AGRICULTURE SUPPLY CHAINS OF PAKISTAN

Sher Khan, Nauman Ejaz and Anwar Shah

The agriculture sector is considered the backbone of Pakistan's economy contributing 24% towards the country's GDP and employing 37.4% of the country's labour force, thus serving as a primary source of livelihood for millions.[38] It is also a potential source for earning foreign reserves, with key commodities such as rice, cotton, vegetables, and fruits impacting the balance of trade. In addition, the sector plays a crucial role in ensuring food security as it aims to achieve and sustain self-sufficiency in staple crops. Despite such an important role and share in the economy, Pakistan's

agriculture sector remains vulnerable to pre- and post-harvest losses. These losses not only impact the farmers but also negatively impact consumers in terms of low-quality and less nutritional agricultural produce. Shortcomings at various stages in the agriculture supply chains such as inadequate storage facilities, lack of processing units, and poor infrastructure contribute to around 30% of fruit and vegetable losses in these chains.[39] The economic impact of these is about $4 billion, thereby reducing farmers' incomes and increasing food insecurity in the country. These

post-harvest losses are more common in perishables such as mangoes, tomatoes, and citrus, where poor handling and lack of cold chain lead to spoilage.

The agriculture supply chains of Pakistan are open to several issues and challenges such as lack of traceability and transparency which significantly contribute to food losses. Statistics reveal that a significant portion of agricultural produce is lost or wasted every year due to poor market information and inadequate tracking systems.[40] These issues hinder farmers and other supply chain stakeholders from making informed decisions regarding distribution and pricing. Challenges with transparency and traceability make it difficult to precisely identify critical loss points that contribute to food and economic losses. These loss points not only impact farmers' income and contribute to food insecurity but also lead to inflated prices and reduced availability of fresh produce in the market. Similarly, the lack of systematic tracking and monitoring systems reduces information penetration at almost every step in the supply chain, more so at the farm level, where the ability of farmers to make timely decisions is severely hampered. This has serious implications; one study shows that farmers with perfect market information have 4.3 times greater access to markets as compared to others.[41] It is no surprise that timely availability of information plays a key role in marketing agricultural produce more effectively.

The emergence of Artificial Intelligence (AI), specifically Blockchain Technology (BCT), was fast-tracked with the launch of bitcoin in 2009[42], which was designed as a decentralised digital currency. At first, BCT was mainly concentrated on cryptocurrencies, however its potential for safe and secure, transparent, and immutable record-keeping quickly received attention in different industries and sectors. Over the years, BCT has evolved beyond cryptocurrencies and enabled smart contract functionality in decentralized finance, voting systems, supply chain management, and digital identity. One significant advancement of BCT in this respect was the introduction of Ethereum in 2015, allowing for programmable smart contracts and expanding the use of BCT.[43]

The recent advances in BCT can assist in identifying critical loss points that negatively impact the agriculture sector of Pakistan and transform traditional supply chains into modern value chains by reducing traceability and transparency-induced losses. The technology can be used to store records of product movements and associated transactions in blocks, enabling customers and stakeholders to trace back the origin of food items from farm to fork. These prospects will provide real-time data on production, harvest, storage, handling, and transportation that can not only be used for monitoring and problem-identification but also to provide timely information for decision-making.

Efficient information flows are specifically important for fresh produce supply chains that are arguably the most affected by climate change; for instance, some estimates indicate a shortfall of 600,000 metric tonnes in Pakistan's mango export in 2024.[44] Farmers, although now increasingly aware of fluctuations in seasonal patterns and the implications in terms of extreme weather events and disease management, have been slow to respond, with many still unaware of the requisite practice changes. BCT can help speed up awareness, as well as, make information accessible for farmers to optimize their operations. Moreover, AI can help stakeholders predict market trends and consumer demands based on the vast amount of data stored through BCT. This will help in making informed decisions regarding crop production and marketing. A recent survey by PwC finds that 84% of supply chain leaders believe blockchain will become a permanent fixture in their organizations.[45]

In addition, the integration of BCT with Internet of Things (IoT) sensors and AI analytics can transform the agriculture sector by optimizing operational efficiency. As an example, IoT-based BCT can assist in monitoring environmental variables such as humidity, temperature, and exposure to toxins during the various stages of the supply chain, while enabling accurate tracking and monitoring of agricultural produce through the chain using timestamps. Such immutable records of the journey of fresh produce from source to destination will ensure the availability of high-quality produce and mitigate food losses. Additionally, AI analytics can process the vast amounts of data generated by IoT devices to identify patterns and predict potential risks and critical events, enabling proactive decision-making and policy responses.

[38]Raza, M. Y., Wu, R., & Lin, B. (2023). A decoupling process of Pakistan's agriculture sector: Insights from energy and economic perspectives. Energy, 263, 125658.
[39]Firdous, N. (2021). Post-harvest losses in different fresh produce and vegetables in Pakistan with a particular focus on tomatoes. Journal of Horticulture and Postharvest Research, 4(1), 71-86.
[40]https://www.dawn.com/news/1394618
[41]https://www.thejaps.org.pk/docs/v-26-03/29.pdf
[42]Mahankali, S. (2019). Blockchain: The Untold Story: From birth of Internet to future of Blockchain. BPB Publications.
[43]Ahmad, M. S., & Shah, S. M. (2021). Moving beyond the crypto-currency success of blockchain: A systematic survey. Scalable Computing: Practice and Experience, 22(3), 321-346.

[44]https://www.deccanherald.com/world/after-high-transportation-costs-pakistan-mangoes-suffer-losses-due-to-climate-change-3033496
[45]https://www.pwc.com/us/en/services/consulting/business-transformation/digital-supply-chain-survey/supply-chain-tech.html

Due to the traditionally informal nature of transactions, monetary fraud is one of the major issues in the agriculture sector. BCT can help in enhancing credibility and accountability among the stakeholders by providing a protected, decentralised ledger of events and transactions in the supply chain, significantly enhancing transactional efficiencies. Thus, by creating and maintaining a complete and authentic record of every transaction; from inputs' selection to the delivery of produce to consumers, BCT can reduce the risk of fraud and disputes, which are currently very common in the supply chains.

Similarly, the implementation of BCT can help streamline the process of conferral and verification of organic and fair-trade certifications, thus enabling farmers to demand premium prices for their certified products both in domestic and international markets. This is specifically important if the Pakistani growers want to keep up with the emerging trends in the fresh produce markets.

In summary, the adoption of BCT in Pakistan's agriculture sector exhibits a significant opportunity for stakeholders to achieve a traceable high-quality product that attracts premium pricing by creating a secure, complete, and transparent record of the entire supply chain, from cultivation to sale, that buyers can use to validate the origin and quality of their food. Research indicates that traceable produce commands price premiums of up to 20% in markets where consumers are increasingly concerned about food safety and quality[46].

Despite the prominent benefits of BCT in the agriculture supply chains, there exist several challenges in its adoption and implementation including

- A lack of awareness and understanding of BCT among farmers and supply chain actors. Most stakeholders are unfamiliar with the benefits and applications of this emerging technology.[47] Addressing this knowledge gap through targeted awareness campaigns and training programs is essential for adoption.
- Low investments in BCT infrastructure such as internet connectivity, computing hardware, and storage solutions. Many rural areas in Pakistan lack reliable access to internet and electricity, making it difficult to deploy blockchain-based systems.

- Significant resource requirements for training farmers and supply chain workers on how to use and maintain blockchain platforms. Given the budgetary constraints of the government sector and the potential positive externalities associated with BCT, it seems implausible that the public or corporate sector alone will be able to garner sufficient resources. Therefore, there is a need for public-private partnerships to train farmers and all other players in the supply chains to fully harness the benefits of BCT.
- Regulatory uncertainty around blockchain systems and digital transactions. Pakistan currently lacks clear guidelines and regulations for the use of blockchain in business applications. This uncertainty deters stakeholders from investing in and implementing the technology. Developing a supportive regulatory framework that provides clarity and safeguards for blockchain-based transactions is necessary to accelerate adoption in the agriculture sector.

Nonetheless, BCT holds significant promise for optimising Pakistan's agriculture supply chains, offering a robust pathway towards food loss minimization, which is crucial for enhancing farmer incomes and food security. To realise this potential, collaboration between the government, industry, and academia is essential. With the implementation of the right policies and incentives, blockchain can indeed revolutionise Pakistan's agribusinesses, fostering a more efficient, transparent, and sustainable ecosystem.

Sher Khan is Lecturer at National Defence University, Islamabad, Pakistan
Dr. Nauman Ejaz is Assistant Professor, International Islamic University, Islamabad, Pakistan
Dr Anwar Shah is a Professor at School of Economic, Quaid-I-Azam University, Islamabad, Pakistan

[46]https://www.sciencedirect.com/science/article/pii/S2666833522001009
[47]https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3814912