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AN INTEGRATED APPROACH TO DIGITALIZATION OF THE AGRICULTURAL PRODUCTS EXPORT: TECHNOLOGIES, ECONOMIC IMPACT AND GLOBAL PRACTICES

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ABSTRACT

This article provides an in-depth analysis of key technological aspects of digitalization in the agricultural sector aimed at increasing productivity, competitiveness, and the sustainability of export chains. It examines the role of innovative tools such as sensors, drones, artificial intelligence (AI), and blockchain in risk management and optimization of production processes. Particular attention is paid to international experience using satellite technologies (using the US as an example) and modern national platforms such as FarmerApp. The article explores the application of digital solutions in logistics, product traceability through RFID and barcoding technologies, and the impact of digital marketing and e-commerce on expanding export opportunities. The article analyzes the economic and social effects of digitalization, as well as key challenges and potential solutions for overcoming them. It concludes that strategic implementation of digital transformation is necessary to integrate the national agricultural sector into global markets and ensure sustainable economic growth.

1. Introduction

Faced with the challenges of a growing global population and climate change, the global agricultural industry is on the threshold of the fourth industrial revolution. Digital transformation in this sector (AgriTech) is not simply a modernization effort, but a strategic imperative for ensuring food security and enhancing global competitiveness. According to the FAO, despite a decline in employment in the agricultural sector from 40% of the global population in 2000 to 27% in 2021 (866 million people) [1], the sector remains a key source of employment and the backbone of the economies of many countries.

The implementation of digital technologies is aimed at risk management, facilitating integration into international markets, and significantly increasing productivity and competitiveness. The purpose of this paper is to conduct a comprehensive analysis of the technological aspects of digitalization in the agricultural sector, assess its multifaceted impact, and identify strategic areas for effective implementation.

This article will examine key technologies, international and national practices, economic and social consequences, and practical challenges of digitalization.

1.1. Key Technological Aspects of Digitalization

Digital transformation in the agro-industrial complex is a complex and dynamic process that extends beyond individual innovations and encompasses the entire value chain, from detailed soil monitoring to the sale of finished products in highly competitive export markets. The comprehensive implementation of modern technologies allows for radically increased efficiency, ensured traceability, and strengthened the agricultural sectors resilience in the face of global challenges. This section is dedicated to the systematization and in-depth analysis of the fundamental technological solutions that shape modern "**smart**" **agriculture,** serving as the foundation for data-driven decision-making. In the following subsections, we will examine in detail how intelligent crop management, sensors, drones, and Big Data optimize production processes. Particular attention will be paid to drones and satellite monitoring, including national experience (**Azerbaijans Agricultural Satellite, FarmerApp**), as key elements of geospatial technologies. The role of artificial intelligence and blockchain in improving predictability and transparency will then be analyzed. A significant section will be devoted to the digitalization of logistics and traceability (**GPS, RFID**), as well as a detailed examination of product identification systems (barcode and RFID). The analysis will conclude with an examination of the potential of e-commerce and digital marketing for expanding sales markets. Exploring these areas will provide a comprehensive understanding of how technological integration is transforming the agricultural sector, making it more precise, profitable, and globally competitive.

1.2. *Intelligent Crop Management: Sensors, Drones, and Big Data*

The modern agricultural sector is undergoing a radical transformation under the influence of the concept of **Precision Agriculture**, the foundation of which is intelligent crop management. This approach is based on the collection, processing, and analysis of huge amounts of data, known as **Big Data,** which enables the transition from average farming methods to highly personalized and efficient ones.

The Role of Sensors and the Internet of Things (IoT). Sensors and Internet of Things (IoT) technologies are a key element in collecting primary data. These devices, installed directly in the soil, on agricultural machinery, or in the atmosphere, provide continuous and objective monitoring of critical parameters. Soil sensors measure moisture levels, pH, temperature, and nutrient content (nitrogen, phosphorus, potassium) in specific areas of the field [2]. Other sensors can track microclimatic conditions, including air temperature, wind speed, and humidity, which is critical for predicting disease outbreaks or optimal irrigation timing. The data obtained allows agronomists to quickly make decisions about the differentiated application of fertilizers and water, significantly reducing costs and minimizing environmental impact [3]. Using such comprehensive information on business processes is the foundation for building a digital enterprise in the agro-industrial complex.

Drones in agricultural. Drones play an indispensable role in monitoring large areas and promptly assessing crop conditions. Drones equipped with multispectral and thermal imaging cameras are capable of obtaining high-resolution images that are inaccessible to satellite monitoring. **Analyzing these images allowsto:**

Assess crop health: Using indicators such as the NDVI (Normalized Difference Vegetation Index), farmers can quickly identify problem areas of a field where plants are stressed due to lack of water, nutrients, or pest infestation [4].

Optimize chemical treatment: Drones are used for the precise application of pesticides, herbicides, and fertilizers (differential application), which significantly reduces chemical consumption (in some cases up to 90%) and reduces the impact on the environment [5].

Forecast crop yields: Regularly flying over fields helps assess plant density, growth dynamics, and maturity, which allows for more accurate yield forecasting and determining optimal harvest times [6].

In the United States, Canada, and Australia, drones have become a primary tool for managing large farms, used both for crop monitoring and for creating detailed 3D models of fields, which helps in irrigation planning.

Big Data. The Power of Big Data Sensors, drones, satellites and agricultural machinery generate a colossal amount of information, Big Data, which is the nerve center of modern agriculture. Big Data technologies are not just storage, but automated processing, analysis and use of information, characterized by large volumes and high speed of changes. Big Data analytics allows us to solve key problems:

Increasing Yield and Quality: Analysis of historical and current data on soil, weather conditions, seed genetics and results of previous seasons allows to optimize production processes, which leads to increased yields and improved product quality [7].

Risk Reduction and Damage Management: Real-time data analysis helps to promptly identify problems in the field (presence of pests, diseases, unfavorable weather conditions) without the need for regular physical inspection [8].

Building highly accurate weather forecasts based on Big Data enables rapid decision-making, saving crops that would otherwise be lost.

Optimization of Resources and Logistics: Analytics helps improve the planning and management of logistics and supply chains, reducing the time and financial costs of transporting and storing export products, which, in turn, increases profitability [9]. Thus, intelligent crop management through the integration of sensors, drones, and Big Data creates a closed loop of knowledge collection, analysis, and application, which is the basis for achieving maximum efficiency and sustainability in the modern agricultural sector.

1.3. *The Role of Artificial Intelligence and Blockchain in Export Logistics and Trade*

Artificial Intelligence (AI) is transforming the agricultural sector, moving it from simple data collection to intelligent processing, which is crucial for optimizing export operations and increasing competitiveness. AI systems using machine learning algorithms are capable of analyzing massive amounts of data, including global market information, weather conditions, seasonal demand fluctuations, and logistical factors, to create accurate predictive models [10 p. 7]. In the context of exports AI plays a key role in two areas:

Demand and Pricing Forecasting: AI is used to forecast market demand for specific agricultural products in various importing countries, which is critical for **export planning**. This allows producers to identify the most profitable markets, production volumes, and develop an optimal pricing strategy [11].

Optimization of Export Logistics: AI enables accurate, data-driven decisions regarding **determining the most efficient export routes and optimal delivery times.** AI algorithms take into account variables such as the state of transport networks, customs procedures, and shelf life (expiration date), minimizing logistical risks and reducing the time perishable goods spend in transit. This directly impacts **reduction of operating costs** and increases export profitability [11].

Thus, AI acts as a powerful tool for supporting strategic decision-making, ranging from crop planning based on expected export demand to global supply chain management (e.g., IBMs **Watson for Agriculture** platform [12])

Blockchain technology complements AI, solving a fundamental problem in modern agricultural exports ensuring trust, transparency, and security in international trade relations. Blockchain is a decentralized and immutable ledger that records every stage of the export product lifecycle, including origin, growing conditions, processing, and transportation. This ensures:

Strengthening Export Partner Trust: The technology guarantees the authenticity of data on quality, harvest date, and storage conditions, which is critical for meeting international importer and certification requirements. If problems arise, blockchain allows for immediate source tracing (e.g., harvest location) instead of traditional, lengthy investigations [13].

Document Flow Optimization: In international agricultural trade, enormous amounts of time and resources are spent processing paper documents (bills of lading, phytosanitary certificates). Blockchain makes it possible to **digitize and automate** this process through "smart contracts," reducing customs delays and simplifying payments between exporters and importers [14].

Improving Food Security: Systems used by **Walmart and IBM [12**] or the **Te-Food** platform [15] demonstrate how blockchain improves food security and reduces risks for end consumers, which is a prerequisite for entering premium markets.

Thus, AI and blockchain together create a technological base that not only increases crop yields but also ensures the economic efficiency and reliability of export activities, integrating the national agricultural sector into global digital trading networks.

1.4. *Digitalization of Logistics and Traceability as a Factor in Export Competitiveness (GPS, RFID)*

For agricultural products, which are mostly perishable goods with limited shelf lives and high susceptibility to seasonal fluctuations, efficient and traceable logistics are becoming not just an operational requirement, but a key to successfully entering export markets and increasing overall economic profitability. Digitalization in freight transportation is based on the use of **Global Positioning Systems** (GPS) and specialized transport management software. These systems allow exporters to monitor product movement in real time, which is critical for fulfilling contractual obligations and maintaining product quality. GPS tracking, combined with big data analytics, allows for the determination of the most efficient and cost-effective delivery routes, taking into account numerous variables: road and weather conditions, border crossing congestion, and temperature control. Intelligent optimization of routes and schedules, as discussed in [15], minimizes operating costs (by reducing fuel consumption and depreciation), shortens delivery times, and, consequently, increases the shelf life of products in the importers market. This directly contributes to the growth of export margins.

RFID and Barcodes: Guaranteeing Traceability and Reducing Risks In the area of warehousing and quality control, product identification systems play a decisive role: barcode (barcode) and radio-frequency identification (RFID) technologies. These technologies ensure total control and identification of goods at all stages of the supply chain, which is especially important for export logistics. Economic Advantages of RFID:

- **RFID** (Radio Frequency Identification) technologies, which use radio frequencies to read information from microchips, are superior to traditional barcodes in a number of respects: they store a larger volume of data, allow reuse, and can be read without direct contact or visibility. This feature automates inventory processes, significantly speeding up the receipt and shipment of goods at export terminals. Large retailers such as Walmart and services like **Amazon Fresh** actively use RFID to optimize warehouse processes and combat theft, reducing non-production losses and increasing the reliability of the entire system.
- **Traceability for International Trust:** In international trade, traceability is a key requirement for ensuring food safety. The use of RFID tags allows for immediate confirmation of product origin and its compliance with international standards. For example, in California, CLGMA uses RFID to improve the security of green leafy crops. Providing complete and reliable information about the products journey (from field to fork) builds trust with foreign partners and facilitates access to premium and regulated markets, thereby increasing export potential and competitiveness. Sodexo and other major companies are using these tags to confirm product origin, which is becoming an integral part of modern export contracts.

Digital logistics, supported by GPS and identification technologies, transforms costs into a competitive advantage, making agricultural export chains fast, reliable, and cost-effective.

1.5. *E-Commerce and Digital Marketing: Expanding Export Horizons*

In the context of globalization and the digital economy, expanding agricultural export opportunities directly depends on the effective use of modern digital sales channels and marketing tools. E-commerce and digital marketing have become powerful drivers of economic growth, enabling producers to overcome geographic barriers and reduce their dependence on traditional intermediaries. Digital marketing provides agricultural producers with analytical tools and marketing platforms that are crucial for finding new customers and business partners in foreign markets. Unlike traditional methods, digital channels provide a targeted approach, allowing them to precisely identify potential importers or distributors based on their demand, preferences, and geographic location. Creating online stores and branded websites allows agricultural enterprises to sell products directly, resulting in increased margins by eliminating the lengthy chain of intermediaries. Electronic catalogs and analytics of consumer behavior data in foreign markets help quickly adapt export offerings (e.g., packaging, batch sizes) to specific market requirements, thereby providing a competitive advantage. E-commerce is not just a sales channel, but a comprehensive mechanism that enables the integration of the national agricultural sector into global logistics and financial networks.

National Platforms and State Support: An example of strategic state support for exports is the Azexport.az e-commerce platform, launched in Azerbaijan in 2016. The portal serves as a one-stop shop for exports, significantly reducing financial and administrative barriers for local entrepreneurs. The portal integrates with more than 15 leading global platforms (including Alibaba and Tradeindia) and utilizes a unique "reverse dropshipping" model, in which the portal

covers local entrepreneurs' membership and marketing costs [16] are a critical mechanism. This provides direct and preferential access to international trade for small and medium-sized farms, promoting the diversification of their export portfolio.

Logistics Optimization through E-Commerce: E-commerce platforms are often integrated with modern logistics systems, including GPS tracking and digital document management, ensuring high speed and transparency of international delivery. This is especially important for perishable agricultural products. By digitalizing orders and customs procedures, delays and errors are reduced, directly impacting logistics costs and, ultimately, the final cost of goods for importers.

E-commerce acts as a powerful tool for economic inclusion and growth. Using these digital channels allows the agricultural sector not only to increase sales volumes but also to build more sustainable and direct commercial ties, thereby strengthening the country's position in the global market.

2. The Economic and Social Impact of Digitalization

Digital transformation in the agro-industrial complex is a powerful catalyst, whose multifaceted impact extends far beyond the traditional measurement of crop yields and encompasses key aspects of economic growth, environmental sustainability, and social development.

From an economic growth perspective, digitalization enables a fundamental shift toward increased efficiency and profitability. The introduction of precision farming, based on sensor monitoring, big data, and AI, allows farmers to precisely dose resources. This leads to a significant reduction in operating costs by optimizing the use of water, fertilizers, pesticides, and fuels and lubricants. Reducing these input costs directly translates into increased enterprise profitability and, consequently, an increase in the agricultural sectors contribution to the countrys Gross Domestic Product (GDP). Furthermore, digital tools such as e-commerce platforms and digital marketing dramatically simplify access to international markets, which is key to export diversification and reducing dependence on a limited number of traditional trading partners.

In terms of sustainability and environmental protection, digital solutions are invaluable. Precision farming promotes a more responsible use of natural resources, as fertilizer and irrigation are applied not uniformly across the entire territory, but strictly according to the needs of a specific area, thereby reducing chemical pollution of soil and water resources. Sensor monitoring and the use of AI for forecasting help minimize climate risks and crop losses from adverse weather events, which directly aligns with the global Sustainable Development Goals (SDG). Thus, digitalization is transforming the agricultural sector into a more environmentally friendly and resource-efficient industry.

Finally, the social benefits of digital transformation cannot be underestimated. The introduction of new technologies is creating new opportunities for entrepreneurship in rural areas, stimulating the development of innovative services and services related to AgriTech (e.g., drone operators and data analysts). Digitalization also makes the agricultural sector more attractive to young and skilled workers, shifting the focus from heavy physical labor to intellectual activity and the operation of high-tech equipment. E-commerce and blockchain platforms, in turn, facilitate direct interaction between farmers and global consumers, reducing intermediary chains and ensuring farmers a fairer share of the final profits, thereby improving living standards in rural communities.4. Challenges and Directions for Agricultural Digitalization Development

Despite the obvious and proven benefits of digital transformation in the agricultural sector, its full and comprehensive implementation is associated with a number of serious systemic challenges. Overcoming these challenges requires not only technological solutions but also strategic government interventions.

One of the most significant barriers is the high cost of implementing innovative technologies. The initial investment required to acquire and install complex systems, such as multifunctional sensors, monitoring drones, powerful AI platforms, and RFID tracking systems, is often prohibitive for small and medium-sized farms, which form the backbone of agricultural production. Overcoming this financial barrier requires active government subsidies or the creation of specialized concessional lending funds for AgriTech projects. Another effective solution is the establishment of technology sharing centers, where farmers can rent expensive equipment or use data analysis services on a cooperative basis, thereby sharing the high initial costs.

The second critical challenge is infrastructure limitations. The high-quality operation of Big Data, AI, and remote monitoring systems (e.g., from satellites or drones) directly depends on the reliability and speed of data transmission. However, many remote rural areas, where agricultural activity is concentrated, still lack high-speed internet and stable mobile communications. Therefore, government programs for the development of rural digital infrastructure are becoming more than just a social project; they are a direct investment in the economic potential of the agricultural sector. This includes the installation of fiber optic lines and the deployment of 5G networks in agricultural regions.

The third key aspect is related to human resources. Technologies such as AI and Big Data analysis require farmers and agronomists to develop new competencies that significantly extend beyond traditional agricultural knowledge. There is a pressing need for specialists capable of processing data, managing complex AI systems, servicing drones, and integrating blockchain solutions into supply chains. Investments in education and retraining are needed, including the development of specialized curricula in Agri-Data Science and Digital Agronomy in higher and secondary educational institutions. Improving digital literacy among active farmers through courses and seminars is also urgent.

Finally, the ethical and legal issues that arise with mass data collection cannot be ignored. Protecting farmers personal data and the confidentiality of information collected via RFID tags, sensors, and satellites require clear and timely legal regulation. National standards and protocols must be developed to ensure data security and integrity, which is also critical for harmonizing with international requirements and ensuring trust in export operations. Furthermore, a legal framework must be created for the use of new technologies, including regulations for agricultural drone flights and standards for implementing blockchain systems in supply chains. Successfully overcoming these challenges will determine the trajectory of the agricultural sector for decades to come.

3. EMPIRICAL ANALYSIS AND ECONOMIC EFFICIENCY OF DIGITAL EXPORT PLATFORMS IN AZERBAIJAN

To validate the conceptual framework of digital transformation in agriculture, this section analyzes statistical data from the "Azexport" portal. The analysis focuses on two key dimensions: the volume dynamics of digital orders and the price efficiency gained through disintermediation.

3.1. Statistical Dynamics of Digital Export Orders

The dataset covers the period from 2017 (the portal's inception) to 2022. During this period, the cumulative value of export orders received via the portal amounted to $3.16 billion.

Table 1. Comparative Dynamics: Azexport Orders vs. National Non-Oil Export (2017–2022)

Year (t)	Azexport Order Volume (Vd) (mln USD)	Growth Rate (ΔVd)	Total Non-Oil Export (Vtotal) (mln USD)	Share of Digital Orders in Potential Export (Vd/Vtotal)
2017	475.0	-	1,538	30.8%
2018	514.1	+8.2%	1,689	30.4%
2019	595.7	+15.9%	1,954	30.5%
2020	610.8	+2.5%	1,850	33.0%
2021	496.1	-18.8%	2,700	18.4%
2022	469.9	-5.3%	3,050	15.4%

***Source**: Author's calculation based on CAERC data.*

As seen in Table 1, prior to the post-pandemic global supply chain restructuring (2017-2020), the ratio of digital orders to total non-oil exports remained stable at approximately **30-33%**. This indicates a high level of digital adoption among exporters during the portal's initial growth phase.

To measure the sustainable growth trend before external shocks (pandemic), we calculate the **Compound Annual Growth Rate (CAGR)** for the 2017-2020 period using the following formula:

$$\mathrm{CAGR} = \left(\frac{\mathrm{V_{end}}}{\mathrm{V_{start}}}\right)^{\frac{1}{n}} - 1$$

Substituting the values for the 2017-2020 interval:

$$\mathrm{CAGR}_{2017-2020} = \left(610.8 — 475.0\right)^{\frac{1}{3}} - 1 = (1.285)^{0.33} - 1 \approx 0.087$$

Result: The platform demonstrated a robust **8.7% annual compound growth rate** in export orders during its pre-pandemic phase, proving the effectiveness of the digital entry strategy.

3.2. Econometric Assessment of Price Efficiency (The "Digital Dividend")

A critical economic impact of digitalization is the elimination of low-value intermediaries, allowing farmers to capture a higher margin. To quantify this effect, we apply the Price Efficiency Model.

We define the **Digital Efficiency Coefficient (Ep)** as the percentage increase in the unit price of a commodity when exported through digital B2B channels compared to traditional channels.

The formula is derived as follows:

$$E_p = \frac{P_{digital} - P_{traditional}}{P_{traditional}} \times 100\%$$

Where:

- $P_{\{digital\}}$– $Export\ price\ per\ unit\ realized\ via\ the\ digital\ platform\ (Azexport).$
- $P_{\{traditional\}}$– $Export\ price\ per\ unit\ realized\ via\ traditional\ offline\ intermediaries.$
- $\left(P_{\{digital\}} - P_{\{traditional\}}\right)$ – The Digital Surplus Value$created\ by\ the\ platform.$

Case Study Application: Cotton Fiber Exports

Based on data from the National Confederation of Entrepreneurs (ASK) [17], we observe the export prices for cotton fiber (ginned cotton) before and after the active utilization of the Azexport platform.

Variable Inputs:

◎ **P_traditional \approx 1,350$ USD/ton** – (Baseline price via traditional intermediaries)

◎ **P_digital \approx 1,750$ USD/ton** – (Price realized via Azexport direct contracts)

- **Calculation:**

$$\mathrm{E_p} = \frac{1750 - 1350}{1350} \times 100\%$$

$$\mathrm{E_p} = \frac{400}{1350} \times 100\%$$

$$\mathrm{E_p} \approx 0.296 \times 100\% = 29.6\%$$

Interpretation of Results:

The calculation reveals an efficiency coefficient of 29.6%. This implies that the digitalization of the export process generated approximately 30% additional revenue per ton for cotton producers. In monetary terms, the "Digital Surplus Value" is $400 per ton.

This empirical evidence suggests that digital platforms do not merely facilitate trade volume but significantly improve **terms of trade** for agricultural producers by bridging the information gap with global buyers.

4. Conclusion

The digital transformation of the agricultural sector is not merely a technological trend but an irreversible strategic imperative, critical for ensuring food security, economic sustainability, and enhancing the global competitiveness of the national agricultural sector. The comprehensive analysis conducted in this study demonstrates that success in this domain requires a multi-layered approach, seamlessly integrating advanced technologies from IoT sensors and drones to Big Data and Blockchain across the entire value chain.

This study provides empirical evidence supporting the economic viability of digital export platforms. The analysis of the "Azexport" portal's data (2017–2022) reveals a robust correlation between digitalization and export growth. The platform generated $3.16 billion in export orders, maintaining a Compound Annual Growth Rate (CAGR) of 8.7% during the pre-pandemic period, which substantiates the sustainability of digital demand. Furthermore, the econometric

assessment of the "Digital Dividend" using the Price Efficiency Model (Ep) confirms that digital disintermediation significantly improves terms of trade for producers. As demonstrated in the cotton fiber case study, direct digital B2B engagement resulted in a 29.6% increase in unit price (an outcome of minimizing information asymmetry), proving that digitalization directly translates into higher revenue for the agricultural sector. Beyond economic metrics, the study highlights the critical role of trust and transparency. Product traceability, enabled by RFID and GPS technologies, ensures logistics optimization, while Blockchain solutions (referencing global practices like Walmart and Maersk) set the standard for origin verification. The empirical dominance of agricultural products (approx. 65-70%) in digital export orders confirms that platforms like "Azexport.az" effectively function as drivers of agrarian export diversification, enabling small and medium-sized farmers to overcome entry barriers and access global markets.

Strategic Challenges and Future Outlook

However, to sustain this "Digital Dividend" and strengthen competitive positions, strategic challenges must be addressed. The scalability of AI and Big Data systems is contingent upon the accelerated development of rural digital infrastructure, specifically high-speed internet access. Financial mechanisms to support technology adoption by smallholders and investment in human capital, training specialists capable of managing intelligent systems. Furthermore, harmonizing legislation regarding data protection and cross-border digital trade will provide the necessary legal framework. In conclusion, the integration of empirical data with conceptual analysis confirms that a strategic focus on comprehensive digitalization is the key determinant of future success. By leveraging national digital platforms and adopting international best practices, the national agricultural sector can achieve higher transparency, significant price efficiency (Ep), and sustainable integration into the global economy, thereby strengthening the country's economic sovereignty.

REFERENCE LIST

1. FAO. (2022) World Food and Agriculture. // Statistical Yearbook. p. 14 https://www.fao.org/3/cc2211en/cc2211en.pdf
2. L. Lenin Kumar , M. Srivani, Md. Tabassum Nishath, (2024) Monitoring of Soil Nutrients Using Soil NPK Sensor and Arduino DOI:10.53550/EEC.2023.v30i01s.049
3. Andreea Nițu ORCID,Corneliu Florea ORCID, Mihai Ivanovici (2025) NDVI and Beyond: Vegetation Indices as Features for Crop Recognition and Segmentation in Hyperspectral Data https://www.mdpi.com/1424-8220/25/12/3817
4. Alex Rogers, Aguiar Zanin, Danilo Carvalho Neves, Larissa Pereira Ribeiro Teodoro (2022), Reduction of pesticide application via real-time precision spraying https://pubmed.ncbi.nlm.nih.gov/35379871/
5. Jianghao Yuan,Yangliang Zhang, Zuojun Zheng, (2024) Grain Crop Yield Prediction Using Machine Learning Based on UAV Remote Sensing: A Systematic Literature Review, https://www.mdpi.com/2504-446X/8/10/559
6. Babasaheb Dnyandeo Patil, Dr. Suneet Gupta, Ansar Isak Sheikh, S. Sandeep Kumar Dr. Pilli. Lalitha Kumari Dr. G. Bhupal Raj, (2023) IoT and Big Data Integration for Real-Time Agricultural Monitoring, https://jazindia.com/index.php/jaz/article/view/1542
7. Nabila Chergui & Mohand Tahar Kechadi, (2022) Data analytics for crop management: a big data view, https://journalofbigdata.springeropen.com/articles/10.1186/s40537-022-00668-2
8. Idrees Alsolbi, Fahimeh Hosseinnia Shavaki, Renu Agarwal, (2023) Big data optimisation and management in supply chain management: a systematic literature review, https://link.springer.com/article/10.1007/s10462-023-10505-4
9. Marwaha S., Kumar C., Ashraful M., (2021) "Application of Artificial Intelligence and Machine Learning in Agriculture" https://krishi.icar.gov.in/jspui/bitstream/123456789/77720/1/Chapter%2021_Marwaha.pdf

10. Javad Feizabadi (2022) Machine learning demand forecasting and supply chain performance https://www.tandfonline.com/doi/full/10.1080/13675567.2020.1803246
11. Watson, (2019) https://www.ibm.com/downloads/cas/ONVXEB2A#:~:text=The%20Watson%20Decision%20Platform%20for%20Agriculture%20applies%20AI%2C%20machine%20learning,generate%20guidance%20for%20smarter%20decisions
12. Walmart, Blockchain in the food supply chain, (2021) https://tech.walmart.com/content/walmart-global-tech/en_us/news/articles/blockchain-in-the-food-supply-chain.html,
13. Maersk (2019) "TradeLens Blockchain" Copenhagen, Denmark And Armonk., p.3 https://www.maersk.com/~/media_sc9/maersk/news/press-releases/files/2019/07/hapag-lloyd-and-one-join-tradelens_press-release_020719.pdf
14. TE-FOOD (2020) "Te-food-white-paper". P.10, https://te-food.com/wp-content/uploads/2020/11/te-food-white-paper.pdf
15. Department of Infrastructure and Regional Development, agriculture sector- PwC. (2017) Technology and Supply Chains for Critical Industries, (Working paper 2 of 3). Australia.. p. 45 https://www.infrastructure.gov.au/sites/default/files/migrated/transport/freight/freight-supply-chain-priorities/research-papers/files/Working_Paper_Agriculture.pdf
16. Huseyn R.Z. Empowering Agricultural Development Through Digital Transformation in Azerbaijan (2020) "Kənd təsərrüfatının iqtisadiyyatı" № 4 (34) p. 143 https://agroeconomics.az/az/read/2003/reqemsal-transformasiya-vasitesi-ile-azerbaycanda-/
17. "Azexport" sayəsində mahlıc 30 faizdən baha ixrac olunur"
18. ***https://azertag.az/xeber/memmed_musayev__quotazexport_quot_sayesinde_mahlic_30_faizden_baha_ixrac_olunur-1076829***