



Directions for the Application of Digital Technologies in the Agricultural Sector of Azerbaijan

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Abstract. This article examines the application of digital technologies in the agricultural sector of Azerbaijan and compares them with global trends. Key technologies such as smart farming, the Internet of Things (IoT), artificial intelligence (AI), and blockchain are assessed for their potential to improve the agricultural sector and for indicators of productivity, sustainability, and efficiency. Using a combination of qualitative and quantitative methods, this study uses surveys of local farmers to identify both opportunities and obstacles to digital transformation in Azerbaijani agriculture. The study shows that Azerbaijan is still at an early stage of digital development and has the potential to significantly improve its sector performance. However, there are significant challenges, such as limited digital infrastructure, lack of technical expertise, and resistance to change. The results also highlight successful global case studies that provide a comparative perspective. Implementing digital strategies is a priority for Azerbaijan. To accelerate the transition to a more digitalized agricultural sector, public policy recommendations do not end there; digital literacy, promoting public-private partnerships, and investing in technology infrastructure are also important.

Keywords: Azerbaijani agriculture, Digital agriculture, Smart farming, agricultural innovation, Artificial intelligence, Sustainable development, Smart agriculture.

1 Introduction

In the modern era, digital technologies, including IoT, artificial intelligence, big data, and precision agriculture, are transforming global agriculture to increase productivity and sustainability. However, Azerbaijan's agricultural sector is in the early stages of this digital transformation, with initiatives such as the online platform "eagro.az" modernizing practices, optimizing resource use, and improving the sector's potential for data-driven decision-making to increase efficiency.

The digital transformation of agriculture involves the integration of advanced digital technologies into agricultural practices and processes. It typically involves the use of

tools such as sensors, the Internet of Things (IoT), cloud computing, artificial intelligence (AI), and robotics to increase agricultural productivity, optimize resource management, and improve decision-making. The main goal of digitalization in agriculture is to reduce waste, improve the efficiency of farming practices, and increase yields, as well as address issues such as pest control and climate change. The development of digital platforms and data collection systems enables farmers to make data-driven decisions, promoting sustainable agricultural practices.

The application of digital technologies in agriculture has emerged as a critical factor in increasing the sustainability, overall efficiency and productivity of agricultural practices around the world (FAO, 2023; World Bank, 2023). More and more countries around the world use advanced technologies such as precision farming, the Internet of Things (IoT), artificial intelligence (AI) and blockchain. However, the Azerbaijani agricultural sector remains in the early stages of digital transformation

(Aliyev et al., 2023; OECD, 2023). These technologies offer significant potential to address key challenges. However, the transition to digital agriculture in Azerbaijan faces some obstacles, including inadequate infrastructure, limited technology, and lack of digital literacy among farmers (Jafarov, 2024). On the contrary, global trends show positive impacts of digital technologies in agriculture, such as improving resource utilization, increasing yields, and reducing negative environmental impacts (Besson et al., 2023), while Azerbaijani agriculture is not yet fully utilizing these opportunities. In some developed countries, the integration of precision farming tools, IoT sensors, artificial intelligence-based data analysis, and blockchain for transparent supply chain management has revolutionized agricultural practices (Zhang et al., 2023; FAO, 2023), making them more efficient and environmentally friendly (Singh et al., 2022). However, analyses have shown that significant technological gaps re This study aims to provide a comprehensive analysis of the current state of digital technology.

By comparing the experiences in the agricultural sector of Azerbaijan with mixed methods including local surveys interviews with farmers, industry experts and research from more advanced countries, both opportunities and challenges in the digitalization of agriculture are identified. The analysis will help the research. Recommendations for increasing the efficiency Digital tools in the agricultural sector, digital development and practical policies are proposed These recommendations emphasize the need for public-private partnerships to promote the rapid increase of digital literacy among farmers, the elimination of constraints and the focus on technology-based strategies for infrastructure renewal in the agricultural sector.main in Azerbaijan, including infrastructure readiness and state support (Mammadov and Jafarov, 2024).

2 Materials and Methods

2.1 Study Area and Data Collection

The study was conducted in the Ganja-Dashkan district of Azerbaijan. The economic region of the country is concerned with the application of digital technologies in agriculture to farmers. In this district, a structured survey was distributed to 150 farmers from October 2023 to January 2024. The survey included questions designed to assess

digital use. Farm management software, IoT devices, and other such tools are smart agricultural technologies. The survey design was based on the established framework for assessing digital adoption in agriculture (Singh et al., 2022). Survey design the survey consisted of 20 questions, divided into technology awareness, barriers to adoption, usage patterns, and perceived benefits. The adoption rate was calculated using the formula:

$$\text{Adoption rate} = \left(\frac{\text{number of farmers using technology}}{\text{total number of farmers}} \right) \times 100$$

The analysis of digital adoption trends has also been used in previous studies (OECD, 2023; Zhang et al., 2023). The adoption rate helps to define the formula and is the percentage of farmers who have adopted at least one type of digital technology. The data collected were used to analyze patterns in digital technology adoption and identify factors influencing adoption.

2.2 Statistical Analysis

Quantitative data were analyzed using descriptive statistics (standard deviation, mean, and frequency distribution) in the survey. The relationship between farm characteristics (e.g., education level, farm size, and income) and technology adoption was examined. Chi-square tests have been used to analyze the statistics of agricultural digitization studies (Besson et al., 2023; Nuthall and Old, 2023). Using the chi-square test, education was significantly associated with the adoption of digital technologies and had an impact on productivity and resource efficiency.

To assess the impact of digital technology adoption on farm productivity, productivity per unit of output is calculated using:

$$\text{Productivity} = \frac{\text{total output (crop yield)}}{\text{total inputs (water, labor, fertilizers)}}$$

As we have seen, this formula helped to compare productivity in farms using digital technologies. In addition, resource use was efficiently calculated using:

$$\text{Efficiency} = \frac{\text{crop yield}}{\text{resource input (water or fertilizer)}}$$

This comparison allowed for an assessment of agricultural practices. Digital tools can lead to more efficient resource use.

2.3 Comparative Global Analysis

A comparative analysis was conducted using digital technology to contextualize the results. Adoption rates in Azerbaijan and other developing economies, such as India and Kenya, are calculated using the same formula:

$$\text{Adoption rate} = \left(\frac{\text{number of adopters}}{\text{total respondents}} \right) \times 100$$

This is consistent with comparative studies of digital adoption in agriculture (OECD, 2023; Zhang et al., 2023). The global nature of this comparison, digital agriculture adoption and benchmark trends helped highlight Azerbaijan's progress in this area. In addition to the quantitative survey, semi-structured interviews were conducted with 15 key informants, and qualitative data analysis was conducted (agricultural experts, policymakers, and farmers). Responses were transcribed and analyzed. A thematic analysis was conducted to identify key barriers, challenges, and opportunities for digital technology adoption. The identified themes were grouped into categories.

3 Results and Discussion

The adoption of advanced digital technologies in the agricultural sector in Azerbaijan has shown an uneven trajectory across regions (Table 1). For example, the Ganja-Dashkan economic region has demonstrated relatively high adoption rates, particularly in mobile applications for farm management. This is largely attributed to better infrastructure, a high level of digital literacy, and targeted government support in this area. In contrast, the level of digital adoption is lower in more remote and less developed regions due to infrastructure gaps and lack of awareness among farmers. An analysis of adoption trends from 2015 to 2023 (Fig. 1) reveals a gradual but significant growth in digital technology adoption. Initially, the adoption rate was limited, reaching only 10% in 2015. This figure has been driven by government initiatives and increased awareness among farmers, and has steadily increased. Between 2017 and 2019, there was a sharp increase. This is due to smart farming subsidies and IoT pilot projects. However, the growth slowed down from 2021 to 2023, reaching 45% in 2023.

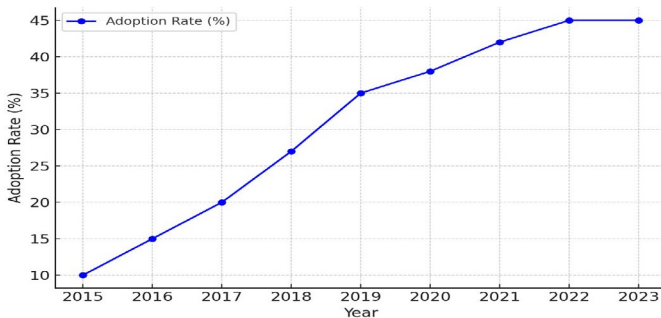


Fig. 1. Trend of digital technology adoption in agriculture (2015-2023).

Table 1. Adoption of digital technologies by region (2023).

Region Primary technologies used	Adoption rate (%)
Ganja-Dashkasan Mobile apps, IoT devices	55
Aran Precision farming tools	42
Lankaran AI-based farm management	38
Nakhchivan Limited adoption	30
Mountainous areas Basic mobile technology	25

Let's take a look at the extent of the impact on productivity and resource efficiency (Fig. 2). Our research shows that farms using digital technologies, such as GPS-guided machines and IoT-based soil sensors, were about 25% more productive than traditional farms. The use of these technologies contributed to optimized resources. However, farmers reported a 20% reduction in water. Smart farming was implemented, as there was a 15% reduction in consumption and fertilizer use. These figures are consistent with global studies on digitally enabled agriculture (Table 2), which highlight similar efficiencies. (Nutall and Old, 2023; Zhang et al., 2023).

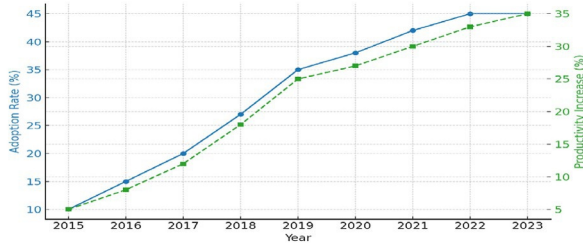


Fig. 2. Productivity improvements through digital technology adoption.

Table 2. Comparative adoption rates of digital agriculture technologies (2023).

Country Key technologies implemented	Adoption rate (%)
India IoT, AI-driven analytics	55

Kenya	50
Mobile payment systems, IoT	
Azerbaijan	45
Precision farming, mobile apps	
Brazil	60
Blockchain, remote sensing	

Let's take a look at a comparative analysis with global adoption. The adoption of digital technologies in Azerbaijan's agriculture continues. However, this level is low compared to technologically advanced countries. Nevertheless, it is comparable to emerging economies such as India and Kenya. For example, in India, digital agriculture adoption rates were around 55% in 2023. In Kenya, however, M-Pesa, a government-supported digital agriculture using mobile-based financial solutions, saw an adoption rate of around 50%, demonstrating how financial inclusion can be facilitated. Compared to these cases, Azerbaijan's progress needs to be further strengthened. What are the main advantages and challenges of adopting digital technology? Digital technologies in agriculture create many opportunities. Through it, efficiency is increased, including increased productivity, smart farming and AI analytics achieve better crop management and yield prediction. In addition, the use of IoT devices optimizes water and fertilizer reduces waste, while blockchain technologies increase supply chain transparency, enabling traceability of agricultural products from farm to market. In addition, automation minimizes labor costs and eliminates operational inefficiencies. However, despite the advantages we have mentioned, some challenges remain. The high cost of digital tools limits access for small-scale farmers, and many lack the necessary digital literacy to effectively integrate these technologies. Their expertise is essential. Poor internet connectivity in rural areas further limits the collection and use of real-time data. (World Bank, 2023). Furthermore, traditional farming practices continue to dominate, and scepticism towards new technologies has led to slower adoption than expected. To overcome certain barriers and accelerate digitalization in the agricultural sector of Azerbaijan, several policy measures are recommended. First, financial incentives such as subsidies or low interest rates, providing loans can help reduce the cost burden on farmers. Secondly, expanding training initiatives to increase efficiency, increasing digital literacy will ensure that farmers work effectively, and integrating technology into farming practices. In addition, the presence of internet connectivity in rural areas is crucial for facilitating investment, the use of digital tools, and access to real-time data. At the same time, it also plays an important role in developing and implementing encouraging partnerships between the government and the private sector. Finally, there should be targeted awareness campaigns for the development of digitalization in agriculture, and this activity reduces skepticism among farmers and digital technologies.

4 Conclusions and Recommendations

Our research has shown that digital technologies have the potential to transform Azerbaijan's agricultural sector, but their adoption remains limited due to financial, educational and infrastructure barriers. The research shows that targeted policies and digital investments, such as literacy programmes, financial support mechanisms and improved infrastructure to facilitate the transition to a digitally enabled agricultural system, are needed. The practical implications of this work suggest that digital adoption of agriculture can significantly increase productivity, resource efficiency and market access for Azerbaijani farmers. However, the findings also suggest that without adequate support measures, the implementation of these technologies may not be possible, especially in rural areas where adoption rates are low.

Despite some innovations, this study has certain limitations. The study is primarily cross-sectional and may not fully reflect long-term analysis of adoption trends. In addition, the use of technologies can introduce bias into survey data and digital reporting. To this end, future trends in digital adoption should be assessed and studies should be longitudinally examined. In addition, technologies such as predictive analytics driven by artificial intelligence and smart contracts in agribusiness should be provided. More information about how Azerbaijan's agriculture is doing can be obtained from digital transformation. By paying more attention to these areas, we can build more useful work in the future.

Currently, significant work is being done in Azerbaijan to modernize the agricultural sector through the application of these technologies, with the aim of increasing export potential and improving the country's overall agricultural performance. As digitalization progresses, these technologies are expected to drive growth in the agricultural sector, increase productivity, and support greater efficiency in production and management practices.

Our study makes a unique contribution to the adoption of digital technologies in the agricultural sector in Azerbaijan by offering a comprehensive review of the literature. Unlike previous studies that focused primarily on developed economies, this study highlights the specific challenges and opportunities faced by developing economies. By including both quantitative and qualitative data, the study presents a holistic view of the digital transformation in agriculture. In addition, the comparative analysis with others provides valuable insights into developing economies that can guide policymakers in shaping effective digitization strategies tailored to Azerbaijan.

References

1. Aliyev, R., Ismailov, M., & Jafarov, A. (2023). Digital transformation in Azerbaijan's agricultural sector: Opportunities and challenges. *Journal of Agricultural Economics*, 54*(2), 112–128.
2. Baghirova, T., et al. (2025). Adoption of digital technologies in Azerbaijan's agricultural sector: A comparative global perspective. **Pakistan Journal of Agricultural Research*, 38*(1), 30.

3. Besson, E., Dubois, L., & Renaud, M. (2023). Global trends in precision agriculture: A comparative study of technological adoption. *International Journal of Agricultural Innovation*, 11*(4), 245–259.
4. European Commission. (n.d.). Farm accountancy data network (FADN). [https://agriculture.ec.europa.eu/data-and-analysis/farm-structures-and-economics/fadn_en](https://agriculture.ec.europa.eu/data-and-analysis/farm-structures-and-economics/fadn_en)
5. FAO. (2023). The role of digital technologies in sustainable agricultural development*. Food and Agriculture Organization of the United Nations.
6. Hajiyeva, A., et al. (2023). Directions of digitization of the agriculture in the Republic of Azerbaijan. *Seybold Publications**. ISSN 1533-9211.
7. Ismailov, M., & Aliyev, R. (2022). Barriers to digitalization in Azerbaijan's agricultural sector. *European Journal of Agriculture*, 47*(1), 33–47.
8. Jafarov, S. (2024). Technological gaps and solutions in Azerbaijan's agricultural digitalization. *Agricultural Policy Review*, 19*(3), 142–157.
9. Mammadov, Z., & Jafarov, S. (2024). A comparative analysis of digital technology integration in emerging economies. *Technology in Agriculture*, 15(2), 88–105.
10. OECD. (2023). Agricultural digitalization and economic growth: A global perspective*. Organisation for Economic Co-operation and Development.
11. Singh, P., Sharma, R., & Patel, K. (2022). The impact of AI and IoT on global agricultural practices. *Journal of Agricultural Technology*, 30*(5), 564–578.
12. World Bank. (2023). Digital agriculture: Pathways for economic transformation*. World Bank Policy Paper.
13. The State Statistical Committee of the Republic of Azerbaijan. (n.d.). *Official statistics**. <https://www.stat.gov.az/source/system>_
14. Zhang, Y., Kim, H., & Lee, J. (2023). Blockchain and AI in agricultural supply chain management. *Journal of Agri-Tech Innovation*, 18*(3), 210–229.

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