

THE ROLE OF TECHNOLOGY IN AGRICULTURAL FARM MANAGEMENT

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Abstract

Agriculture is a fundamental pillar of the global economy, contributing to food security, job creation and economic development. Effective farm management becomes crucial to maximize productivity and sustainability in this context. Agricultural farms can be classified according to their size: small, medium and large. Each category presents specific challenges and opportunities, and optimal management must be tailored to these characteristics. This article aims to explore the role of technology in agricultural farm management, analyzing the various solutions and applications available and providing conclusions and proposals for the future. This article looks at the use of drones and monitoring systems, smart irrigation systems, precision agriculture, the use of blockchain technology in the agricultural supply chain, and the integration of IoT in agriculture.

Key words: farm management, innovative technologies, precision agriculture.

INTRODUCTION

Agriculture, one of the oldest human activities, has evolved significantly over time, becoming increasingly sophisticated and efficient. In the digital age we live in, technology plays an increasingly important role in all aspects of life, including agriculture.

Today, farmers face many challenges, including increasing demand for food, climate change, dwindling natural resources and the need to maintain environmental sustainability. In this context, technology becomes an essential tool for optimizing the management of agricultural farms and improving efficiency, productivity and sustainability.

The optimal management of agricultural farms requires an adaptive and strategic approach, taking into account the specifics of each category of farm. By implementing modern technologies, using data (Kamilaris et al., 2017), diversifying production (Schöning et al., 2023), and collaborating and adopting sustainable practices (Jeroen et al., 2012), farmers can significantly improve the performance and sustainability of their holdings (Prisacaru & Caradja, 2019).

The implementation of modern technologies in agriculture (Alotaibi & Nadeem, 2021; Bhatia & Bhat, 2020) allows farmers to better manage

their resources, increase productivity and improve the sustainability of their operations (Vesa, 2008). From the use of drones and monitoring systems to precision agriculture and IoT integration (Jirapond et al., 2019; Piancharoenwong & Badir, 2024; Ravesa & Shabir, 2022), technology brings numerous benefits that can radically transform the way agricultural activities are conducted.

MATERIALS AND METHODS

To achieve the main goal of the paper, research reports and specialist articles were studied to identify current trends, challenges and proposed solutions to emphasize the role of technology in the management of medium-sized farms. This will allow a deep understanding of the management dynamics of medium-sized farms and provide a solid basis for formulating relevant conclusions and proposals.

RESULTS AND DISCUSSIONS

1. Use of drones and monitoring systems

Drones and monitoring systems are a major innovation in agriculture, giving farmers the ability to collect accurate and detailed data about field conditions. These technologies

enable real-time crop monitoring, problem detection and prompt intervention to minimize losses and maximize yields.

Drones equipped with multispectral cameras can capture detailed images of fields, identifying areas affected by disease, pests or nutritional deficiencies. This data is then analyzed to provide accurate recommendations on the necessary treatments. For example, drones can detect water stress in crops, allowing farmers to adjust irrigation to save water and maintain plant health.

Monitoring systems based on sensors placed in the field can measure soil moisture, temperature, nutrient levels and other important parameters. This information is transmitted in real-time to farmers, who can make informed decisions about resource management and application of agricultural inputs. Continuous monitoring also allows for early identification of problems and their prevention, thus reducing the need for costly interventions and significant damage.

2. Smart irrigation systems

Climate change and increased competition for water resources have made efficient water management essential in agriculture. Smart irrigation systems use sensors and monitoring technologies to assess soil moisture, water needs and weather conditions, providing accurate and efficient irrigation.

These systems allow the automatic adjustment of applied water quantities according to the specific needs of crops and environmental conditions. For example, a smart irrigation system can reduce or stop irrigation on rainy days, thus saving water and reducing costs. At the same time, it can increase the amount of water applied during periods of drought, ensuring that plants receive enough water to grow healthily.

In addition to water savings, smart irrigation systems help reduce soil erosion and improve soil quality. By precisely applying water, excessive soil saturation and nutrient runoff are avoided, thus maintaining long-term soil fertility.

3. Precision agriculture

Precision agriculture is a modern approach that involves the use of advanced technologies to

precisely monitor and manage agricultural operations. This is based on the collection and analysis of data to optimize the use of resources and increase productivity.

One of the pillars of precision agriculture is the use of GPS systems for accurate land mapping and monitoring of agricultural operations. Farmers can create detailed field maps, identifying specific problem areas such as nutrient-poor soil or areas of low crop density. This information allows the precise application of agricultural inputs, such as fertilizers and pesticides, according to the needs of each area. Sensors and drones are also essential in precision agriculture, providing detailed and real-time data on the condition of crops. This information is analyzed to provide accurate recommendations on required treatments, irrigation optimization and resource management. For example, soil sensors can measure nutrient and moisture levels, allowing farmers to adjust fertilization and irrigation to maximize yields.

Agricultural management software plays a crucial role in integrating and analyzing the collected data. These applications allow farmers to monitor crop performance, plan farm operations and make informed decisions based on hard data. The software can also provide weather forecasts, pest warnings and recommendations to optimize production.

4. Using blockchain technology in the agricultural supply chain

Blockchain is a data storage and transmission technology that ensures transparency, safety and efficiency in the agricultural supply chain. By using blockchain, information about the origin, processing and transport of agricultural products can be securely and transparently recorded, thus ensuring their quality and authenticity.

In the agricultural supply chain, blockchain can be used to track products from farm to consumer. Every stage of the process, from harvesting and processing, to transport and sale, can be recorded on a blockchain, providing complete traceability. This allows any problems, such as food contamination or fraud, to be quickly identified and the necessary corrective action taken.

Blockchain can also improve the efficiency and transparency of business transactions. By using smart contracts, farmers and traders can enter into automated agreements based on predefined conditions. For example, a smart contract can stipulate that payment for agricultural products will be made automatically upon their delivery in good condition. This reduces the risk of misunderstandings and delays in payments, ensuring a more efficient and secure supply chain.

5. Integration of IoT in agriculture

IoT is another technology that is transforming the way farmers manage farm operations. IoT devices such as soil sensors, weather sensors, and Internet-connected agricultural equipment enable real-time monitoring of environmental conditions and crop performance.

IoT soil sensors can measure moisture, temperature and nutrient levels, providing farmers with detailed information about soil health. This data is transmitted in real-time to farmers, who can make quick and informed decisions about irrigation, fertilization and other necessary interventions. Continuous soil monitoring also allows for the early identification of problems and their prevention, thus reducing the need for costly interventions and significant damage.

IoT weather sensors can provide accurate forecasts and warnings of extreme weather conditions, allowing farmers to plan their operations based on weather conditions. For example, sensors can warn farmers of impending frost, allowing them to take measures to protect crops. These warnings can also help farmers optimize the timing of planting and harvesting, thereby maximizing yields and reducing the risks associated with adverse weather conditions.

Internet-connected agricultural equipment such as smart tractors and combines enable remote monitoring and control of farming operations. This equipment can be programmed to perform specific operations such as planting, irrigating and harvesting based on data collected by IoT sensors. This enables the automation and optimization of agricultural processes, reducing the need for manual intervention and improving efficiency.

SWOT analysis of the role of technology application in agricultural farm management **Strengths**

1. Increasing operational efficiency:

- The use of technology, such as precision agriculture, automation and digitization, allows for more efficient management of resources and daily activities.
- Real-time monitoring of crops and soil reduces losses and optimizes the use of agricultural inputs (water, fertilizers, pesticides).

2. Cost reduction:

- Automation and robotization can significantly reduce labour costs.
- Using data and predictive analytics helps prevent problems and reduce risk, thereby saving financial resources.

3. Improving product quality:

- Precise monitoring of growing conditions and optimal application of inputs lead to obtaining higher quality agricultural products.
- Post-harvest technologies such as humidity and temperature sensors help maintain product quality during storage and transport.

4. Access to information and data:

- Modern technologies enable the collection and analysis of a large amount of farm data, which can be used to make informed and strategic decisions.
- Digital farm management platforms provide an overview and planning tools that improve overall management.

Weaknesses

1. High initial costs:

- Implementation of advanced technologies requires significant financial investment, which can be an obstacle for small and medium farms.
- Equipment and software maintenance and upgrade costs can also be high.

2. The need for technical skills:

- Effective use of modern technologies requires advanced technical skills and continuous training.
- The lack of qualified personnel in the use and maintenance of technological equipment can represent a disadvantage.

3. Dependence on infrastructure:

- Advanced technologies depend on basic infrastructure such as internet connection and electricity, which can be deficient in rural areas.

- Technical problems or equipment breakdowns can cause interruptions in farm activity.

4. Data security:

- Using digital platforms involves cyber security risks such as data loss or theft.
- Protecting sensitive information and ensuring compliance with data protection regulations requires additional measures and costs.

Opportunities

1. Continuous innovations:

- The rapid development of agricultural technologies provides continuous opportunities to improve farm management.
- Early adoption of new technologies can provide a competitive advantage in the market.

2. Access to new markets:

- Modern technologies allow product traceability and compliance with quality standards, facilitating access to national and international markets.
- Digital marketing and e-commerce platforms open up new sales and promotion channels.

3. Sustainability and ecological responsibility:

- Efficient use of resources and reduction of negative impact on the environment contribute to agricultural sustainability.
- Green technologies and sustainable practices can attract environmentally concerned consumers and potential investors.

4. Funding and subsidies:

- There are numerous funding programs and grants available to farmers who want to adopt advanced technologies.
- Government and international organization support for the digitization of agriculture can facilitate access to funds and resources.

Threats

1. Market and price volatility:

- Fluctuations in the prices of agricultural inputs and final products can affect the profitability of technology investments.
- Economic and commercial uncertainties can negatively influence profitability and long-term planning.

2. Climate change:

- Extreme and unpredictable climatic conditions can negatively affect the efficiency of agricultural technologies.
- Adaptation to climate change requires additional investments and the development of new technological solutions.

3. Regulations and compliance:

- Legislation on the use of technology and data protection may impose additional constraints and costs on farmers.

- Changes in agricultural regulations and policies can create uncertainties and risks for technology investments.

4. Resistance to change:

- Conservatism and reluctance to change can delay the adoption of advanced technologies in agriculture.
- Cultural and educational barriers can limit the acceptance and effective use of new technologies by farmers.

CONCLUSIONS

- Improved efficiency and productivity: the use of technology in the management of agricultural farms leads to a significant increase in efficiency and productivity, by optimizing the use of resources and agricultural processes.
- Improved sustainability: modern technologies contribute to reducing the impact on the environment, by reducing the consumption of water, energy and chemical inputs. They also enable more efficient management of natural resources and maintenance of soil fertility in the long term.
- Food quality and safety: the integration of technology in the agricultural supply chain ensures the traceability and authenticity of food products, helping to guarantee their quality and safety. Blockchain and other data storage technologies enable the rapid identification of problems throughout the agri-food chain and the prevention of fraud.
- Adaptability to climate change: IoT technologies and monitoring systems allow farmers to quickly adapt to climate change and effectively manage the risks associated with adverse weather conditions. This contributes to reducing vulnerability and maintaining the stability of agricultural production.
- Automation and cost reduction: Smart farm equipment and automated irrigation systems enable the reduction of manual intervention and operational costs. Automating agricultural processes improves efficiency and allows farmers to

focus on other important aspects of farm management.

Proposals regarding the implementation of technology in agricultural holdings

- ❖ Investment in technology and innovation: farmers should be supported in adopting modern and innovative technologies through subsidy and financing programs. Investment in research and development is also essential to continue innovation in agriculture.
 - ❖ Education and training: farmers need to be educated and trained on the use and benefits of modern technologies. Training programs, information and knowledge transfer, and workshops can help farmers understand how to effectively integrate modern technology into their daily operations.
 - ❖ Digital infrastructure: the development of digital infrastructure, high-speed internet networks and IoT infrastructure, is essential for the effective implementation and use of modern technologies in agriculture. Companies in the technology sector should work together to ensure access to the necessary infrastructure.
 - ❖ Collaboration and partnerships: farmers, researchers, technology companies and government institutions should collaborate to develop and implement innovative technology solutions to provide to farmers. Partnerships between different actors in the agricultural sector can facilitate the exchange of knowledge and resources, helping to optimize the management of agricultural farms.
 - ❖ Sustainability policies: promoting policies and regulations that encourage the use of sustainable technologies in agriculture that include environmental protection measures, efficient management of natural resources and reduction of greenhouse gas emissions.
- In conclusion, technology and innovation play an essential role in transforming and optimizing agricultural farm management. Through the use of drones, smart irrigation systems, precision agriculture, blockchain technology and IoT, farmers can improve the efficiency, productivity and sustainability of their operations.

Investments in technology, education and continuous training of farmers, but also the development of digital infrastructure and the promotion of sustainability policies are essential to fully exploit the potential of technology in agriculture. This will enable all farmers to meet future challenges and ensure sustainability and global food security.

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