Digital transformation of the agricultural system in Algeria

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Abstract:

This study aims to examine **digital transformation in the agricultural system in Algeria** by analyzing the conceptual framework of digital transformation, the current state of the agricultural sector, modern digital applications, challenges facing digitalization, and future prospects. The study revealed that digital transformation is a strategic tool to enhance productivity, improve decision-making quality, and ensure sustainable development. Practical applications such as precision agriculture, Internet of Things (IoT), artificial intelligence, drones, and big data were highlighted, as they contribute to improving production and reducing costs. However, digitalization faces several challenges, including weak digital infrastructure, lack of skilled workforce, high technology costs, and the urban-rural digital divide. The study provided key recommendations, including infrastructure development, human resource training, innovation support, and adequate financing. The future of digital agriculture in Algeria depends on a comprehensive strategy that integrates modern technology to achieve food security and environmental sustainability.

Keywords: Digital transformation, Smart agriculture, Digital technology, Algeria, Sustainable development.

JEL Classification Codes: Q16, Q55, O13, O33, Q18

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Introduction

The contemporary world is witnessing profound and accelerating transformations as a result of the digital revolution that affected various economic sectors, where digital transformation has become a key pillar to achieve sustainable development and enhance the competitiveness of countries. The agricultural sector is one of the sectors most in need of this transformation, given its vital role in achieving food security and addressing the challenges associated with population growth, climate change and natural resource scarcity.

In this context, Algeria is seeking to develop its agricultural sector through the integration of modern technologies, but the pace of digital transformation is still below the required level compared to the available possibilities. The challenge is how to move from traditional agriculture to data-driven smart agriculture and digital technologies such as artificial intelligence and the Internet of things.

The problem of the study: In the light of the above, the problem of the study centers around:

To what extent does digital transformation contribute to improving the performance of the agricultural system in Algeria, and what are the challenges that hinder its implementation?

Sub-questions: The following sub-questions are therefore included

- What is Digital transformation in the Agriculture sector?
- What is the use of digital technology in Algerian agriculture?
- What are the main obstacles to the implementation of smart agriculture in Algeria?
- What are the mechanisms to enable digital transformation in this sector?
- What are the future prospects for digital transformation in the Algerian agricultural system?

Study hypotheses: The study is based on the following assumptions:

- There is a positive relationship between digital transformation and improved agricultural productivity.
- The agricultural sector in Algeria suffers from a weak adoption of digital technologies.

- Limited digital infrastructure is a major barrier to digital transformation.
- Digital transformation can contribute to food security if supported by effective policies.

Importance of the study: The importance of this study stems from:

- The strategic importance of the agricultural sector in achieving food security.
- The need to develop agricultural production methods using modern technology.
- Highlighting the role of digital transformation as a tool for achieving sustainable development.
- Provide a scientific insight that can benefit decision makers and researchers.

Objectives of the study: This study aims to:

- Analysis of the reality of digital transformation in the agricultural system in Algeria.
- Identify the most important challenges that hinder its implementation.
- Highlight the role of technology in improving agricultural production.
- Submit proposals for the development of smart agriculture in Algeria.

Reasons for choosing a topic: This topic was chosen for the following reasons:

- The novelty and importance of the topic in the context of global digital transformations.
- It is directly related to food security and sustainable development issues.
- The need for applied studies in the Algerian environment.
- The researcher's interest in the intersection of economics with technology.

Limits of study

- **Spatial boundaries**: The study is limited to Algeria.
- **Time limits**: Focuses on the recent period associated with the spread of digitization (approximately 2015 to the present).
- **Objective limits**: It is limited to studying digital transformation in the agricultural sector without addressing the rest of the sectors.

Study difficulties: The most important difficulties that may face this study:

- Lack of accurate data and statistics on agricultural digitization.
- Limitations of previous studies in the Algerian context.
- The difficulty of quantifying the impact of digital transformation accurately.
- Limited availability of modern field resources.

The method used in this study is based on:

- **Analytical descriptive approach**: To describe the reality and dimensions of digital transformation in the agricultural sector.
- **Comparative approach (when needed)**: To compare the experience of Algeria with some of the leading countries in smart agriculture.

Secondary sources such as official reports and scientific studies are also relied upon.

The structure of the study was divided into the following axes:

- **The first theme** is the conceptual framework for digital transformation in agriculture
- **The second theme** is the reality of the agricultural system in Algeria
- **The third theme**: Digital transformation applications in agriculture
- **The fourth theme** is the challenges of digital transformation
- **The fifth pillar**: Prospects for the development of digital agriculture in Algeria

Previous studies

- A recent study by **Bassad and Saedi (2025) points** to the increasing role of digital transformation in the development of the agricultural sector in Algeria, where it aimed to analyze the impact of digitization on food security during the period (2015-2024). The study is based on a mixed approach that combines quantitative analysis of technology adoption rates and qualitative analysis of policy frameworks, with field interviews with a number of actors in the agricultural sector. The results found that the adoption of precision farming techniques and artificial intelligence contributed significantly to improving agricultural productivity by a significant percentage, reducing post-harvest losses and enhancing the efficiency of the use of water resources. The study also showed that the level of food sufficiency has improved thanks to the integration of digital solutions into agricultural value chains, confirming that digital transformation is a strategic tool for achieving food security and sustainable agricultural development.
- The study of **Ramash Ahlam Wafa et al. (2024) refers** to the analysis of the relationship between the digital economy and the agricultural sector in Algeria during the period (2000-2022), where it relied on the ARDL model to measure the relationship in the short and long term. The study found that there is a significant relationship between the use of the Internet and mobile phone and the development of the agricultural sector, which indicates that the use of digital technology contributes to improving agricultural performance. On the other hand, there was a negative correlation with some traditional indicators, reflecting the limited integrated digital transformation within the agricultural system.
- The study of **Gharib al-Taous and Darid Hanan (2021) also addressed** the topic of *e-agriculture as a strategic option* in light of the digital transformation, where it focused on the importance of integrating information and communication technology in the development of the Algerian agricultural sector. The study relied on the descriptive analytical approach, and concluded that the shift toward digital agriculture is an imperative to improve productivity and enhance competitiveness, especially in light of the challenges associated with resource scarcity and climate change, but the success of this transformation remains dependent

on the development of digital infrastructure and the rehabilitation of human resources.

- In the same context, a study published in the Economic Journal of Ibn Khaldoun University of Tiaret (2022) on *climate-smart agriculture in Algeria highlighted the* adoption of modern technologies such as information and communication systems can contribute to adaptation to climate change and achieve sustainable agricultural development. The study found that Algeria has significant potential to implement this model, but this requires strengthening agricultural extension programs and training farmers to use modern digital technologies.
- A scientific research project at Souq Ahras University (2023-2026) entitled *Smart agriculture as a mechanism to achieve sustainable agricultural development and food security in Algeria is part of the* academic efforts to support digital transformation in the agricultural sector, where it seeks to develop applied models of smart agriculture based on modern technology. this will enhance food security and increase the efficiency of agricultural production.

Firstly. The conceptual framework for digital transformation in agriculture

Recent decades have witnessed fundamental shifts in the nature of economic activities as a result of the rapid development of information and communication technologies, where digital transformation has become one of the main drivers of economic growth and productive efficiency. The agricultural sector is among the sectors increasingly affected by these transformations, especially in light of the challenges associated with food security, climate change, and natural resource scarcity. In this context, Algeria is seeking to adopt modern models based on digitization in order to develop its agricultural system and improve its performance.

1. The concept of digital transformation

Digital transformation is a holistic process that aims to integrate digital technologies into various activities and processes, leading to fundamental changes in the ways of production, management and decision-making. This concept is not limited to the use of technology, but includes the restructuring of organizational and economic models to suit the digital environment (World Bank, 2021). It is also seen as a

means to enhance efficiency, improve the quality of services and increase competitiveness.

In the agricultural context, digital transformation refers to the use of digital tools to manage agricultural resources and improve production, through reliance on data and smart technologies (FAO, 2022).

2. the concept of digital agriculture

Digital agriculture refers to the use of digital technology at various stages of the agricultural process, from planning and production, to marketing and distribution. Its most important tools are smart applications, agricultural databases, and e-marketing platforms. These tools contribute to improving production efficiency and reducing costs, as well as enhancing the transparency of agricultural markets (FAO, 2021).

Digital agriculture is also one of the key entry points for modernizing the agricultural sector, especially in developing countries seeking to improve productivity and achieve food security.

3. the concept of smart agriculture

Smart agriculture is a production system based on the use of modern technologies such as artificial intelligence, the Internet of things, and big data, with the aim of improving agricultural decision-making and increasing resource efficiency. This model is seen as an advanced development of digital agriculture, relying more on predictive analysis and smart systems (World Bank, 2019).

Smart agriculture is especially important in the face of climate challenges, helping to adapt to environmental changes and achieve agricultural sustainability.

4. The characteristics of digital transformation in agriculture

Digital transformation in the agricultural sector has several key characteristics, most notably the intensive reliance on data in decision-making, where data on soil, climate and production are collected and analyzed. This shift is also highly automated, reducing reliance on manual labor and increasing the accuracy of agricultural processes.

In addition, digital transformation is characterized by high precision in the use of resources, known as precision agriculture, where water and fertilizer use is rationalized according to crop needs. This shift also promotes integration among the different actors in the agricultural chain

through digital platforms that connect producers and consumers (FAO, 2020).

5. Tools and techniques of digital transformation in agriculture

Digital transformation in agriculture is based on a set of modern tools and technologies that contribute to improving productivity and efficiency. Foremost among them is the Internet of things, which is used to monitor environmental conditions such as soil moisture and temperature. Artificial intelligence is also used in data analysis, production forecasting and early detection of diseases.

In addition, GIS plays an important role in agricultural land analysis and planning activities, while drones are used to monitor crops and accurately assess their condition (World Bank, 2020).

6. The objectives of digital transformation in the agricultural sector

Digital transformation in the agricultural sector seeks to achieve a set of strategic objectives, including improving agricultural productivity through the optimal use of resources, reducing costs, and increasing product quality. It also aims to enhance food security by increasing production and improving the efficiency of supply chains.

Furthermore, digital transformation contributes to supporting environmental sustainability by reducing waste of natural resources and improving water management, making it an effective tool for achieving sustainable agricultural development (FAO, 2022).

7. The requirements of digital transformation in agriculture

Achieving digital transformation in the agricultural sector requires a set of prerequisites, including the development of digital infrastructure, especially in rural areas, and the provision of efficient communication networks. It also requires the rehabilitation of human resources by training farmers in the use of modern technology.

In addition, government support plays a pivotal role by developing policies and strategies that support digital transformation, and by providing financing for technology projects. Encouraging innovation and investment in startups are key to the success of this transformation (World Bank, 2021).

8. Digital transformation and sustainable agricultural development

Digital transformation is closely linked to the achievement of sustainable agricultural development, contributing to improved resource efficiency and reduced negative environmental impacts. It also helps to enhance resilience to climate change through the use of advanced technologies in agricultural production management.

In this context, digital agriculture is seen as one of the future solutions to global food challenges, especially in light of the growing demand for food and the scarcity of natural resources (FAO, 2023).

It is clear from the above that digital transformation represents a qualitative shift in the nature of agricultural activity, as it contributes to improving productivity and enhancing sustainability. However, achieving this transformation requires an enabling environment that includes digital infrastructure, qualified human resources, and supportive policies, especially in countries such as Algeria that are seeking to develop their agricultural sector and keep pace with global transformations

Secondly. **The reality of the agricultural system in Algeria in the light of the digital transformation**

The agricultural sector is one of the vital sectors in Algeria's economy, as it plays a key role in achieving food security, providing jobs and supporting rural development. However, the sector faces multiple challenges, mainly related to low productivity, climate change, and limited water resources, which requires the adoption of modern digital approaches to overcome these problems.

1. Characteristics of the agricultural sector in Algeria

The agricultural sector in Algeria is characterized by several structural characteristics that affect its performance and productivity. One of the most notable features is climate diversity, with agricultural land stretching from the Mediterranean climate in the north to the desert climate in the south, allowing for diversification in agricultural production but also posing challenges in resource management (FAO, 2021).

The sector is also characterized by fragmentation of agricultural property, with small and medium holdings prevalent, which limits the possibility of widespread use of modern technologies. In addition, there

is still a heavy reliance on traditional methods of production, which has a negative impact on productivity and efficiency (World Bank, 2020).

2. The reality of the use of technology in Algerian agriculture

Despite efforts to modernize the agricultural sector, the level of digital technology use remains relatively limited. The prevalence of modern technologies such as precision agriculture and GIS is weak, as well as the limited use of digital applications in farm management (FAO, 2022).

The use of the Internet and smart applications in agriculture is still in its early stages, especially in rural areas with poor digital coverage. This situation directly affects farmers' ability to access up-to-date agricultural information and make data-driven decisions (World Bank, 2021).

3. Digital infrastructure in rural areas

Digital infrastructure is one of the critical factors in the success of digital transformation in the agricultural sector. In Algeria, there is still a digital divide between urban and rural areas, with many agricultural areas suffering from poor Internet services and the absence of effective communication networks.

This shortage makes it difficult to implement digital technologies, such as the Internet of things or digital platforms, limiting the spread of smart agriculture. This situation is also an obstacle to the development of digital services for farmers (World Bank, 2021).

Thirdly. The role of government policies in supporting transformation

1. The agricultural digital

The Algerian State is making efforts to develop the agricultural sector through programs to support farmers and encourage investment in agriculture. Some initiatives have been launched to integrate technology into the agricultural sector, but these efforts are still limited and fall short of a comprehensive digital strategy (FAO, 2022).

There is a clear need to establish **comprehensive and well-defined policies** to support digital transformation, including the development of infrastructure, provision of financing, and the promotion of scientific research and innovation in the agricultural sector.

2. Challenges Facing the Digitalization of the Agricultural Sector

Digital transformation in Algerian agriculture faces several challenges, which can be summarized as follows:

- **Technical challenges:** Weak digital infrastructure and limited availability of modern technologies.
- **Human challenges:** Lack of digital skills and insufficient training of farmers in using technology.
- **Financial challenges:** High cost of investing in digital technologies.
- **Institutional challenges:** Lack of coordination among stakeholders and weak supporting institutional frameworks.

These challenges confirm that digital transformation requires **comprehensive reforms at multiple levels** (World Bank, 2020).

3. Opportunities for Digital Transformation in Algerian Agriculture

Despite these challenges, Algeria has significant potential to develop digital agriculture, including vast agricultural land, diverse natural resources, and increasing interest in innovation and technology.

The spread of smartphones also represents an opportunity to enhance the use of digital applications in agriculture, particularly in agricultural extension services and e-marketing. These factors can accelerate digital transformation and improve the performance of the agricultural sector (FAO, 2021).

4. Performance Indicators of the Agricultural Sector in Algeria

The agricultural sector in Algeria has shown relative improvement in recent years in terms of its contribution to GDP and job creation. However, agricultural productivity remains below its potential compared to available resources.

Achieving self-sufficiency in certain agricultural products remains a challenge, reinforcing the need to adopt digital transformation as a means to improve efficiency and increase production (World Bank, 2021).

It is evident that the agricultural system in Algeria suffers from structural imbalances that limit its performance despite its considerable development potential. Digital transformation is a strategic option to improve productivity and sustainability; however, achieving this requires

overcoming challenges related to infrastructure, human resources, and public policies.

Fourthly. Applications of Digital Transformation in the Agricultural System

Technological advancement has led to the emergence of various digital applications that have fundamentally transformed agricultural production methods. Agriculture is no longer based solely on traditional experience but increasingly relies on data and intelligent analysis. The adoption of these applications is a key pillar for improving productivity and achieving sustainability, especially in countries like Algeria seeking to modernize their agricultural systems.

1. Precision Agriculture

Precision agriculture is one of the most prominent applications of digital transformation. It relies on data to optimize the management of agricultural resources by collecting and analyzing information on soil, moisture, and temperature.

This approach contributes to optimizing water and fertilizer use, reducing costs, and increasing productivity by tailoring inputs to specific field needs (FAO, 2020).

2. Internet of Things (IoT)

IoT connects agricultural equipment to digital networks, enabling continuous monitoring of environmental conditions through sensors measuring soil moisture, temperature, and water levels.

This allows farmers to manage their farms remotely and make real-time decisions, improving efficiency and reducing risks (World Bank, 2020).

3. Artificial Intelligence in Agriculture

Artificial intelligence plays a crucial role in analyzing agricultural data, forecasting production, and detecting diseases and pests early.

It also provides recommendations on planting, irrigation, and fertilization, increasing productivity and reducing losses (FAO, 2022).

4. Geographic Information Systems (GIS)

GIS is used to analyze spatial data related to agricultural land, helping identify suitable farming areas, plan land use, and monitor environmental changes.

It supports strategic decision-making through accurate mapping of crops and natural resources (World Bank, 2021).

5. Drones

Drones are used to monitor crops, providing high-quality images for assessing plant health and detecting diseases.

They are also used for precise spraying of fertilizers and pesticides, reducing costs and improving efficiency (FAO, 2021).

6. Digital Platforms and Smart Applications

The spread of smartphones has led to the emergence of digital platforms such as:

- Agricultural advisory applications
- Agricultural marketing platforms
- Farm management applications

These platforms connect farmers to markets and provide timely information, enhancing transparency and increasing farmers' income (World Bank, 2021).

7. Agricultural E-commerce

E-commerce enables farmers to sell directly to consumers, reducing intermediaries and increasing profits.

It also expands market access and improves supply chain efficiency (FAO, 2022).

8. Big Data

Big data is used to analyze large datasets related to weather, soil, and markets, enabling better forecasting and strategic decision-making.

It also improves risk management and reduces losses due to natural factors (World Bank, 2020).

9. Digital Transformation in the Algerian Context

Despite limited implementation, some initiatives have emerged, such as agricultural advisory apps and attempts to integrate information systems.

Startups are increasingly offering innovative digital solutions, indicating a gradual shift toward smart agriculture.

Conclusion

This study examined digital transformation in the Algerian agricultural system through five main axes: conceptual framework, current situation, applications, challenges, and future prospects.

1. Digital transformation is a strategic necessity.
2. Promising applications exist (AI, IoT, drones, big data).
3. Significant challenges persist (infrastructure, skills, cost, governance).
4. Strong opportunities exist if supported by appropriate policies.

Recommendations

- Develop rural digital infrastructure
- Enhance farmers' digital skills
- Support research and innovation
- Provide financial support
- Improve regulatory frameworks
- Promote agricultural e-commerce

Future Prospects

- Transition to smart agriculture
- Integration of big data and predictive analytics
- Achieving environmental sustainability
- Expansion of digital markets
- Strengthening local innovation systems

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