ЕКОНОМІКА

Agri-Startups and the Digitalization of Algerian Agriculture: Evidence from Mini-Cases

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This article explores the digitalization of the Algerian agricultural sector as a strategic response to chronic challenges such as low productivity, climate change impacts, and the continued reliance on traditional production methods. The study aims to analyze the pivotal role of agricultural startups (AgriTech) in accelerating this transformation by examining practical evidence from local mini-cases rather than relying solely on theoretical models. Using a qualitative methodology, the research investigates specific innovative enterprises, including AKT-FARMS, Nabatic, El Firma DZ, and AirCrop.

The findings reveal that these startups are successfully implementing advanced technological solutions such as smart irrigation systems, AI-driven soil monitoring, drone-based disease detection, and digital platforms that connect producers directly to consumers. The analysis highlights that while the Algerian government has introduced supportive policies—such as the «Start-up Label» and Executive Decree No. 1275 to foster innovation within universities—significant structural barriers persist. These obstacles include insufficient funding for high-tech projects, weak digital infrastructure in rural areas, and a digital skills gap among traditional farmers. The study concludes that transitioning to a modern, resilient agricultural model requires a holistic ecosystem approach. This entails enhancing rural connectivity, fostering deeper partnerships between scientific research and entrepreneurs, and implementing comprehensive training programs to ensure sustainable development and national food security.

Keywords: Agricultural Startups, Digitalization, Innovation, Sustainable Development, Algerian Economy.

Problem Statement and Analysis of Recent Research. Agriculture is one of the vital sectors of the Algerian economy [1], contributing to food security, job creation, and rural development [2]. However, the sector has continued to suffer from deep structural imbalances resulting from the adoption of traditional methods of production and management [3-4], and the weak integration of modern technology into its various cycles. In addition, there are severe climate challenges, including water resource scarcity, desertification, and the changing agricultural seasons. This refers to the shifting and irregular timing of planting and harvesting periods caused by climate variability, such as delayed rainfall, shortened growing seasons, and unpredictable temperature changes) [5] This weakens its competitiveness and increases the food import bill [6]. In this context, agricultural digitization has emerged as a strategic option that allows to improve efficiency and productivity and ensure the sustainability of resources, through the adoption of big data analytics tools, artificial intelligence, and the Internet of Things in the service of agricultural practices [7-8].

Recent scientific literature suggests that digital transformation in agriculture has become a global trend that is strongly imposing itself [9] with many countries, both developed and developing, making qualitative leaps thanks to the integration of technology into their agricultural systems [10]. Digitization has enabled the development of smart irrigation systems, monitoring plant health, tracking supply chains, and improving market access through digital platforms [12–11]. In this direction, agricultural start-ups have emerged as a key actor capable of introducing innovation faster than traditional structures, due to their organizational flexibility and dynamism in the adoption of technological solutions [13-14].

In Algeria, despite policies to encourage innovation and entrepreneurship, the digitization of agriculture is still moving at a reluctant pace [15]. Field studies have shown that the prevalence of digital solutions in agricultural practices is limited, often associated with individual initiatives or non-generalized pilot projects [16–18]. Recent reports indicate that the utilization rate of smart agriculture technologies (e.g., remote sensing, drones, and data analysis) remains low compared to available potential [19–20]. Algerian agricultural startups also face multiple obstacles, including a lack of funding for technology projects, weak digital infrastructure in rural areas, a lack of effective R&D networks, and bureaucratic constraints that limit their rapid growth [21-22].

However, some local micro-experiments are beginning to reveal promising opportunities. Startups specializing in the development of irrigation tracking apps, platforms for marketing agricultural products online [17] , and solutions for monitoring farmland via satellite imagery and drones have emerged. Despite their small size, these initiatives demonstrate the sector's ability to embrace digital innovation if an enabling institutional and financial environment is available [23-24].

In terms of research, Algerian studies in recent years have focused on characterizing the general situation of smart agriculture, analyzing structural obstacles to the introduction of digitalization, and reviewing international experiences that can be leveraged [25-27]. However, there is a lack of research that relies on local case studies of startups active in the field [28], leaving an important knowledge gap in understanding the mechanisms of success or failure of these enterprises, and lessons that can be learned to disseminate them more widely. Linking theoretical research findings to experiments. The actual microscope in the field is an essential step to move beyond the descriptive nature of the current literature and to move to practical approaches that contribute to the formulation of more realistic policies.

Therefore, the central problem that this research seeks to address is the question: How can Algeria move from a traditional agricultural model to an innovative model based on digitization and emerging agricultural entrepreneurship.

The aim of the research. This study aims to analyze the role played by agricultural startups in accelerating the Digitization of Algeria agriculture, by extrapolating lessons learned from some local micro- cases that represent practical models of entrepreurial innovation in the agricultural field. It focuses on highlighting how these enterprises, thanks to their resilience and reliance on modern technological solutions, can contribute to overcoming the sector's structural challenges, such as poor productivity, limited water resources, and fluctuating supply chains Sales. The research also seeks to show the extent to which institutions are able to transfer technology to the agricultural field, develop more effective digital marketing channels, and generate data that can be exploited in strategic decision-making, which allows to enhance the competitiveness of national agriculture and lay the foundations of an integrated digital system. Thus, the research aspires to fill a knowledge gap in the Algerian academic literature,which has often been limited to theoretical treatment or review of international experiences, by presenting a practical approach based on local case studies, in a way that contributes to the formulation of a scientific and applied vision capable of supporting sustainable development and enhancing food security.

Materials and Research Methodology. This research relied on a qualitative approach aimed at analyzing the role of agricultural startups in the process of digitization of agriculture in Algeria, through a case study and an in-depth reading of the relevant literature. The qualitative approach was chosen in view of the nature of the subject, which is characterized by complexity and overlap between economic, social and technological dimensions, which makes quantitative analysis alone insufficient to understand the dynamics affecting the agricultural digital transformation. The qualitative approach allows for an in-depth study of the local context, and the extraction of patterns of challenges and opportunities, including It aligns with the research objectives.

At the data collection level, the study was based on a mix of primary and secondary sources. Official documents and reports issued by national and international institutions and bodies concerned with agriculture, rural development and digital transformation were analyzed, as well as available statistics on the reality of startups in Algeria. The research also relied on a review of various academic literature, including local scientific articles on issues of smart agriculture and agri-entrepreneurship, as well as research published in peer-reviewed journals included in Scopus databases and Web of Science, which made it possible to build a comparative knowledge base that links the Algerian experience with modern global research trends.

Analytically, the case study method was used as the most appropriate method to examine the micro-experiments of agricultural start-ups, by focusing on their digital innovations, management patterns, and results achieved in the field. The comparative analysis method was also adopted to extract the similarities and differences between the selected cases, and to identify lessons that could be disseminated more broadly.

Results and discussion. Algeria is Africa's largest country and the third largest Arab economy and has returned to the upper tier of middle-income countries, according to the World Bank's July 2024 ranking. Over the past two decades, Algeria has made progress in economic and human development, through investments in infrastructure projects and the implementation of redistributive social policies, which have contributed to reducing poverty and significantly improving human development indicators [43].

The agricultural sector remains one of the main pillars of the production system in Algeria and through the following table we show the contribution of agriculture to the GDP of Algeria during the period from 2016 to 2023.

Through the table 1, we note that the percentage of the contribution of the agricultural sector to the GDP does not exceed 12,9%, which remains weak despite the efforts made by the state, and this reflects the low income of this sector and the dependence on the revenues of petroleum collection at a high rate [44].

The main challenge facing the Algerian economy remains the heavy reliance on hydro-carbon sector revenues and public spending. The hydrocarbon sector accounted for 14% of GDP, 83% of exports, and 47% of budget reve-nues during the period between 2019 and 2023. Algeria aspires to diversify its economy to ex-pand sources of income and improve employ-ment prospects,especially among young people due to the country's demographic character. The overall unemployment rate is estimated at 12,7% in 2024, reaching 25,4% among women and 29.3% among Youth (between 15 and 24 years) [43].

Agricultural digital transformation supports agricultural productivity and improves ope-rational efficiency through precision agriculture and GIS applications, enabling farmers to make better decisions about resource use. Second, digital solutions help to enhance the environmental sustainability of agricultural practices by rationalizing the monitoring and management of environmental risks and the use of natural resources [45].

Table 1 – **Contribution of the Agricultural Sector to Algeria's Gross Domestic product (2016-2023)**

Year	Gross Domestic Product (GDP), billions of DZD	Agricultural GDP, billions of DZD	Share of Agriculture in GDP, %
2016	17514.,6	2140,3	12,22
2017	18876,2	2219,1	11,75
2018	20425,3	2421,6	11,85
2019	23090,1	2589,8	11,21
2020	29002,1	2619,8	12,53
2021	25157,8	2759,2	10,96
2022	32028,4	3323,1	10,37
2023	32588,7	4204,4	12,90

Source: compiled by [44].

Agriculture is undergoing a radical transformation thanks to digital-driven startups, enhancing productivity, sustainability, and the efficiency of supply chains. The digitization of agriculture provides innovative solutions to traditional problems such as poor efficiency, price volatility, and lack of information, and opens up new horizons for smallholder farmers and rural areas [29–30]. Digital Agriculture / Agriculture 4.0 refers to the integration of multiple digital technology systems and media within the agricultural value chain in order to make agricultural practices more efficient and sustainable [31]. It is also defined as a strategic approach that integrates ICT into agricultural processes to improve productivity, manage resources, and facilitate market access. These technologies include field sensing and the Internet of Things (IoT), drones and satellite remote sensing, farm management systems and big data, artificial intelligence analytics, and digital exchange and marketing platforms [33-32]. The functional goal of digitization is to reduce the waste of resources (water, fertilizers, energy), improve yield indicators and product quality, and enable decision-makers and farmers to make timely decisions Based on accurate data [5-19].

Aspects of digitalization can be categorized into integrated practical axes: Precision Agriculture that allows for the specialized application of inputs, Digital Farm Management Systems (FMIS) that manage registration, tracking and reporting processes, Digital Market and Finance Services that connect the product to the consumer and enable simplified financing mechanisms, and Data Governance mechanisms which establishes an interoperable national information infrastructure among actors. These axes do not operate in isolation but rather complement to generate a dual techno-economic and social impact [16-34].

AgriTech startups are pivotal actors in this context. Their flexible nature, their focus on specialized technical products and services, and their innovative business models (marketplace platforms, subscription services, telemetry solutions) [35], make them an accelerator for the adoption of modern technologies within the fields and more quickly than traditional supply systems. In theory, their role works on the axes of technological innovation, business model innovation, and the generation of local data that feeds future analytics and policies. The effectiveness of these institutions depends on the integration of financing, structural, organizational and formative factors [36-37].

In November 2024, Algeria announced the completion of the digitization of the National Agricultural Register, and the issuance of digital cards for farmers in all 58 provinces, making this project one of the main pillars for building reliable field data for farms and emerging agricultural enterprises. Official data and specialized sources show that agriculture retains an important economic and social position in Algeria, as its contribution to GDP ranges from 10-13% and employs a significant proportion of the rural population within the framework of the agricultural labor force, making any improvement in the productivity of the sector have a significant impact on the macroeconomy [38-39]. The Algerian government has also put forward an ambitious plan to upgrade irrigated areas, reaching 3 million hectares by 2028, focusing on the southern corners of the country, which are sensitive areas in terms of water scarcity and climate impact. In this context, digitization can play important roles in terms of smart irrigation systems, humidity monitoring sensors, water measurement and control tools that enable improved water use and waste reduction in many other advantages [40-41].

The Algerian government supports agricultural production through a set of policies and instruments aimed at accelerating the digital transformation of the sector [45]. Among the most significant initiatives is the National Agricultural Digitalization Program, supervised by the Ministry of Agriculture and Rural Development, which includes the creation of a National Digital Agricultural Register and the issuance of electronic farmer cards. These tools enable the collection of reliable field data on farmers and agricultural investors, facilitating better targeting financial and technical assistance. In addition, several funding mechanisms through the National Fund for Agricultural Development (CNDA) have been established to promote the acquisition of smart equipment, automated irrigation systems, and water monitoring sensors. The state also encourages public–private partnerships and collaboration with university research centers to develop digital solutions adapted to Algeria's agroecological context [46].

Within the broader framework of innovation and digital entrepreneurship policies, the government adopted Executive Decree No.1275 of September 27, 2022, which integrates start-up enterprises and business incubators into universities and higher education institutions. This initiative has fostered an academic environment conducive to applied research and

digital innovation, particularly in the field of smart agriculture (Agri Tech). It has encouraged students and researchers to transform their graduation projects into viable start-ups, thus strengthening the link between academic knowledge and the practical needs of the agricultural sector.

To further improve this process, it is recommended to expand pilot projects for agricultural digitalization to include southern and mountainous regions, enhance farmers' training in digital tools, and develop rural digital infrastructure – particularly broadband internet – to ensure inclusive access to innovation. Moreover, the establishment of specialized Agri Tech incubators connecting researchers, start-ups, and traditional farmers could significantly accelerate the adoption of innovative solutions [47-48].

In this regard, the growing number of start-ups in Algeria can also be seen as an indirect instrument of state support. Since 2020, the government has introduced a special legal framework known as the «Start-up Label», providing financial, fiscal, and administrative incentives to encourage innovation—including in the agricultural sector. This policy has motivated many young entrepreneurs to create digital solutions for agriculture, such as smart sensing systems, agricultural data management platforms, and ecommerce for farm products. As a result, these start-ups have become key drivers of the modernization and sustainable transformation of Algerian agriculture.

The number of startups in Algeria has reached about 9,000 by July 2025, a figure that represents a remarkable growth compared to 2019, when the number did not exceed 200. The Algerian government aims to increase this number to 20,000 by the end of 2029. Among the most important start-up enterprises in the agricultural sector that have achieved significant successes, we mention:

AKT-FARMS (Algerian Knowledge Technologies Farms) is an Algerian digital agriculture startup based in Algiers, a private sector limited liability enterprise that focuses on the use of state-of-the-art technologies such as sensors to explore and analyze soil fertility, as well as relying on data from satellites and drones) and field monitoring of sensors in the fields, as part of partnership agreements with the Chamber of Agriculture of the Province of Algiers, the Belkacem Habba Institute, and the National Union of Agricultural Engineers. Operationally, the Foundation has conducted a number of field days (about eight pilot fields)

to introduce sensors and soil analysis, with the aim of providing detailed maps of soil properties (water, nutrients, electricity, temperature) and directing irrigation and fertilization according to the real need instead of generalizing. The company also seeks to send data analyses to farmers to enable them to understand the fertility of their soil and make better agricultural decisions, and it is worth mentioning that the project is accompanied by the Ministry of Agriculture and Rural Development and the National Professional Office for Cereals, considering the cultivation of major crops such as wheat as one of the national strategic priorities. As for the structural aspects, AKT-FARMS is classified within the professional technical services sector under professional guidance based on scientific research and development [22].

Although there is no official financial data on the pricing or revenue structure, the organization's business model is similar to that of other Algerian digital agriculture companies such as FilahaTech and Nabatic, where the cost of technical services usually ranges between 40 USD and 100 USD per hectare per year depending on the type of service and the level of technical support.

Nabatic Company is a startup specialized in the development of smart applications on the Internet, as it launched a digital platform called «Vito», which gives farmers an opportunity to find solutions to diseases that may affect their agricultural crops, where the farmer takes a photo and sends it through the digital platform that works to identify the problem and guide the farmer to the appropriate solutions thanks to the information included in the platform, which includes more than 100 crops and 300 pests or diseases that may affect agricultural products in addition to counter-products To eliminate them, this platform also allows farmers to learn about the selling points of various products that have to do with agricultural crops such as: pesticides, fertilizers, seeds, and other products [21].

El firma DZ is a national project launched by the Algerian Ministry of Agriculture and Rural Development in 2024 and represents one of the most important tools for agricultural digital transformation in Algeria. This platform aims to connect producers directly with consumers through an official electronic space that allows the sale of agricultural products without intermediaries, while ensuring the quality of products and competitive prices.

The platform is part of a national strategy to modernize agricultural markets, enhance transparency and combat speculation, as it allows

consumers to locate producers and points of sale closest to them through an interactive geographical map containing data from more than 300 public points of sale affiliated with the Ministry and 200 private points of sale spread across 58 states. Farmers and producers can also register online through a digital form to join the national network according to specific regulatory conditions.

The platform is supervised by the National Professional Office for Vegetables and Meat (ONILEV), in cooperation with the Ministry's General Directorate of Digitalization, and is part of a series of government programs aimed at rehabilitating the agricultural sector and enhancing its role in national food security. This initiative is in line with the policies of the Algerian government related to the rehabilitation of agricultural lands, the expansion of irrigated areas, the launch of strategic crops (such as wheat, corn, and oilseeds), in addition to the modernization of agricultural marketing channels through digital media.

Through this platform, Elfirma.dz has become the National Digital Agri-Commerce Platform, as it represents a link between producers, consumers and public bodies, contributes to the regulation of the national market, enables farmers to display their products directly, and supports the transition towards a sustainable agricultural digital economy [39-47].

AirCrop Company is a start-up based in Algiers, where it has focused on developing solutions for smart agriculture based on drones equipped with artificial intelligence technologies. These drones conduct field tours of crops, equipped with GPS technologies and multispectral cameras, allowing the production of accurate maps for the early detection of agricultural diseases, pests, and nutrient deficiencies in the soil. The foundation's initial experiments included monitoring large areas exceeding 6,700 hectares, with ambitions to expand its services to millions of farmers and thousands of food companies in Algeria. Through this innovation, AirCrop seeks to raise agricultural productivity and rationalize resource consumption in line with the principles of green growth .Five innovative projects in different agricultural fields were crowned, on Thursday (May 29th) in Algiers, with the fifth edition of the «Africa Cepsa Inouf – Sid Ahmed Faroukhi» Award for Agricultural Innovation, at the conclusion of the 23rd edition of the International Salon of Agriculture «Cepsa Agriculture 2025». Algerian startups won the first four places, with the AirCrop project, which specializes in precision agriculture and crop monitoring via

drones, winning the first prize, while the second place went to the "FilahaTech" platform for smart agriculture, and the «Biolife» project for the production of natural food supplements came in third place.

Farm Ai Company: It is an example or technology of how to exploit creative technology and innovation to serve the agricultural and agricultural sector, which faces several obstacles and great challenges that necessitate the search for smart and effective solutions, established in 2022 in Algiers, and this startup also aims to achieve the quality of agricultural crops and services and raise the levels of productivity and profitability of farmers through the extensive use of smart technology in the agricultural field to help them confront one of the serious diseases, which is represented in Wheat rust that affects wheat fields, as this disease affects the annual yield of wheat agricultural products by 22%, in addition to its rapid spread and difficulty in treating it if it is not detected early. The FARM Ai Foundation also works to provide assistance to farmers in using technological means in order to prevent and eliminate diseases before they occur, and it is also working on developing a model based on artificial intelligence and drones to take pictures of fields and farms and then analyze them through advanced algorithms, to observe and detect any early signs of diseases and send advance alerts [21].

The results of the micro-case study highlight that agricultural digitization in Algeria is no longer a theoretical option, but a reality that has begun to materialize through the initiatives of entrepreneurial start-ups, despite their limited scope [1-5]. Models studied (AKT-FAR,Nabatic, El Firma DZ) have shown that digital innovation canprovide practical solutions to chronic traditional problems, from poor soil yields and irrigation challenges to marketing and supply chain management [1]. These experiences confirm that the success of agricultural digitalization depends on the availability of a supportive environment that includes targeted financing, specialized incubators, research-applic networks, and a robust digital infrastructure in rural areas [42]. On the other hand, a comparison with the international literature reveals that Algeria has real opportunities to accelerate the digital transformation of agriculture if it puts in place clear mechanisms to value emerging innovations and link them to national plans for food security and sustainable development.

The integration of artificial intelligence, the Internet of Things (I), and big data analytics is expected to increase the sector's productivity

by up to 20-30% over the next decade, based on similar international models, with the consequent reduction in the food bill and improved competitiveness [10-16].

The lessons provided by these startups are an important knowledge and empirical base for formulating more realistic and effective digital agricultural policies, with the need to be accompanied by farmer training programs and sustainable financing for innovative projects [6].The transition from isolated situations to a national system of smart agriculture requires a strategic vision that makes digitalization a key pillar for the restructuring of the agricultural sector in Algeria [17-18].

Despite the innovative solutions and promising potential of agricultural start-ups, they face a number of structural and functional challenges. The most prominent of these are the lack of funding for digital agricultural projects compared to other sectors, the weakness of digital infrastructure in rural areas where agricultural activity is concentrated, and the lack of integration into agricultural value chains, as their cooperation with traditional farmers remains limited due to a lack of trust or a weak digital culture [21-22]. Added to this is the difficulty of accessing international markets, which makes many innovations confined to an experimental scope without the required industrial and commercial expansion.

Conclusion. This study demonstrates that agricultural start-in Algeria have become a genuine driver of digital transformation in the agricultural sector. They play a pivotal role in integrating technological innovation into the production system through the use of Artificial Intelligence (AI), Big Data, and Machine Learning (ML) technologies that now form the foundation for soil and water management, crop monitoring, and agricultural data analysis. The results indicate that the adoption of these tools by start-ups and farmers contributes to higher productivity, improved efficiency, and reduced production costs, thereby strengthening food security and rural development.

Despite these positive indicators, the ecosystem of agricultural innovation in Algeria still faces several structural barriers, notably the limited financial resources available for digital agricultural projects, the weakness of communication infrastructure in rural areas, and the lack of data integration among institutions. Moreover, the insufficient digital literacy of some farmers remains a real obstacle to the large-scale adoption of technology. However, there are also positive factors, such as strong political will, government policies supporting start-ups, the implementation of Executive Decree No. 1275 integrating innovation incubators within universities, and the growing contribution of the private sector in developing low-cost local digital solutions.

Therefore, the future of digital agricultural transformation in Algeria depends on the ability of the state and all stakeholders to establish a comprehensive national ecosystem based on three strategic pillars enhancing digital infrastructure in rural areas and linking it with Big Data programs; developing partnerships between scientific research and start-ups to localize AI and ML applications in agriculture; training a new generation of young farmers capable of using smart tools and managing resources through data-driven decision-making.

Adopting these orientations represents a fundamental starting point toward building an integrated national smart agriculture system, contributing to the modernization of the agricultural economy, the achievement of sustainable development, and the strengthening of Algeria's food sovereignty by 2030.

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Агростартапи та цифровізація сільського господарства Алжиру: результати міні-досліджень

Ассія Брахімі

У статті досліджується цифровізація аграрного сектору Алжиру як стратегічна відповідь на хронічні проблеми, зокрема низьку продуктивність, наслідки зміни клімату та тривалу залежність від традиційних методів виробництва. Метою дослідження є аналіз ключової ролі аграрних

стартапів (AgriTech) у прискоренні цієї трансформації шляхом вивчення практичних доказів на основі локальних мінікейсів, а не виключно теоретичних моделей. З використанням якісної методології у роботі проаналізовано діяльність конкретних інноваційних підприємств, зокрема AKT-FARMS, Nabatic, El Firma DZ та AirCrop.

Результати дослідження свідчать, що зазначені стартапи успішно впроваджують передові технологічні рішення, такі як інтелектуальні системи зрошення, моніторинг ґрунтів на основі штучного інтелекту, виявлення хвороб рослин за допомогою дронів, а також цифрові платформи, що забезпечують прямий зв'язок між виробниками та споживачами. Аналіз показує, що попри запровадження урядом Алжиру низки підтримувальних політик — зокрема програми «Start-up Label» та Виконавчого декрету № 1275, спрямо-

ваного на стимулювання інновацій у межах університетів, — зберігаються суттєві структурні бар'єри. До них належать недостатнє фінансування високотехнологічних проєктів, слабка цифрова інфраструктура у сільській місцевості та дефіцит цифрових навичок серед традиційних фермерів. У статті зроблено висновок, що перехід до сучасної та стійкої моделі сільського господарства потребує комплексного екосистемного підходу, який передбачає посилення сільської цифрової доступності, розвиток тісніших партнерств між науковими установами та підприємцями, а також упровадження комплексних програм навчання для забезпечення сталого розвитку та національної продовольчої безпеки.

Ключові слова: аграрні стартапи, цифровізація, інновації, сталий розвиток, економіка Алжиру.

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