

Using digital technology to promote sustainable livestock production in Algeria

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Date of receipt: 16/09/2025

Date of acceptance:14/11/2025

Abstract:

In light of the growing challenges facing the agricultural sector, such as water scarcity, climate change, and increased demand for innovative products, digital technology is emerging as a solution to improving and reducing waste, as well as achieving sustainability. A study has also been conducted on specific applications such as the Internet of Things, artificial intelligence, and critical data analysis in the nutrition, health, and pasture management sectors. The study reviews the reality of animal production in Algeria, identifying opportunities and challenges.

Keywords: Use, Digital Technology, Animal Production, Sustainable Development.

Jel Classification Codes: O3, (O3 + Q1),Q 16, Q15.

1. Introduction:

The livestock production sector is a fundamental pillar of food and economic security in Algeria, contributing to the provision of animal protein, generating income for breeders, and maintaining ecological balance in some areas. However, this sector faces significant challenges, including scarcity of natural resources (especially water and grazing land), climate variability that affects the quality and availability of feed, high production costs, and epidemic diseases that threaten livestock herds. These challenges call for the adoption of new and innovative approaches that ensure the sustainability of livestock production, improve its quality, and increase its efficiency.

In this context, digital technology emerges as a transformative tool with tremendous potential to enhance sustainability in the livestock sector. The digital revolution, which includes the Internet of Things (IoT), artificial intelligence (AI), big data analytics, and blockchain, provides innovative solutions for livestock monitoring, improved management, and product traceability, contributing to informed, data-driven decision-making. These technologies can contribute to reducing resource consumption, improving animal health and welfare, and increasing productivity, thereby enhancing environmental, economic, and social sustainability.

This study aims to analyze the potential and applications of digital technology in promoting sustainable livestock production in Algeria. The study aims to assess the sector's readiness to adopt these technologies, identify potential barriers, and present a proposed framework for their effective integration. The study adopts a descriptive analytical approach, reviewing the scientific literature related to sustainable livestock production and digital technology, with a focus on the Algerian context. It also aims to provide practical recommendations for policymakers, farmers, and researchers to maximize the use of these technologies in building a more resilient and sustainable livestock sector.

1.1 The Problem:

To meet future food demand, increasing food production must come primarily through enhancing the intensity and efficiency of land and water use, the genetic potential of plants and animals, and the fisheries and forest resources available to small farmers, particularly in developing countries.

The livestock sector faces the challenge of producing enough food to meet the growing consumer demand of a growing population, while simultaneously reducing greenhouse gas emissions to protect the environment.

Based on the above, the following question can be posed:

- What is the actual role and potential impact of Digital Technologies in overcoming the "Productivity Efficiency Gap" and achieving Sustainable Development in Algeria's livestock sector, considering the current structural and climatic challenges?

To answer this main question, we divided it into a set of sub-questions as follows:

1. What are the most prominent current performance indicators for the livestock sector in Algeria?
2. How can smart farming technologies and digital environmental management contribute significantly to improving productivity and reducing losses in the Algerian livestock sector?
3. What are the shortcomings in current government policies that hinder livestock breeders from adopting digital technologies and achieving sustainability in the sector?
4. What are the challenges and prospects for animal production in Algeria?

1.2 Significance of the Study:

The importance of this study lies in the following points:

- 1- Improving sustainable agricultural practices to improve food quality using integrated and organic methods, and avoiding pesticides containing chemicals that are harmful to crops and food, as well as to the overall health of humans and animals.
- 2- Pollution control: By controlling and reducing pollutants, we can reduce chemical, bacterial, and viral contamination and enhance animal production.
- 3- Developing manufacturing processes: Through food, animal product manufacturing processes can be improved using modern technologies, advanced equipment, and preventive methods that improve production and reduce any risks resulting from contaminated materials.
- 4- Animal products and food resources are among the best sources of high-quality protein and beneficial nutrients.

5- Enhancing food security by providing essential animal products.

1.3 Study objectives:

The study seeks to achieve a set of objectives, including:

- 1- Understanding the concept of digital technology and sustainable animal production.
- 2- Identifying the most important modern technologies used to increase animal production in Algeria.
- 3- Knowing Algeria's strategy for promoting sustainable livestock production.
- 4- Identify the most important epidemic diseases affecting livestock, and the most important challenges and modern solutions for emerging diseases.
- 5- Understand how digital technology can improve animal production in Algeria.
- 6- Understand the advantages and disadvantages of modern technology in animal husbandry.

1.4 Previous studies:

1.4.1 Study: Phelan. J **"Trends in registration systems for breed improvement and production management in transitional and developing countries: A future vision for the dairy industry"**, FAO Symposium Proceedings, Switzerland, 2002.

The study aimed to describe the reality of meat and dairy production in developing countries and its relationship to future population trends and different production systems. It outlined the need to increase production levels. The study concluded by briefly describing dairy production systems by comparing different countries: South American countries, which have a system where cattle are grazing on privately owned natural and cultivated pastures, and other regions such as sub-Saharan Africa, where cattle produce three-quarters of the milk, with public ownership of natural pastures that provide most of the food for the animals, In Asia, cows and buffaloes produce equal shares of the total milk supply, and the close relationships between crops and livestock are summarized, providing a production system that allows greater control over animal feed inputs than in pastoral systems.

1.4.2 Osama Daoud's study, 2019, titled **"Nutritional Strategies to Reduce Heat Stress in Broiler Chickens,"** a doctoral dissertation. The research

aims to conduct applied scientific research that benefits farmers by increasing productivity in quantity and quality for the purpose of raising the self-sufficiency rate, which leads to achieving food security, Focusing on the most significant problems facing livestock in Jordan, the study examined the impact of rising temperatures during the summer, and even during other months of the year, on poultry farming. It also examined the changing environmental factors in the livestock sector, with the aim of helping solve farmers' problems related to the effects of high temperatures.

The results of the research, which was supervised by Dr. Abdul Rahman Al-Fatafta and his assistant, Dr. Anas Malkawi, concluded that available and inexpensive feed additives should be used, in addition to modifying feeding times, to obtain positive results that are easy to apply from a practical standpoint, The results of the experiment led to improving the quality of meat, raising the immunity and health of birds, reducing the mortality rate, and improving the quality of meat in general, This has had a positive impact on profit margins and reduced losses resulting from heat stress, particularly when it comes to lower mortality rates. The research results are expected to increase self-sufficiency in animal products, reduce losses in the livestock sector, and improve the quality of animal products to ensure they are competitive and available to consumers.

1.4.3 Asmaa Sayed Ibrahim's study, 2024, titled **"The Role of Modern Technology in Improving Agricultural Production Efficiency and Achieving Food Security in Tanzania."**

The study aims to identify the role and importance of modern technology and digital technology in the agricultural sector to reduce poverty in Tanzania, and to know the extent of the importance of the services provided by modern technology to raise the efficiency of agricultural production, and to analyze indicators of modern technology, to know the extent of its ability to raise the efficiency of agricultural production, Based on the efforts made by the state to achieve this, especially by increasing the budget for the agricultural sector and scientific research, developing the infrastructure, and analyzing indicators of modern technology and clarifying its impact on food security in Tanzania.

The study concluded the importance of modern technology in the agricultural sector to achieve sustainable agriculture, Increasing agricultural

crops, raising production efficiency, increasing exports, achieving food security, and clarifying Tanzania's 2030 plan to achieve a sustainable food system in Tanzania. The study also concluded the important role played by many organizations in holding conferences and strategies to raise the efficiency of agricultural production and achieve food security. The study also found a relationship between the use of modern technology in the agricultural sector and increasing and improving agricultural production.

5.1 Defining Research Concepts:

1.5.1 The Concept of Digital Technology:

The concept of digital technology refers to all electronic technologies, including various tools, automated systems, devices, and technological resources that generate, process, or store information. This includes any computer-aided software and technological systems designed to perform a specific task. (Johnson & Williams, 2019, p. 30)

1.5.2 The Concept of Sustainable Livestock Production:

The availability of local natural resources and their efficient use play a significant role in the livestock production sector. A successful livestock development strategy requires the formulation of resource management plans that complement economic, environmental, and social objectives. Particular attention must be paid to land use systems and natural resources necessary to optimize livestock production. (Reijnders & Huijbregts, 2018, p. 142)

1.6 Methodology Used:

1.6.1 Methodological Definition:

Methodology, derived from the Arabic root (nahaj), signifies an adopted, clear, or pursued path. Technically, it refers to the systematic procedure by which one achieves verifiable truth or scientific knowledge (Hanafi, 2000, p. 17).

1.6.1 Approach Adopted:

This study employs the Descriptive Analytical Approach. Its primary objective is to highlight the role of digital technology in fostering sustainable livestock production in Algeria. To balance theoretical and applied perspectives, the analysis is supported by statistical data and applied field estimates (used for demonstrative purposes), enabling a critical evaluation of the success or failure of current policies.

1.7 Theoretical Frameworks: A Socio-Technical Integrated Approach

The study aims to explore how digital technology can be leveraged to achieve sustainable development goals in animal production, moving beyond traditional, rent-based production models. To build a coherent framework, two theories are integrated to form a socio-technical approach addressing both breeder behavior (the agent) and economic structure (innovation).

1.7.1 Uses and Gratifications Theory

Dating back to the 1940s, this theory is foundational for analyzing the breeder's behavior (the active audience), emphasizing their deliberate choice of communication means (technologies) to satisfy specific needs.

Core Assumptions and Required Gratification:

1. Audience members are active participants using media to achieve predetermined goals.
2. Media use reflects the audience's perceived needs, influenced by individual differences and social interaction.
3. The audience chooses the messages; individuals use communication media, not the reverse (Severin, 1992, p. 178).

The Required Gratification in livestock production is achieving immediate economic return and security, specifically by minimizing unforeseen losses (e.g., mortality) and enhancing spending efficiency (e.g., feed optimization).

1.7.2 Technological Innovation Theory

This theory is crucial for understanding the dynamics of economic growth and the organizational structure (the system). Economist Joseph Schumpeter viewed innovation as the engine of growth, triggering "creative destruction" that replaces obsolete structures with more efficient systems.

Key Models:

- A. The Linear Model: Assumes sequential stages of innovation (basic research $\rightarrow$ applied research $\rightarrow$ development $\rightarrow$ commercialization).
- B. Open Innovation: Developed by Henry Chesbrough, this model suggests leveraging external knowledge sources (startups, universities) to enhance innovation capacity (Chesbrough, 2003, p. 235).

1.7.3 Proposed Theoretical Integration (The Socio-Technical Approach)

The integrated framework addresses the core dilemma: "Why is technology adoption weak despite its availability?"

- A. Innovation Theory explains the structural gap (the failure of the governmental linear model).
- B. Gratifications Theory explains the behavioral deficit (the breeder's resistance due to the perceived lack of immediate or secure economic return).

2. The Reality of Livestock Production in Algeria:

Deep Statistical and Applied Analysis dz

The livestock sector is a vital pillar of food security, contributing 26% of agricultural income, Despite Algeria ranking second in the Arab world for sheep wealth (Sahaliya & Salem, 2025, p. 157), the sector faces extensive structural and climatic challenges (Al-Kilani & et al, 2022, pp. 46-47).

2.1 Analysis of Demographics and Productivity (The Quantity-Quality Paradox)

Algeria suffers from a significant "Production Efficiency Gap," necessitating imports as local production of meat and milk remains below self-sufficiency (Jadi & Serir, 2021, pp. 346-348).

Sector	Head Count / Annual Production (2023 Estimate)	Qualitative/Applied Problem (Diagnosis)
Sheep	Over 28 million head	Environmental Pressure: Pasture degradation and high reliance on subsidized feed over natural grazing (Sustainability issue).
Cattle	Approx. 1.9 million head (800k dairy)	Low Yield: National average production is \$approx 3,500\$ liters/year, compared to \$approx 8,000\$ liters/year globally (Genetic/Management issue).
Milk (Raw)	2.7 - 3 billion liters annually	Management and Data Gap: Deficit results from poor climatic and nutritional management and weak tracking (Technical issue).

Poultry	500-600 thousand tons white meat	Fragile Environment: Sector is vulnerable to massive losses from disease and heat stress, despite partial self-sufficiency (Al Jazeera, Net, 2022).
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2.2 Analysis of the Efficiency Gap (Crisis of Waste and Data Absence)

The crisis is characterized as "resource waste" rather than "resource scarcity," largely attributed to the absence of digital data management systems:

2.2.1 Cattle: Lack of precision feeding leads to either feed waste (cost) or under-nutrition (poor yield).

2.2.2 Red Meat: The prolonged fattening cycle in traditional systems (due to poor genetics and management) increases fixed and variable costs, elevating the final consumer price.

3. The Role of Modern Technology in Enhancing Production: From Theory to Field

Bridging the "Efficiency Gap" requires transforming technology from mere "tools" into "measurable, localized solutions."

3.1 Digital Livestock Technologies and Impact Measurement

Modern technologies are implemented to optimize production and resource use.

Digital Technology	Applied Function	Impact Measurement (References/Application Estimate)
Ventilation Control Systems	Electronic control systems regulating temperature and airflow using sensors (e.g., displacement systems).	Reduced Health Costs: Automated ventilation has been shown to reduce mortality from heat stress and respiratory diseases in model farms (Riely, 1999).
Automatic Milking Robots	Automated milking, feeding arm, and sensor-based milking, creating individual cow health	Quality Improvement: Reduces mastitis and labor costs. Application is highly restricted locally.

	records (Jousan, Paula, Block, & Hansen, 2007, p. 345).	
Genetic Modification/IoT	Genetic improvement for traits like higher growth/milk yield (Heyman, 2005, p. 358).	Production Loss: The lack of Smart Collars/IoT in traditional farms is estimated to result in the loss of 1 to 2 insemination cycles annually.
Precision Feeding Systems	Automatic delivery of precise feed quantities and types based on the animal's specifications and health status (Hegarty, Goopy, Herd, & McCorkell, 2007, p. 1485).	Economic Saving: Digitization can save an estimated 15% to 20% of the annual feed bill (which constitutes 60-70% of operating costs).

3.2 The Link between Livestock Production and Sustainable Development

Livestock is a powerful driver of economic, social, and environmental change (Bertilsson, 2015, p. 148). Animal-sourced foods provide essential high-quality protein and micronutrients. Its role is pivotal in:

- A. Increasing food quantity and diversity.
- B. Driving economic transformation.
- C. Providing primary income for low-income individuals (Clark, Dame, Service, & Dobson, 2010, p. 299).

4. Algeria's Sector Support Policy: A Critical Applied Review

The Algerian government prioritizes the livestock sector to enhance food security.

4.1 Critique of Financial Support Policies (The Economic Rentier Trap)

4.1.1 Policy: Providing soft (interest-subsidized) loans (World Bank, 2023), tax exemptions (Kalil, 2019), and direct feed price support.

4.1.2 Critical Analysis: This support is "consumptive" (sustaining survival) rather than "investment-based" (driving modernization). It lacks mechanisms to mandate or finance digital tools (e.g., IoT sensors) or sustainable local feed solutions (e.g., Hydroponic Barley).

4.2 Critique of Genetic Improvement Policies (Planning Waste)

4.2.1 Policy: Encouraging the importation of high-yield breeds (Ben Drah & Belhaj, 2020, p. 57), promoting artificial insemination (FAO, 2022), and offering guidance on nutrition (Zaytoun & Ben Aissa, 2021, pp. 120-121).

4.2.2 Critical Analysis: Importing superior genetics without providing the surrounding digital management system (precision feeding, climate control) constitutes "Planning Waste." Imported breeds decline toward local productivity levels but at a higher maintenance cost.

4.3 Critique of Animal Health and Biosecurity (The Traceability Crisis)

4.3.1 Policy: Organizing periodic national vaccination campaigns and strengthening the veterinary network (FAO, 2022).

4.3.2 Critical Analysis: Algeria suffers from the absence of a "National Digital Traceability System." Reliance on paper records hinders rapid epidemic containment (threatening biosecurity). Digitization (using RFID chips) is crucial for epidemic control and accessing global export markets (Economic Sovereignty).

4.4 Agricultural Extension and Scientific Research

Agricultural Extension serves as the bridge connecting scientific knowledge (represented by research findings) with practical application in farmers' fields. The primary goal is to empower farmers to adopt improved practices and technologies to enhance productivity, improve quality, and promote sustainability.

4.4.1 Activating Agricultural Extension Centers

Agricultural Extension Centers (as mentioned by the World Bank in 2023) are the focal points for knowledge transfer. Their activation entails:

A. Equipping the Centers: Supplying them with necessary resources, such as display equipment, extension publications, and small laboratories for basic soil and water analysis.

B. Qualifying Extension Agents: Ensuring the presence of qualified and trained agricultural extension agents who possess effective communication skills and an understanding of farmers' local needs.

C. Awareness Programs: Launching regular campaigns to educate farmers on the importance of new technology, pest and disease management, and modern irrigation techniques.

D. Reaching the Farms (Outreach): Instead of waiting for the farmer to come to the center, the extension agent must go to the field and farm to provide direct and practical advice.

4.4.2 Providing Specialized Training Programs

Training aims to raise the competence of both farmers and extension agents:

A. Training for Extension Agents: Focuses on the latest research findings, effective extension techniques (such as participatory learning), and digital transformation in agriculture.

B. Training for Farmers: Training is offered on specific topics tailored to their needs, such as:

1. Integrated Pest Management (IPM): Utilizing sustainable methods for pest control.

2. Water Harvesting and Drip Irrigation: To increase water use efficiency.

3. Climate-Smart Agriculture (CSA) Practices: To address climate change challenges.

4. Post-harvest Handling: To reduce losses and increase returns. (World Bank, 2023)

5. Challenges and prospects of animal production in Algeria

5.1 The main challenges affecting animal production in Algeria:

The reality of animal production in Algeria is affected by several fundamental challenges:

5.1.1 Climate change and scarcity of water resources and pastures:

Algeria is one of the countries affected by climate change, which leads to fluctuating rainfall rates, increased drought periods, and the degradation of natural pastures (Brown & Davis, 2020, pp. 18-20), This situation directly impacts the availability and quality of feed, increasing feeding costs and threatening the sustainability of herds, especially for traditional breeders who rely on free-range grazing. (Lee & Kim, 2021, p. 78)

5.1.2 Reliance on imported feed: Feed represents a significant portion of the cost of production, and Algeria relies heavily on imported raw materials such as corn and soybeans (Boukhalfa, 2023) This dependence exposes the

sector to global price fluctuations and affects the stability of the local market.

5.1.3 Weak breeding and management methods: A large portion of breeders still rely on traditional breeding and feeding methods, and there is a weak application of modern technologies such as artificial insemination, which negatively impacts animal productivity. (Brown, R; Davis, L, 2020, p. 89)

5.1.4 Epidemic diseases: Animal diseases pose a constant threat to livestock and require continuous efforts in prevention and control, depleting resources and leading to significant economic losses. (Chen & et al, 2022, p. 230)

5.1.5 Infrastructure and marketing problems: Many rural areas lack sufficient infrastructure to support modern livestock production, and marketing chains can be inefficient, affecting access to products at affordable prices. (Al-Harak, News, 2024)

5.1.6 Lack of accurate data: Obtaining accurate and up-to-date statistics on herd size and production rates is a challenge, hindering the development of effective, science-based development policies. (Miller & Taylor, 2017, p. 188)

5.2 Future prospects and trends in animal production in Algeria:

The Algerian government recognizes the importance of the livestock sector and seeks to develop it as part of its vision to achieve food security and reduce dependence on imports, Current trends include:

5.2.1 Encouraging investment in local production: Incentives are being offered for investment in dairy cattle breeding and increasing milk production, along with supporting local feed production projects to reduce dependence on imports, such as the opening of national feed production units.

5.2.2 Breed Improvement: Working to import high-yielding breeds and encouraging artificial insemination to improve herd quality and increase production efficiency.

5.2.3 Digitizing the sector: There is a growing trend toward adopting digital technology to promote sustainable livestock production, improve management, and monitor animal health, as detailed in the previous analytical article. (Smith & Jones, 2018, p. 210)

5.2.4 Diversifying Feed Sources: Searching for Local Alternatives to Imported Raw Materials in the Feed Industry, Such as Barley and Wheat. (Boukhalfa, 2023)

The reality of livestock production in Algeria faces complex challenges, but at the same time, it possesses great potential for growth and development through the adoption of comprehensive strategies focused on technological modernization, improved management, investment in human resources, and the promotion of applied scientific research to address climate and economic challenges.

Conclusion:

The critical analysis of the research topic revealed several important findings that shed light on the current status of animal production in Algeria and the potential for digital transformation.

1- Current State of Production: Despite its strategic importance, the livestock sector in Algeria faces a significant gap between domestic production and consumption, necessitating the import of essential products such as red meat and milk powder. Although the poultry sector has achieved good levels of self-sufficiency, reliance on imported feed remains a major challenge.

2-Enabling Technology: The study demonstrated a growing awareness of the importance of digital technologies in the sector, such as ventilation control systems, LED lighting, milking robots, and automated feeding and cleaning systems. These technologies indicate a trend toward modernization, albeit limited at present.

3- Government Policies: The Algerian government is making significant efforts to support the sector by providing soft loans, tax and customs exemptions, and feed price subsidies, in addition to programs to improve breeds, develop the veterinary network, and organize vaccination campaigns.

4- Current Challenges: The sector faces multiple challenges, most notably climate change, water and pasture scarcity, heavy reliance on imported feed, the prevalence of traditional breeding and management methods, and the threat of epidemic diseases. These challenges pose obstacles to achieving full sustainability.

5- Potential for Digital Transformation: The study indicates that adopting digital technologies can serve as a pivotal solution to address these challenges. These technologies can contribute to reducing production costs, improving product quality, increasing farm efficiency, and raising profitability levels, thereby enhancing the environmental, economic, and social sustainability of the sector.

Recommendations:

To enhance the role of digital technology in sustainable livestock production in Algeria, the following are recommended:

1- Develop digital infrastructure: Invest in providing high-speed internet access in rural and semi-desert areas to enable breeders to use digital technologies.

2- Capacity building and capacity building: Organize training programs and workshops for breeders, agricultural engineers, and technicians to raise awareness and improve the use of digital technologies on farms.

3- Promote research, development, and innovation: Support research projects focused on adapting digital technology to local conditions in Algeria and developing innovative solutions that address sector-specific challenges.

4- Provide financial incentives and government support: Provide soft loans and subsidies to breeders to adopt modern technologies, in addition to developing policies that support the digitization of the agricultural sector.

5- Establish national data platforms: Establish central platforms for collecting and analyzing livestock production data, enabling evidence-based decision-making and improving strategic planning.

6- Strengthening public-private partnerships: Encouraging collaboration between government agencies, technology companies, and farmers to develop and implement innovative digital solutions.

Adopting these recommendations will accelerate the pace of digital transformation in the Algerian livestock sector, contributing to sustainable food security, increased productivity, reduced losses, and improved livelihoods for farmers. The future lies in aligning traditional practices with technological innovations to ensure a prosperous and resilient livestock sector in Algeria.

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