ROMANIAN AGRICULTURAL RESEARCH, NO. 40, 2023
First Online: March, 2023. DII 2067-5720 RAR 2023-118

CHALLENGES OF DIGITAL TRANSFORMATION IN AGRICULTURE FROM ROMANIA

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ABSTRACT

Agriculture plays a crucial role in Romania's economy, a fact that accelerates the search for ways to maximize production yield and profit. The aim of the paper is to study the characteristics of the transformation of agriculture in the context of digitization. Research methods include scientific and theoretical approaches to assess the state of agriculture and its potential in the context of digitization, such as system and situation analysis. The current stage of agricultural development is characterized by a significant transformation of management and production processes due to the introduction of digital technologies. The experience has convincingly shown that the traditional forms of development of agricultural production have practically exhausted themselves. In the new conditions of financial and economic activity, the scientific and technological progress becomes decisive. In agriculture, the digital transformation has a significant impact on material and human resources, increases the productivity of crops, improves the quality of agricultural and livestock products. The digitization of agriculture is extremely important, because it is a source of agricultural economic growth and can become a strong incentive for the innovative development of the sector. Investments in the development of digital infrastructure in rural areas can improve the living conditions of the rural population, with local authorities solving more efficiently the problems within their competence. Also, the digitalization of agriculture will promote the development of small farms in rural areas and contribute to the diversification of the rural economy.

Keywords: digital transformation, agriculture, digitalization, digital tools.

INTRODUCTION

Digital technologies are rapidly transforming the economy and the society. Their implementation allows reducing information and transaction costs, increasing efficiency, creating new jobs, creating new sources of income and saving resources. Digital technologies can help agriculture meet the global challenges it faces. With population growth, enterprises are forced to work more intensively, which negatively affects the quality of land resources. Soil wears out, water bodies are depleted and polluted, animals suffer. Numerous problems and limited opportunities to increase production and product quality objectively contribute to the introduction of digital technologies (Holzinger, et al., 2022). This will allow the most efficient use of natural resources, with high labour productivity and the optimization of the use of different categories of personnel, which, in turn, will have a positive impact on the liquidity of enterprises. Many scientists have dealt with the problems of socio-economic and technological development of digital agriculture (Ferrari, et al., 2022; Khanna, et al., 2022; Ngo, et al., 2022).

Digital agriculture is a rapidly growing field that is transforming the way of grow and manage the crops. It is a combination of traditional farming practices and modern

Received 30 November 2022; accepted 2 March 2023.

technology, such as sensors, robotics and data analysis to improve the efficiency and sustainability of agricultural production. Digital agriculture is a tool for farmers to increase yields, reduce costs and improve sustainability. For example, sensors can be used to monitor soil moisture levels, enabling farmers to irrigate their crops more efficiently. Data analysis can be used to identify areas of the field that need more attention, such as areas with poor soil fertility or pest infestations. Robotics can be used to automate tasks such as weeding and harvesting. Robotic milking systems are one of the most outstanding technologies brought to dairy farms by the digitalization of agricultural sectors (Ors, et al., 2022). The use of digital agriculture also has potential to improve food security. By monitoring crop health and yields, farmers can better predict and plan for food shortages. This can help reduce the risk of famine and malnutrition in developing countries. Digital agriculture also has the potential to reduce environmental impacts. By using data analysis to identify areas of the field that need more attention, farmers can reduce the amount of fertilizer and pesticides they use. This can help reduce water pollution and soil degradation. Overall, digital agriculture is a powerful tool for improving agricultural production and sustainability. It has the potential to improve food security, reduce environmental impacts and increase yields and profits for farmers. As technology continues to advance, digital agriculture will become more widespread and have an even greater impact on the way to grow and manage the crops (Baierle, et al., 2022; Zhou, et al., 2022).

Precision farming elements are increasingly being used by large and compact farms. The introduction of innovative solutions is characterized by the fact that this segment is developed by large vertically integrated agricultural holdings, while medium and small farms are still slowly implementing solutions due to their financial situation and the lack of specialized personnel. Since the share of ancillary households and small farms in the total volume of agricultural production in the country is extremely high, this generally slows down the introduction of new technologies and the development of the agri-food sector as a whole. Small agricultural enterprises are currently a consumer of digital services aimed at solving specific product promotion and marketing problems, for example, using specialized markets (Kosior, 2022). This is one of the reasons why the agri-food system continues to lag behind other sectors of the economy in terms of digitization.

Market development is also hampered by a long chain of intermediaries between agricultural producers and the final consumer. The use of digital platforms that directly connect raw material suppliers, transport/logistics companies and end-users of products will eliminate intermediate links in the chain. The companies that offer such platforms are actively working in this direction, which also act in the sense of connecting suppliers of agricultural machinery, agrochemicals, seeds and other consumables with agricultural producers. The Internet of Things (IoT) and wireless sensor networks are digital technology may significantly contribute to more sufficient and sustained production in agriculture. These make information available in real-time, reliable and farm-specific (Bayih, et al., 2022; Lugonja, et al., 2022). To achieve practical success of human-centred artificial intelligence in agriculture was identifies three some important frontier research areas: intelligent information fusion; robotics and embodied intelligence and augmentation, explanation; verification for trusted decision support (Qin, et al., 2022).

Two nexuses for future research, the different dimensions of value and the social and institutional arrangements to support digitization in agriculture, are highlighted. Interdisciplinarity and transdisciplinarity are very important and it is necessary to address the binary nature of current analytical frameworks. Action research is also needed to inform policy, not only instrumentally by strengthening the evidence base, but also conceptually, to stimulate new thinking. (Ingram, et al., 2022; Martens and Zscheischler, 2022).

Romanian farms are poorly digitized due the high costs of the digital infrastructure, as well as the lack of financing resources. Romanian farmers are open and aware to improve the farm management through the implementation of digital technologies (Zeca, 2022). Until now, digitization in agriculture has mainly been limited to the automation of certain activities, for example, monitoring the condition of crops or monitoring the health of animals, automating harvesting or automating individual business processes, including the trading of agricultural products through markets. At the current stage of development, the possibilities of "smart" automation and the use of integrated systems of precision agriculture that collect data and make decisions on the management of production processes and agricultural machinery are expanding.

MATERIAL AND METHODS

Scientific articles were used in the preparation of the article. Abstract-logical, comparative-analytical, system analysis and synthesis were used as research methods.

RESULTS AND DISCUSSION

Due to its specificity, digitization can also be carried out in stages and is characterized by the introduction of individual elements of digital agriculture with short payback periods (quick win tactics) as an alternative to the simultaneous digitization of all elements of the agricultural chain. For example, satellite positioning technologies for agricultural machinery and equipment, monitoring and quality control systems for agricultural work, including with the help of:

- precision agricultural systems that provide parallel machine control, speed control and work quality;
- creation of electronic field maps in 3D format for calculating the Normalized Differences of Vegetation Index (normalized vegetation index) of crops, yield prediction based on NDVI field data (Petcu and Toncea, 2019) and images from spatial resources;
- accounting and resource control systems, for example, which ensure, based on the use of sensor data, the control of the movement and stopping of equipment, the analysis of the unloaded volume and productivity, electronic weight, electronic accounting, in order to achieve an integrated agricultural management system.

In this sense, agricultural systems urgently need innovative solutions, complete infrastructure, which could play an important role in achieving the global goal of improving food security and improving rural livelihoods. Digital technologies can strengthen the interconnectedness of the agri-food system and eliminate the factors that reduce its effectiveness. The Internet provides access to technical information, encourages collaboration and interconnection along the value chain. Big Data provides a basis for improving productivity and decision-making and enables real-time alerts, for example, in disaster management settings. Examples of digital technologies that could revolutionize agriculture and value chains are sensors, satellites, robots and drones. Sensors and satellites provide information on soil conditions, weather and temperature and crop growth. They offer agricultural producers the opportunity to increase productivity by optimizing the management of their farms, reducing the use of fertilizers, pesticides and water and also contribute to achieving higher and more sustainable results. At the same time, the introduction of digital technologies can bring with it certain difficulties, increase the digital divide in the system and reduce jobs, especially where agriculture is the main source of jobs.

Digitization can radically change not only the rural labor market, but also the relationship between agribusiness entities, including in the field of management and investments in agriculture. For example, vertical farms, unlike traditional ones, can also be located in the urban environment. Farms create ideal conditions for growing plants, they are quite productive, you just need to plant seeds and harvest fresh micro-plants, herbs or berries. Greens grown in

vertical farms taste great because pesticides and fertilizers are not used in production. The investment attractiveness of the projects makes vertical farms self-sustaining in a few months, saving money at all stages of implementation, while observing agricultural production processes and receiving agribusiness advice can be done online via the Internet.

Agribusiness crowd-funding and crowd-investing as new tools to attract investment have already become a reality, online digital markets selling "green" and "organic" products are already known.

Digital technologies in agriculture

The digital transformation of agriculture relies heavily on the integrated implementation of a number of digital technologies within the interconnected concepts of precision agriculture and smart agriculture. Despite the fact that the individual elements of precision agriculture have been used for more than 20 years, it is only now that there are integrated solutions in the field of sustainable agricultural production that save resources that combine different types of sensors, Internet of Things technologies, automated and driverless vehicles pilot, robotic manufacturing systems, platform technologies for big data processing and machine learning.

If in the past the use of information technology was limited to the use of computers and software only for financial management, now innovations in the field of agricultural digitization are used more and more widely, affecting almost all aspects of enterprises.

There is a large number of internal IT developments on the market, which are mainly separate local software products built on the platform for various specific business processes, most often for one or more strategic partners. In addition, quite often these products are in the pilot stage and there are not so many finished solutions that offer a ready-made complex product.

Software solutions includes software developers with whom one can:

- combine equipment from different manufacturers, automate processes, collect analysis. These also include artificial intelligence systems for unmanned control of agricultural machinery. Thus, they equip the harvesting machines with sensors, after which they start harvesting by themselves, make their own route and avoid obstacles;

- services that include the ability to create a map by manually entering coordinates, such as saving history and weather forecast, entering data on field inspections, a crop rotation log;

- mobile applications and web service for farm management, such as crop inspection organization, season planning, field work management, data exchange with the team and seed producers;

- agricultural enterprise management systems with a built-in agroanalytics module;

- unified systems for managing the agronomic service of agricultural enterprises that provide a complete picture of crop health based on data collected both manually and automatically and help to make maintenance decisions;

- complex software and hardware systems for monitoring equipment, technological processes, processing and conversion of telemetry data, as well as conducting all economic activities of the company in a single digital circuit;

- database systems with information about the characteristics of the field and which provide a forecast of yield based on mathematical models;

- applications with updated product information and mixing calculator;

- services that allow the purchase of seeds, fertilizers, plant protection products, agricultural chemicals and even agricultural machinery;

- websites for company customers where product quantities can be calculated and ordered.

Manufacturers of tractors, combines, harvesting equipment have created joint ventures between to develop unmanned vehicles, including agricultural machines and agricultural robots. Autopilots were created for a combine, using ideological observation, a geolocation and route control system and similar systems for tractors were developed. Automated driving systems for harvesters are also in high development.

Communications operators occupy a strong position in the field of transport monitoring, including agricultural machinery. They offer cattle monitoring solutions. In addition to the animal's location, they can determine body temperature and react to activity. All monitoring parameters are displayed in the client's personal account.

The use of modern technological solutions and the use of digital platforms make it possible to improve product quality, reduce communication time, reduce non-production costs and, therefore, increase the level of competitiveness of agro-food complexes. Despite the fact that agri-food complexes - some faster, some slower - are moving towards digitalization, they alone will not be able to turn the tide. To overcome the existing gap, there is a need for state-level support, investment in innovation, development of appropriate infrastructure, markets and human capital.

Problems preventing the introduction of digital technologies

Despite the many benefits of digitization in the agricultural sectors, there are several challenges that prevent the widespread adoption of digital technologies. These include:

- Lack of Awareness: many farmers and food producers are not aware of the benefits of digitization and as a result, may not be motivated to adopt new technologies. This is particularly true for small-scale farmers who may not have the resources to invest in digital technologies;
- Cost: the cost of implementing digital technologies in the agricultural sectors can be expensive, especially for small-scale farmers. This can make it difficult for these farmers to adopt digital technologies, which may be seen as a luxury rather than a necessity;
- Technical Challenges: the implementation of digital technologies in the agricultural sectors can also be prevented by technical challenges, such as a lack of infrastructure and access to reliable internet connectivity. This can make it difficult for farmers and food producers to collect and analyse data and make informed decisions;
- Data Privacy and Security: the digitization of the agricultural sectors involves the collection and storage of sensitive information, such as personal and financial data. This can raise concerns about data privacy and security, particularly in the context of cyber-attacks and data breaches.

Factors affecting digitalization in agriculture

The digitization of the agri-food sector is influenced by several factors, including:

1. Government Policies: government policies play a critical role in promoting the digitization of the agri-food sector. This includes funding for research and development, tax incentives for companies that invest in digital technologies and support for farmers and food producers who adopt digital technologies;
2. Market Dynamics: the digitization of the agri-food sector is driven by market dynamics, including consumer demand for transparency and quality in the food system and the need for increased efficiency and competitiveness in the food industry. As a result, companies and organizations are investing in digital technologies to improve their operations and meet the needs of consumers;
3. Technological Advancements: the rapid pace of technological advancements is also driving the digitization of the agri-food sector. As new technologies become available, they are being adopted by farmers, food producers and food companies to improve their operations and meet the needs of consumers. For example, the use of drones and sensors for precision agriculture is becoming increasingly common as these technologies become more affordable and accessible.
4. Access to Capital: the availability of capital is also a key factor in the digitization of the agri-food sector. Companies and organizations need access to capital to invest in digital technologies and infrastructure and to implement digital solutions. This can be a challenge for small-scale farmers and food producers, who may not have access to the capital they need to adopt digital technologies.

Directions to intensify the process for digitization of the agriculture

The digitization of the agriculture is an ongoing process and there are several directions that can be taken to intensify the process, including:

- *Investment in Research and Development*: investment in research and development is critical for the continued growth and development of digital technologies in agriculture. This includes investment in new technologies, such as artificial intelligence and blockchain and in the development of new applications and solutions for the sector;
- *Education and Training*: education and training are essential for the widespread adoption of digital technologies in agriculture. This includes training for farmers and food producers, who need to be able to use digital technologies effectively, as well as training for food companies and organizations, who need to be able to implement and manage digital solutions;
- *Infrastructure Development*: infrastructure development is also critical for the digitization of the agriculture. This includes investment in internet connectivity, particularly in rural areas and in the development of data storage and processing systems;
- *Public-Private Partnerships*: public-private partnerships are also important for the digitization of the agriculture. These partnerships can bring together government, industry and academic organizations to support the development and implementation of digital technologies and solutions.

The digital transformation of agriculture refers to the integration of digital technology in all aspects of the agriculture sector, including farming, food production and supply chain management. The goal of this transformation is to increase efficiency, productivity and profitability while reducing waste and environmental impact.

One key aspect of the digital transformation of agriculture is precision agriculture, which uses data and technology to optimize crop yields and resource usage on a field-by-field basis. This can include technologies such as GPS mapping, soil sensors and drones to collect data on crop health, soil conditions and weather patterns. The data collected is then analysed to inform decision-making in areas such as seed selection, planting patterns, fertilizer application and irrigation.

Another area where digital technology is having an impact is in livestock management. The use of sensors, wearables and other monitoring devices can provide farmers with real-time data on the health and behaviour of their animals. This information can be used to improve herd management, prevent disease outbreaks and reduce animal stress.

In addition to on-farm applications, the digital transformation of agriculture is also affecting the supply chain. The use of blockchain technology is one example of how digital technology is being used to improve transparency and efficiency in the food supply chain. By providing a secure, decentralized record of transactions, blockchain can help to trace the origin of food products, track their movement through the supply chain and ensure that food safety regulations are being met.

The digital transformation of agriculture is not without its challenges, however. One key challenge is the lack of infrastructure and technical expertise in many rural areas, which can limit the adoption of digital technologies. Additionally, there are concerns around data privacy and ownership, as well as the potential for technology to exacerbate existing inequalities in the agriculture sector.

Despite these challenges, the digital transformation of agriculture holds great promise for improving efficiency, productivity and profitability while reducing waste and environmental impact. In order to fully realize the potential of these technologies, it will be important to address the infrastructure and expertise gaps, as well as concerns around data privacy and ownership.

Based on available scientific and theoretical approaches, it is possible to propose a certain structural and logical model for the introduction of digital technologies in agriculture. The digitization of agriculture can be appreciated through the following indicators: 1) the share of GDP that is formed

in the digital economy (at the moment it is quite small). The prospects of the impact of digital technologies are significant in most sectors of the economy, so the state is interested in IT research, development and implementation; 2) the profitability of production at enterprises that implement digital technologies; 3) the number of IT specialists in the total number of employees. Information and communication technologies are of great importance in the development of the agricultural sector. They cover the activities of the subjects of the regional markets of agricultural products, the main functional areas, including sectoral planning and forecasting, product quality control, the pace of the innovation process at different management levels. Great strides have been made in the development of agriculture in the digital direction through the use of high-tech methods of control and regulation of various stages of the production cycle and preparation for agricultural work. New high-tech methods improve the quality of farm animals and crops used in the food industry, crops and raw materials and preserve soil fertility. Agricultural innovations cover all stages of the production cycle and can significantly reduce losses, for example, in grain production. In addition to the introduction of innovative modern technologies, the effective development of agriculture also requires qualified personnel, the formation of educational institutions for digital skills, new generation specialists with digital skills and the ability to work in an automated production environment.

The introduction of GPS navigation technologies can reduce land management costs. New technologies make it possible to determine the land use system and land condition. Research directly related to state information systems for land management was carried out in local universities. As a result of the study, it was revealed that the regulatory framework for the regulation of land relations presents numerous shortcomings and omissions and requires the improvement of the legislative regulation of state functions. It is possible to obtain more accurate data and assess the fertility of agricultural land after conducting an inventory and certification of land, developing the state record of soil fertility indicators.

The digital transformation of agriculture contributes to the achievement of the following objectives:

- qualitative improvement of financial, economic and production indicators;
- improving economic stability and reducing the consequences of the main types of risks for agribusiness;
- increasing the quantitative indicators of production in order to enter new markets, expanding the range of finished products;
- the development of the personnel policy in the agricultural sector to improve the situation on the regional labor market and eliminate the shortage of personnel;
- organizing the effective monitoring of agricultural lands, including their legal status and the change of ownership;
- the implementation of digital solutions for monitoring the production process and forecasting the main indicators of the farms.

Today, the main problem that slows down the development of digital agriculture is the low rate of implementation of the achievements of scientific and technological progress, because it requires a significant structural, production and personnel transformation at the regional level. This limitation is complicated by the low resource potential, the lack of investment attractiveness of even large agricultural enterprises due to high risks. To solve this problem, the state should assume the role of investor. The introduction of IT should take place everywhere, it will contribute to a long-term positive effect in the social and economic sphere, change the situation in the regional labor markets and attract new sources of investment. In the regions of the country, there is a positive experience in implementing a project approach to the digital development of agriculture, which requires investment and coordination of the efforts of the authorities, the business environment and the population.

In order to eliminate the problems that prevent the digital transformation of Romanian agriculture, it is necessary to:

- Gradual improvement of the regulatory and legal framework to remove barriers to the use of advanced technological solutions and create a system of incentives for implementation;
- Improving the education system to meet future staffing needs, developing proposals for changing career guidance and educational standards, including clarifying existing educational programs, including specialized and vocational secondary. The popularization of the "professions of the future", the change of career guidance activities;
- The creation of test bases, including on the basis of educational institutions of agricultural universities, for the approval of technical solutions, testing of fundamental and applied research, experimental design in the field of digital transformation of agriculture;
- Improving public support measures, subsidizing agricultural producers who equip production processes with indigenous sensors and IoT systems for technology management. Formulating proposals for farmers and cooperative entities, including to stimulate the transition to technologies that reduce the carbon footprint, including in the production of agricultural and food products for export markets, as well as in the production of packaging and logistics;
- Improving approaches to stimulate the development of internal technologies for storing and ensuring security (cyber security) of data;
- The creation of competence centers for the digital transformation of agriculture in order to coordinate efforts to digitize the transformation of agriculture;
- Creation of an organizational association, of experts and analysts at the level of the agricultural sector to formulate proposals to stimulate the introduction of digital technologies, including in the framework of financial support (granting of subsidies).

CONCLUSIONS

The digitization of the agriculture is a complex and ongoing process, influenced by a range of factors including government policies, market dynamics, technological advancements and access to capital. Despite the challenges and obstacles, the digitization of the sector offers significant benefits for farmers, food producers and consumers, including increased efficiency and productivity, improved food safety and quality and enhanced transparency and reliability in the food system. By investing in research and development, education and training, infrastructure development and public-private partnerships, we can continue to intensify the digitization process and realize the full potential of digital technologies in the agriculture.

Digital technologies are driving rapid change in all parts of the value chain, from agricultural production to the final consumer. The introduction of these technologies will improve efficiency, create new jobs, create new sources of income and save resources. The potential impact of digital technologies on agri-food markets requires further analysis. Solving problems requires increased cooperation between all actors. Consensus is also needed on how best to create a regulatory framework that maximizes the benefits of digital technologies for agriculture and minimizes the associated risks.

ACKNOWLEDGEMENT

This work was carried out through the Program NUCLEU within the framework of the National Research Development and Innovation Plan 2022-2027, carried out with the support of Ministry of Research, Innovation and Digitalization, no: 23020101.

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