Smart Agriculture: A Strategic Choice for the Sustainability of Food Security A Study of the Experiences of Certain Arab Countries

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Abstract: This study aims to highlight the importance of smart agriculture as a modern farming approach in achieving food security in Arab countries. Food security is one of the most prominent challenges facing the Arab region, due to several economic and demographic factors, in addition to limited water resources, desertification, poor soil quality in some areas, and climate fluctuations, all of which threaten traditional agricultural production. In this context, smart agriculture which relies on digital technology, artificial intelligence, the Internet of Things, and renewable energy represents an effective option for enhancing agricultural production efficiency and improving resource sustainability. It contributes to rationalizing water consumption through smart irrigation systems, improving soil and crop management, and enhancing farmers' ability to adapt to climate change through early prediction of weather conditions and plant diseases. The study concluded that adopting smart agriculture methods in Arab countries is not merely a technical choice, but a strategic one to support food security, achieve self-sufficiency, and reduce dependence on food imports. This requires public and private investments in digital infrastructure, building farmers' capacities, and encouraging scientific research and regional partnerships.

Keywords: Smart agriculture, Internet of Things, Artificial Intelligence, Food Security.
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1. Introduction

Food security is one of the most prominent challenges facing Arab countries amidst increasing population growth, climate change, and the decline of natural resources such as water and fertile agricultural land. Despite the significant human and material potential that the Arab region possesses, it still suffers from a growing food gap, which has made it heavily reliant on imports to meet its basic needs for grains, oils, and sugar..

Against the backdrop of persistently high global food prices and supply chain disruptions caused by the Russian-Ukrainian war, many Arab countries have turned to supporting local agriculture by focusing on smart agriculture. This is achieved through the adoption of modern methods and technologies in the agricultural sector. Smart agriculture relies on Fourth Industrial Revolution technologies, such as artificial intelligence, the Internet of Things, big data analytics, and renewable energy, to improve resource use efficiency and increase agricultural production while preserving the environment. Consequently, adopting this agricultural model in Arab countries represents a strategic choice for enhancing food security, reducing the food gap, and overcoming the structural challenges that hinder sustainable agricultural development in the region; this situation leads us to the following problem statement:

To what extent can smart agriculture contribute to enhancing food security and overcoming the structural challenges facing the agricultural sector in Arab countries, given the heavy reliance on food imports, water resource scarcity, and accelerating climate changes?

1.1 Research Hypotheses

To address the aforementioned problem, we propose the following hypotheses:

- Smart agriculture technologies contribute to improving agricultural productivity in Arab countries through the efficient use of resources (water, soil, fertilizers).
- The transition toward smart agriculture enhances the sustainability of the Arab agricultural sector, as the use of modern technological means in farming enables better adaptation to climate fluctuations and rationalizes resource utilization.
- The adoption of smart agriculture reduces the food gap in Arab countries and contributes to improved management of agricultural supply chains, thereby ensuring food security.

1.1 Importance of the Research

The significance of this research lies in the importance of smart agriculture as an agricultural approach that relies on the use of modern technological innovations in farming to address the challenges of climate change and rationalize resource use. Smart agriculture reduces the consumption of water, fertilizers, and energy through smart irrigation systems, protected cultivation, precise soil analysis, and controlled application of fertilizers and pesticides. This helps bridge the gap between limited resources and growing demand, thereby contributing to the dimensions of sustainable development. Moreover, smart agriculture is characterized as a low-cost farming method compared to traditional agriculture, making it a viable option for Arab countries to enhance local production and address food deficits.

1.3 Research Objectives

The research aims to:

- Clarify the concept of smart agriculture and food security.
- Study the state of food security in Arab countries.
- Present the experiences of certain Arab countries in the field of smart agriculture.
- Highlight the importance of smart agriculture in achieving food security in Arab countries.

1.4 Research Methodology

The descriptive and analytical method was adopted, Description was used to present the concepts related to smart agriculture and food security, as well as to outline the experiences of certain Arab countries in the field of smart agriculture, while analysis was employed to study the reality of food security in Arab countries.

1.5 Previous Research

The following is a review of the most important existing research related to the research topic:

- **Bouchnaf Fayza (2023) *Climate*-Smart agriculture as a strategic to achieve agricultural development and sustainable food security in Algeria for the period (2014-2015) - Reality and the need for reform.**

This study aims to address the importance of smart agriculture as an innovative technology for achieving agricultural development in Algeria and, consequently, attaining the dimensions of food security. It also examines the various challenges and obstacles that hinder the realization of the expected outcomes of this approach in Algeria, among the findings of this study, that Algeria possesses a set of potentialities that enable it to implement a climate-adapted smart agriculture project. However, it still remains weak in terms of its practical application.

- **Saaouli yakoub (2025) Digitization of the Agricultural Sector to Address Strategic Challenges and Ensure Food Security - The Case of Tunisia.**

This study clarifies the concept of e-agriculture and the necessary conditions for its implementation, while identifying the levels that could advance the Tunisian national e-agriculture plan. It concluded that modernizing agriculture through technological innovations particularly artificial intelligence, precision farming, and big data analytics can significantly enhance production while reducing human intervention. Therefore, integrating these strategies promotes environmental, social, and economic sustainability.

- **Bouabdelli yacin & gherbi Rachid, Smart agriculture as a strategic option to achieve food security inAlgeria**.

This study aims to highlight the role and importance of smart agriculture in achieving sustainable food security in Algeria. It concludes that the optimal solution to Algeria's food security challenge lies in adopting smart agriculture, which relies on and is supported by modern technologies.

Through the review of previous studies, it was found that they share the same study variables as our research, namely smart agriculture and food security. However, what distinguishes our study from the previous ones is that it presents models of smart agriculture implemented in certain selected Arab countries within the framework of the research.

2. The concept of smart agriculture

2.1 Definition of Smart Agriculture

Smart agriculture is a modern concept introduced by the Food and Agriculture Organization of the United Nations in 2010 as a response to the need to adapt agricultural development to climate challenges. The organization defined it as: "an approach that helps guide agricultural systems to support development and ensure food security under changing climate conditions." (Siyari, & Jebali, 2023, p. 31)

Smart agriculture refers to the application of modern technologies such as artificial intelligence and the Internet of Things (IoT) to enhance agricultural production and improve resource use efficiency while reducing environmental impacts. This involves precise monitoring of crops and soil through sensors, big data analytics, and the use of drones and robots to perform agricultural tasks with high precision. The goal is to achieve sustainable increases in food production, adapt to climate change challenges, and ensure food security. It is based on the following principles: (Bouchnafa, 2023, p. 112)

2.2 bjectives of Smart Agriculture

- Developing and enhancing the agricultural system by relying on modern farming methods and mechanisms that increase productivity without depleting natural resources.
- Improving the quality and enhancing the characteristics of the final agricultural product.
- Increasing the efficiency of agricultural resource use and boosting production, which contributes to achieving food security on one hand, and preserving natural resources and their sustainability on the other.
- Providing stable and sustainable food supplies for growing populations.
- Ensuring the provision of safe, healthy, and contamination-free food, free from chemical fertilizers and pesticides harmful to health and the environment.
- Overcoming the negative impacts of climate change on agricultural systems.
- Reducing emissions and limiting pollution sources, thereby preserving the environment and resources for future generations.
- Minimizing the negative environmental impact of the agricultural sector through sustainable practices. (https://blogs.lamah.com)

2.3 Smart Agriculture Technologies

Smart agriculture relies on a variety of technologies, including:

2.3.1 Smart Agriculture Technologies Related to Information Technologies

Internet of Things (IoT): It refers to the process of connecting any device to another via the Internet, ranging from mobile phones to household appliances and machinery used in agricultural fields, enabling their operation, control, and the sending and receiving of data. These devices continuously collect and process data, allowing farmers to respond quickly to emerging issues and changes in environmental conditions. This cycle begins with observation, followed by diagnosis, and then decision-making, (Mouqaddam & Farès, p. 65) Among the main applications of the Internet of Things in agriculture, see: (https://www.mokosmart.com/ar/iot-in-agriculture/)

Soil and Crop Monitoring: Farmers gain an in-depth understanding of the condition of the soil and crops while quickly identifying issues through sensors that monitor soil moisture, nutrients, temperature, and other parameters. Farmers can use this data to anticipate potential problems and implement preventive measures.

Precision Agriculture and Input Management: Instead of applying uniform inputs (water, fertilizers, pesticides) across entire fields, precision agriculture adjusts inputs based on detailed data and conditions specific to the plant, row, or plot level. This allows for a significant reduction in waste.

Livestock Monitoring and Management: Internet of Things (IoT) technology enhances and simplifies livestock management through smart ear tags, wearable biometric devices, video cameras, and environmental sensors. These tools provide in-depth information on the health, nutrition, and growth of animals.

Greenhouse and Indoor Farming Automation: Greenhouses and indoor vertical farms have become controlled and automated environments thanks to Internet of Things (IoT) technology. Every parameter can be monitored and optimized, including climate, supplemental lighting, hydroponic nutrients, and more. In a greenhouse facility in the Netherlands, the installation of sensors for heating, ventilation, air conditioning, and smart outlets reduced energy costs by 50%.

Weather and Environmental Monitoring: Weather stations equipped with smart sensors and advanced communication technologies allow for precise monitoring of crop climates. The data are transmitted to platforms that analyze potential risks, such as frost, drought, precipitation, and pest pressure, in order to trigger immediate alerts for timely intervention.

Smart Irrigation and Water Management: Through water monitoring via the Internet of Things (IoT) and smart irrigation systems, farmers can maintain optimal moisture levels while improving usage efficiency. Integrated weather data and soil sensors allow automatic adjustment of drip irrigation schedules, tailored to the zone, crop, and growth cycle.

Artificial Intelligence: This refers to a type of algorithms and mathematical models that process data and simulate human cognitive abilities for decision-making. Given the immense volume of daily agricultural data obtained from various sensors and IoT devices—such as temperature, climate, humidity, soil conditions, crop status, pests, water quantity and salinity, as well as soil pH and other conditions—the use of artificial intelligence is essential to obtain an accurate understanding of farmland conditions. This is achieved through data analysis and processing, enabling the extraction of relevant forecasts (Mouqaddam & Farès, 2023, p. 65).

Digital Platforms : Digital platforms serve as a fundamental pillar of smart agriculture, encompassing:

- **Smart Farm Management Systems:**
  - Integrated platforms for monitoring crops, soil, and weather conditions.
  - Analytical tools for planning agricultural cycles.
  - Data-driven decision support systems.
- **Farmer-to-Consumer Connecting Platforms:**
  - Direct digital marketplaces for agricultural products.
  - Applications linking farmers with processing and manufacturing facilities.
  - Platforms enabling consumers to trace product origins.
- **Supply Chain Tracking Systems:**
  - Blockchain technologies to ensure transparency and quality.
  - Coding systems for tracking product movement from farm to consumer.
  - Logistics and inventory management platforms.

Satellite Monitoring: Satellite monitoring is one of the technologies that has transformed modern agriculture. Multispectral satellite imagery is used to track crop health and provide valuable information to farmers. This technology enables:

- Analysis of plant health using the NDVI index.
- Monitoring of soil moisture levels.
- Identification of areas in the field that require special attention.
- Yield prediction and productivity estimation.

Using this data, farmers can make informed decisions regarding irrigation, fertilizer application, and pest management, thereby improving productivity and reducing costs. (https://farmonaut.com/africa).

2.3.2 Smart Agriculture Technologies Related to Equipment

Agricultural Robots: These are automated machines that use artificial intelligence, sensors, and computer vision to perform specific agricultural tasks such as harvesting, precision spraying, crop monitoring, weed control, and seeding. These robots provide innovative solutions to improve productivity, reduce costs, and decrease pesticide use, thereby enhancing agricultural efficiency and promoting more sustainable farming (https://worldofplants.ai/farming-robots/).

Drones: Drones are technologies used in smart agriculture to monitor and assess crops, photograph farmland, map plots, measure air components, and quickly and safely spray pesticides. They transmit data in real time to software that analyzes it and guides farmers on the best actions to take. Drones are also used to identify damaged plants in order to implement necessary corrective measures.

Autonomous Tractors: The agricultural sector benefits from the advantages of autonomous tractors. which combine remote sensing systems (GPS) and automation, allowing for precise and controlled driving to avoid excessive soil compaction. These tractors are programmed to autonomously detect plowing areas in fields, adjust speed, and avoid obstacles such as irrigation equipment, people, and animals while performing tasks. The use of smart tractors can revolutionize the agricultural industry by facilitating plowing, uniform seeding, as well as monitoring growth levels and forecasting harvest periods (Siari & Jebali, 2023, p. 35)

Automated Grain Unloading: Automated grain unloading refers to the use of automated systems to transport and unload bulk grains, such as pneumatic suction machines that use airflow to move grains through pipes, or mechanical conveyor systems such as belts and bucket elevators, which transport grains vertically or horizontally. The design of these systems takes into account factors such as dust prevention, unloading efficiency, and operational safety to ensure a smooth process. These technologies aim to improve the efficiency of unloading and packaging operations in ports, stations, and warehouses, thereby reducing manual labor and human errors, while increasing the speed and accuracy of operations.

2.4 Smart Agriculture Methods

The methods of smart agriculture are numerous and varied, including the following:

Vertical Agriculture: Vertical agriculture involves growing crops stacked in vertical layers within an enclosed environment. It is often practiced in urban areas due to its ability to thrive on limited surfaces. The plants generally do not require soil, as most are hydroponic, with roots regularly supplied with water and nutrients. This practice heavily relies on technology to monitor the plants and determine the appropriate levels of light, humidity, temperature, and gases. Its importance lies in increasing crop production in confined spaces, while ensuring local food supply and helping to address certain environmental challenges. Following zero-waste principles, vertical farms aim to maximize resource use and recycle waste: the water used to irrigate crops on upper levels gradually flows down to lower levels, and unused organic waste serves as livestock feed (Siari & Jebali, 2023, p. 36).

Use of Nuclear Technologies in Agriculture: Nuclear technologies are employed to induce crop diversity, enabling plants to withstand drought, salinity, or pests. Similar techniques are applied to characterize the genetic composition of indigenous or locally adapted animals, combining high productivity with resistance to local diseases. These technologies are also used to determine the intensity and spread of pests and animal diseases, thereby allowing for the rapid implementation of measures to address them. (Mouqaddam & Farès, 2023, p. 66)

Greenhouses: Greenhouses are glass structures that protect crops from external factors such as rain, wind, temperature fluctuations, and pests. They are equipped with advanced control systems that regulate irrigation, heating, and lighting to create an optimal climate based on data measured by sensors, with the aim of improving crop production. (Siari & Jebali, 2023, p. 37)

Climate-Smart Livestock Production: Improved livestock management helps reduce greenhouse gas emissions from enteric fermentation. This is achieved through the selection of species and breeds, enhanced feed management, sustainable grazing practices, pastoral agroforestry, diversification within and beyond farms, and manure management, all aimed at improving the sustainability of livestock production (Belhetahat, 2024, p. 252).

Smart Fisheries: Climate change affects the abundance and distribution of fishery resources, as well as the suitability of certain sites for aquaculture, thereby impacting the ecosystem services they provide. Several options exist to support the growth of this sector in an intelligent and sustainable manner, including improved site selection and design, sustainable water management practices, selective breeding and genetic improvements, and the strengthening of emergency and biosecurity measures (Belhetahat , 2024, p. 253).

3. The concept and reality of food security in Arab countries:

3.1 Definition of Food Security

Food security is defined as: "The state's provision of the requirements of all its population of goods and food materials in the required quantity, and the various types of necessary food, drink, and nutritional materials to the extent needed by the people. This is in addition to specifying the source of this food by determining how the state obtains it, whether through local production or from foreign sources." (Akroud, 2022, p. 54)

Food security is: "The ability of a society to provide the basic food needs for its citizens, and to guarantee a minimum of these needs regularly through the local production of food commodities, and by providing sufficient earnings from exports to be used for importing what is necessary to bridge the gap in domestic food production without any complications or pressures from any source." (Siari & Jebli, 2023, p. 29)

The concept of food security refers to: "The necessity of providing individuals with the required quantities of food products. This provision may rely on cooperation with other countries or on self-reliance alone. This term is based on three pillars: the availability of goods, on a continuous basis, and at prices affordable to the consumer". (Al-Hayari)

Food security is based on four fundamental pillars: (Siari & Jebli, 2023, p 30)

The Production Pillar: This involves ensuring sufficient quantities of food.

The Storage Pillar: This refers to storing quantities that ensure stability in the supplied amounts and their steady flow to the markets.

The Distribution Pillar: This entails delivering food to its places of consumption using means of transportation.

The Consumption Pillar: This reflects the consumption pattern that should reduce waste and promote rational use.

Food security does not mean self-sufficiency or self-reliance, as many believe. The concept of food security does not go beyond its fundamental dimension, which is to provide a stockpile of basic food requirements for a period sufficient for the state to manage the replenishment of this stockpile, avoiding any shortfall. This can be achieved through self-reliance or by resorting

to imports. As for the time period for a stockpile to be considered strategic and achieving food security for a state, it varies from one country to another and from one food item to another. However, it generally ranges from no less than two months to no more than one year. (Akroud, 2022, p. 5)

3.2 Dimensions of Sustainable Food Security

The dimensions of sustainable food security include the following: (Ben Shaa & Hadri, 2023, p 236)

Availability: Availability means providing the supply of food commodities, whether from local production or the global market. Provision here refers to the adequacy of the supply in terms of both quantity and quality. It is measured by the state's ability to provide sufficient food supplies for its population, whether from local production or external markets.

Physical Access to Food: This refers to individuals having sufficient resources to obtain enough food for a nutritious and sound diet. The possibility of physical access is determined by households' ability to access the food they need, whether through their own production or through the market.

Physical Access to Food: This refers to individuals obtaining sufficient resources to purchase adequate food for a nutritious and sound diet. The possibility of physical access is determined by households' ability to access the food they need, whether through their own production or through the market.

Economic Access to Food: Economic access to food is determined by households' ability to purchase the required quantities of food. The volatility of basic food prices and purchasing power are key factors determining this access. Consequently, the prices of goods and products must be affordable for individuals, or there should be a possibility to provide them as aid to the poorest segments of the population.

Utilization of Food: This refers to how the body uses the various nutrients contained in food, ensuring sufficient energy intake through diverse diets and the rational distribution of food within the household. Food utilization is determined by several factors: food safety and nutritional content, food preparation methods, dietary diversity, and the distribution of food within the family

Agency: This is a modern dimension and a principal pillar of food security linked to human rights. It is defined as the capacity of individuals or groups to make their own decisions about the food they consume and produce, and how food is produced, processed, and distributed within food systems. It also includes the ability to participate in shaping food system policies and governance. When agency is realized, all people and groups can make choices and use their voices to shape the agricultural and food system, as well as livelihood opportunities.

Sustainability: Sustainability refers to the ability of food and nutrition systems to maintain the economic, social, and environmental foundations that can generate food security for future generations. Sustainability also means that a sustainable food system is consistently viable (economic sustainability), provides broad benefits to society (social sustainability), and has positive or neutral impacts on nature (environmental sustainability). A food system's capacity can be linked to sustainability when it is able to achieve sustainable development goals despite crises, shocks, and threats.

3.3 The Reality of Food Security in Arab Countries

The 2023 report of the Arab Organization for Agricultural Development indicates that approximately 59.8 million people in the Arab region, or 12.9%, suffer from malnutrition. Food security in this region faces significant challenges, including climate change, which has heavily impacted natural and agricultural resources, desertification, water scarcity, and the degradation of soil fertility, thereby reducing agricultural production capacity, The report also highlights the consequences of regional conflicts in countries such as Yemen, Syria, Sudan, and Palestine, which have led to the destruction of agricultural infrastructure and the displacement of populations, causing severe food shortages and increasing rates of poverty and hunger. Moreover, the Russia-Ukraine war has affected food security by disrupting supply chains for staple commodities such as cereals and oils, resulting in higher prices for imported food, The state of food security in Arab countries can thus be illustrated more clearly as follows:

Production of Major Food Commodities in Arab Countries: Arab countries produce a variety of agricultural products that differ by region. Cereals, in all their forms, are among the most important agricultural products, alongside vegetables, fruits, and red and white meats. The 2023 report of the Arab Organization for Agricultural Development indicates that cereal crops represent one of the main food commodities in the Arab world and contribute the largest share to the value of the gap in major food commodities, In 2023, cereal production in the Arab region reached approximately 51 million tons, representing an increase of 2.56 million tons compared to 2022. Wheat is the primary cereal crop, accounting for about 48.03% of cereal production in the Arab world, followed by other crops whose importance varies depending on production volumes. The report also highlights that Arab countries have made notable improvements in providing major food commodities to their populations despite the economic and environmental challenges facing the region.

Food Availability Through Trade: According to the 2023 report of the Arab Organization for Agricultural Development, exports from Arab countries reached 23,616.6 million $ in 2021, 24,953.6 million $ in 2022, and 25,171.2 million $ in 2023, reflecting the year-to-year changes in export volumes, Regarding imports, although they decreased in 2023 to 77,945.9 million $ compared to 94,157.8 million $ in 2022, these figures demonstrate the significance of agricultural product imports for Arab countries. The quantity imported is thus nearly three times the quantity exported, the same report indicates that the Arab region is heavily dependent on the import of cereals, oils, and sugar, importing between 40% and 60% of its wheat needs and about 85% to 90% of its sunflower oil needs. This makes the region vulnerable to global market fluctuations and geopolitical changes.

Food Deficit in Arab Countries: A country's food deficit is defined as the difference between the amount of food required to meet the basic needs of its population and the quantity available locally, According to the 2023 report of the Arab Organization for Agricultural Development, the food deficit in Arab countries amounted to 40.39 billion $, compared to 42.27 billion $ in 2022, with this decrease attributed to the reduction in food imports in 2023, Arab countries show high levels of self-sufficiency for certain food commodities such as vegetables, fish, fruits, legumes, and potatoes. The report also indicates that cereals account for 48.08% of the total value of the food deficit, with wheat, rice, and corn alone representing 87% of this group, thus highlighting the importance of these commodities in the overall food deficit.

4. Smart Agriculture as a Strategic Option to Ensure Food Security in Arab Countries

In order to ensure food security and reduce the food deficit, many Arab countries have launched significant initiatives to develop the agricultural sector by integrating modern technologies into farming and implementing smart agriculture techniques. Several notable experiences have thus been carried out in various countries, including:

4.1 Experience of Algeria

The World Economic Forum in Davos ranked Algeria among the global leaders in food security in its 2023 report, thanks to its national production. Additionally, the Food and Agriculture Organization (FAO) of the United Nations placed Algeria first in Africa and in the Arab world for the years 2020, 2021, and 2022 in terms of achieving the United Nations Sustainable Development Goals related to food security, The latest report of the World Food Programme's "Zero Hunger" initiative for 2030 indicated that Algeria ranked first in Africa in terms of food security. According to statements by the President of the Republic in November 2024, the agricultural sector now contributes 15% to the Gross Domestic Product, generating a total added value of 37 billion $ and accounting for more than a quarter of the workforce, or 2.7 million workers, Despite these high rankings by international organizations, the government continues to make progress in increasing food production, now through smart agriculture. This approach takes into account the rapid development of technologies, notably through the widespread use of renewable energy for irrigation, the use of solar energy for pumping instead of fuel-powered engines, and collaboration with universities as essential partners to promote innovation. Within this framework, two national agricultural schools have been established to help connect agricultural projects with modern scientific research, An agricultural and food hub, as well as a seed bank, have also been established, along with the creation of a gene bank (Yahi) Several smart agriculture initiatives have been implemented in Algeria, including the following (Harfouch, 2024, pp. 391–392):

Experiences of the Scientific and Technical Research Center for Arid Areas of Biskra (CRSTRA): In light of the threats posed by desertification, drought, and low rainfall in these regions, and to address these escalating climate challenges, researchers from the Scientific and Technical Research Center for Arid Areas in Biskra (CRSTRA) conducted experiments in smart agriculture for strategic crops such as sugar beet, saffron, and chia. This was achieved through the development of a smart irrigation system, which reduced water usage by up to 40%.

Experience of Vitroplant Algeria: This is an Algerian-Italian company founded in 2017 in the Wilaya of Blida, specializing in agricultural plant technology. It has a nursery dedicated to the production of fruit trees and rootstocks through tissue culture using the in vitro propagation technique—a method that allows rapid growth of young plants and the production of disease-free trees, The nursery includes a laboratory equipped with all scientific tools and modern technologies for the production of young plants through tube culture (artificial culture), followed by their transfer to climate-controlled, intelligent plastic greenhouses. These greenhouses are equipped with the most advanced agricultural technologies, including smart sensors that monitor climatic factors such as humidity and temperature to provide optimal conditions for the development of young fruit tree plants.

Experience of the Start-up Farm AI: Farm AI is a start-up specializing in agricultural technology, founded in 2022. The Farm AI project illustrates how technology can serve the agricultural sector. An Algerian team of seven members developed an innovative solution to combat the fungal wheat disease, rust, which spreads rapidly within 5 to 7 days and destroys an

average of 22% of wheat plants, The final solution consists of a digital application accessible on farmers' smartphones, combined with the use of drones equipped with a computing system for early detection of wheat rust. These drones capture images of the fields, identify affected areas, and analyze the images using advanced neural networks, then send alerts to farmers via the mobile application.

4.2 Experience of the United Arab Emirates

According to World Bank statistics, the contribution of the agricultural sector to the United Arab Emirates' gross domestic product (GDP) reached 0.7% in 2023. The country has made significant progress in the field of food security, ranking 23rd globally in 2022, The UAE is working towards its goal of becoming the world's leading country in the Global Food Security Index by 2051, through the National Food Security Strategy 2051, This o
bjective is based on developing sustainable local production supported by technology, and on the widespread adoption of smart technologies in food production, This is reflected through: (Mahmoud Al-Assaad**)**

4.2.1 The efforts of the United Arab Emirates in the field of smart agriculture

In 2014, the United Arab Emirates inaugurated the Agricultural Innovation Center, a strategic step aimed at strengthening and developing the country's agricultural sector. This center was established to keep pace with recent developments in this vital field and seeks to ensure the sustainability of agriculture through innovation and the adoption of advanced agricultural technologies. Its activities include conducting in-depth scientific research and providing specialized advice to farmers and investors in the sector, thereby contributing to improved productivity and crop quality**.**

In 2018, the United Arab Emirates launched the National Food Security Strategy 2051, which aims to build an integrated national system focused on promoting sustainable food production**.** This strategy is founded on the use of modern technologies and innovative solutions to strengthen local production and reduce dependence on food imports.

In 2019, the United Arab Emirates launched the "Food Tech Challenge", the largest competition of its kind in the world. This challenge aims to explore innovations and technologies capable of transforming traditional agricultural practices, thereby promoting **e**fficiency and sustainability. It also seeks to develop innovative solutions for food production and management in the UAE, contributing to the achievement of food security and enhancing the country's resilience to future challenges in this field.

4.2.2 Smart agriculture models in the United Arab Emirates

The Dubai Food Technology Valley: The Food Technology Valley in Dubai is the world's first city specialized in agricultural technology. Established in 2021, it aims to triple food production. This pioneering initiative seeks to achieve food security and promote environmental sustainability, Located in the "Warsan region", this valley spans a vast area of 18 million square meters, offering an ideal environment for the development of innovative and sustainable agricultural methods, while attracting talents and creative minds, The valley aims to strengthen the UAE's exports of fresh produce to regional and global markets. It is expected to produce more than 300 varieties of crops through the use of the most advanced agricultural technologies, The project consists of four main zones**:** the agricultural engineering and technology zone, the food innovation incubators, the research and development center, and the logistics systems zone.

Vertical Farming: "Badia Farms" is the first farm to adopt vertical farming technology in Dubai. Spanning an area of 8,500 square meters, this farm uses hydroponic cultivation to produce vegetables and aromatic herbs for local restaurants, thereby helping to provide fresh and high-quality products, Projects such as "Badia Farms" aim to realize the "farm-to-table" concept, further strengthening Dubai's position as a global destination for fruit and vegetable production.

Dubai Industrial City also hosts a new vertical farm owned by " Badia Farms", which uses cutting-edge technologies, reflecting the United Arab Emirates' commitment to innovation. "Emirates Flight Catering" and **"**Crop One" are investing 40 million dollars in the construction of the world's largest vertical farming facility, located near Al Maktoum International Airport in Dubai, This project represents a strategic partnership with "Crop One Holdings"**,** a global leader in vertical farming headquartered in the United States**.**

Agricultural Greenhouses: The United Arab Emirates is working to promote the use of hydroponic technology among farmers. This technique relies on nutrient-enriched water to grow plants with little or no soil. It has revolutionized the agricultural **sector** by enabling a reduction in water consumption by up to 70% and eliminating the use of harmful chemicals**,** Hydroponic technology requires less space while producing higher yields, making it an ideal solution for a desert environment like that of the United Arab Emirates, First introduced in the country in 2009, this method has led to a significant increase in the number of hydroponic greenhouses**.** In this context, "Pure Harvest Smart Farms" has developed a high-tech greenhouse system equipped with smart climate control, allowing for the maintenance of optimal growing conditions and ensuring water recycling**.**

4.3 Egypt's Experience

The agricultural sector is one of the key pillars of the Egyptian economy, employing about 55% of the labor force and contributing 13.5% to the gross domestic product (GDP), Like many countries around the world, Egypt has placed great importance on smart agriculture as a modern mechanism to overcome challenges hindering sustainable agricultural development**,** such as the scarcity of freshwater resources**,** the limited availability of arable land, and the continuous population growth, In this context, the Egyptian state has sought to leverage the modern technological revolution in agricultural practices through various models and applications, including: (Mohamed El-Saghir Mohamed, 2024, pp. 403-405

Implementation of modern technologies in large agricultural projects: These technologies are being applied in major national agricultural projects, the most important of which is the "New Delta Valley Project". This project employs modern agricultural techniques, including pivot irrigation technology, which is remotely controlled to optimize the irrigation system and manage water usage efficiently; In addition, plastic silos have been built as part of the "Future of Agriculture in Egypt" project, one of the flagship initiatives of the New Delta Valley. These fully automated silos, which operate without human intervention, are used to store wheat harvests and ensure efficient management of agricultural production.

Smart Agriculture Application: The Ministry of Agriculture has launched a smart agriculture application, in collaboration with several local and international institutions, with the aim of enhancing the use of artificial intelligence among farmers**;** this application includes a pilot program focusing on four main crops, including wheat and rice. It features a scientific database that lists all crop disease symptoms, accompanied by illustrative images and detailed descriptions of the most appropriate treatments and control methods, In addition, the application addresses

various issues faced by farmers throughout the agricultural production cycle**,** thereby contributing to improved crop management and the promotion of sustainable and technologically advanced agriculture.

Mobile Applications: In December 2021, the "Hodhod" Smart Farmer Assistant was launched an Arabic language mobile application based on artificial intelligence technologies, designed to establish more effective communication with farmers, The application provides digital agricultural extension content covering topics of interest to farmers and smallholders, enabling them to easily access reliable agricultural advice and guidance, This initiative represents a qualitative leap in the agricultural advisory system**,** making it instant, accurate, and personalized according to each farmer's needs and the pests likely to affect their crops, When a farmer notices an abnormality or infection in their crops at any stage of the agricultural cycle, they can take a photo with their mobile phone and send it through the application. Using artificial intelligence, the system identifies the type of pest and provides the necessary recommendations to treat the infestation and minimize its effects**.**

The Digital Agricultural Map: As part of strengthening water accounting and assessing water, productivity, a collaboration was established with the United Nations Food and Agriculture Organization (FAO) to map agricultural crops using satellite imagery, with the aim of accurately determining the water needs of different crops and optimizing the use of every drop of water.

Project to Strengthen Governance of Sustainable Aquaculture Production: The General Authority for the Development of Fishery Resources collaborated with the United Nations Food and Agriculture Organization (FAO) to launch a project aimed at strengthening biosafety governance to support sustainable aquaculture production in Egypt. This project focuses on the sustainable development of aquaculture through a national strategy for aquatic animal health. Within this framework, an advanced reference laboratory has been established for the analysis of fish, water, soil, and feed, in accordance with global market requirements.

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4.4 Experience of Saudi Arabia

Agricultural land in Saudi Arabia represents approximately 22.7% of its territory, or more than 2.15 million km². According to World Bank statistics for 2023, the agricultural sector contributes 2.5% to the Gross Domestic Product (GDP). This sector has experienced significant growth in recent years, with its contribution to GDP reaching around 114 billion riyals (USD 30.4 billion) in 2024, compared to 109 billion riyals (USD 29 billion) in 2023, according to the annual report "Saudi Vision 2030" for 2024 (https://aawsat.com/), Since the launch of Vision 2030, the Saudi government has placed special emphasis on the agricultural and livestock sectors, in response to the challenges facing agriculture in the kingdom, such as water scarcity and climate change. This focus is reflected in the adoption of innovative technologies and modern strategies aimed at developing agriculture and ensuring the continuity of food production. The kingdom is thus undergoing a major transformation in the use of modern

agricultural technologies to improve crop productivity and preserve natural resources (Nabil, 2024), Among the smart agriculture techniques employed in Saudi Arabia are the following: (https://almaraiksa.com/blog/saudi-leads-middle-east-agriculture-technology?)

Hydroponic Agriculture: Hydroponic agriculture is one of the most widely used techniques in Saudi Arabia. It involves growing plants without soil, using nutrient solutions. This method reduces water consumption and promotes rapid plant growth, making it an ideal solution in a desert environment where water resources are limited.

Vertical Farming: Vertical farming allows the use of small urban spaces to grow multiple types of crops on stacked layers. This technique is a notable example of optimizing both space and water, enhancing agricultural production while reducing resource consumption.

Use of Solar Energy in Agriculture: Saudi Arabia makes extensive use of solar energy in agricultural activities to power irrigation systems and other farming operations. These solutions help reduce reliance on traditional energy sources and lower operating costs, thereby enhancing the sustainability of the agricultural sector.

Use of Artificial Intelligence in Crop Management: Artificial intelligence is used in agriculture to improve crop management by monitoring climatic and soil conditions. This enables farmers to make data-driven decisions, increasing production efficiency and reducing crop losses.

Desalination of Water for Agricultural Purposes: Saudi Arabia relies heavily on seawater desalination to meet agricultural needs, particularly in desert areas facing water scarcity. This technique makes it possible to practice agriculture in environments previously considered non-arable.

Smart Farms: Smart farms rely on technologies such as the Internet of Things (IoT) to monitor agricultural conditions, including soil, climate, and humidity. These technologies help improve the use of agricultural resources and increase productivity.

Use of Organic and Enhanced Fertilizers: The "Almarai Fertilizers" plant is one of the main contributors to the development of the agricultural sector, providing a wide range of organic and enhanced agricultural fertilizers, such as "Almarai Fertilizer," "Peatmos National," and "Enhanced Agricultural Fertilizer." These products meet the needs of farmers aiming to improve soil fertility and increase crop productivity, thereby directly contributing to strengthening agricultural sustainability.

Creation of Digital Platforms: Among the best agricultural applications in Saudi Arabia is the "Murshidik Al-Zira'i" (Your Agricultural Advisor) app, an integrated platform that allows farmers, landowners, and agriculture enthusiasts to ask questions and receive specialized answers directly from certified engineers and experts in various agricultural fields. It covers all stages, from land preparation to harvest, using artificial intelligence technologies, and also provides additional services such as weather forecasts, central market data, and livestock advisory service, The application has established itself as one of the leading digital service platforms in the region, receiving multiple awards, including the **"**Arab Digital Government Shield**"** for the best Arab application, the United Nations Friends Union Award for sustainable development, and an ISO quality certification. Since its launch, it has achieved remarkable milestones: over 6.4 million technical consultations provided to farmers, more than 282,000 registered farmers, 441 specialized advisors, and over 1.5 million voice calls handled. (Ministry of Environment, Water, and Agriculture)

5. Conclusion

The adoption of smart agriculture methods constitutes an important solution to enhance agricultural productivity and ensure the sustainability of resources in Arab countries. Thus, investing in digital infrastructure and adopting modern technologies such as precision agriculture, smart irrigation, and the Internet of Things form an essential foundation for addressing food security challenges and bridging the food gap. Consequently, we have reached the following results:

- The adoption of smart agriculture technologies makes it possible to increase agricultural productivity, reduce resource waste, and strengthen the sustainability of agricultural systems.

Among the main causes of the food deficit in Arab countries are low local agricultural production, rapid population growth, and dependence on imports.

- Arab countries rely on importing a wide range of agricultural products, particularly cereals, which account for 48.08% of the food gap.
- The Arab world possesses significant agricultural potential that qualifies it to achieve sustainable food security, provided that greater attention is given to the agricultural sector.
- Smart agriculture represents a promising strategic choice for achieving food security in Arab countries, especially in light of growing challenges related to climate change, water scarcity, and heavy dependence on food imports.
- There are disparities among Arab countries regarding the level of adoption of modern agricultural technologies. The United Arab Emirates and Saudi Arabia are among the most advanced countries in using smart agriculture technologies, due to the particular attention these two states have given to investment in this field.
- Arab countries face numerous challenges in implementing smart agriculture technologies, including weak communication and internet infrastructure—particularly in rural areas—the high cost of technological equipment imported from developed countries, the limited use of such technologies by farmers, and the inefficiency of agricultural policies, among others.

We propose the following recommendations:

- The need to rely on self-sufficiency in the production of basic food commodities in order to ensure sustainable food security and reduce dependence on imports.
- Develop national and regional strategies for the implementation of smart agriculture within the framework of sustainable agricultural development plans.
- Increase investments in agricultural technologies and supporting digital infrastructure.
- Support scientific research and innovation in the field of modern agricultural technologies, while giving special importance to the training of human resources.
- Encourage partnerships between the public and private sectors for the transfer and localization of agricultural technologies.
- Strengthen joint Arab cooperation to address environmental and food challenges through regional integration projects.
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6. References

Ben Chaâa, N & Hadri, D. (2023) Smart Agriculture and the Requirements for Its Application to Achieve Food Security Sustainability in Arab Countries, Journal of North African Economics, 19 (31), 2023.

Bouchnafa, F. (2023) Climate-Smart Agriculture as a Strategic Approach to Achieve Agricultural Development and Food Security Sustainability in Algeria (2014–2020): Reality and Need for Reform, Journal of Business and Trade Economics,. 8 (1).

Harfouche, Z & Ben Atta Allah, A. (2024) Attempt to Use Smart Agriculture Applications as a Mechanism to Develop Agricultural Production in Algeria, Journal of Finance, Investment, and Sustainable Development, 9 (1) 1.

Siyari, N & Jebali, H. (2023) Smart Agriculture as a Future Bet for Agricultural Development and Food Security – Challenges and Prospects, Al-Basair Journal for Research in Economic, Commercial and Management Sciences, 2 (1).

Moqaddam, N & Fares, T. (2023) The Move Toward Smart Agriculture to Achieve Food Security in Arab Countries: With Reference to Successful Arab Experiences, Journal of International Economics and Trade, 5 (1).

Mohamed El-Saghir, Mohamed, K. (2024) The Role of Climate-Smart Agriculture in Mitigating the Impact of Climate Change on Egypt's Agricultural Sector, Journal of African and Nile Basin Studies and Research,. 8 (2).

Akroud, S. (2022) Food Security: The Problem of Defining the Concept and Its Dimensions, Ma'alim Journal for Media and Communication Studies, 4 (2).

Smart Agriculture: The 7 Most Important Use Cases to Know in 2024. Retrieved from https://www.mokosmart.com/ar/iot-in-agriculture/. Accessed on 20/05/2025.

Farmonaut – Enhancing Agricultural Productivity: Modern Technologies for Satellite Monitoring and Farm Management. Retrieved from https://farmonaut.com/africa . Accessed on 25/05/2025.

Farming Robots: The Smart Future of Agriculture. Retrieved from https://worldofplants.ai/farming-robots/. Accessed on 25/05/2025.

Al-Hayari, I. The Concept of Food Security. Retrieved from https://mawdoo3.com Accessed on 11/05/2025.

Yahia, A. Smart Agriculture as a Strategic Choice in Algeria. Retrieved from https://www.independentarabia.com/node/549711/. Accessed on 02/06/2025.

Hammoud, A. Innovative and Smart Agriculture in the UAE: Steps Toward a Sustainable Future. Retrieved from https://woogarden.com. Accessed on 10/06/2025.

Reda, N, Smart Agriculture in the Kingdom: Saudi Leadership Toward a Sustainable Future, Retrieved from https://www.tech-mag.net/. Accessed on 15/06/2025.

How Saudi Arabia Leads the Middle East in Agricultural Technology. Retrieved from https://almaraiksa.com/blog/saudi-leads-middle-east-agriculture-technology. Accessed on 20/07/2025.

Ministry of Environment, Water and Agriculture (Saudi Arabia). Retrieved from https://www.mewa.gov.sa/ar/MediaCenter/News/Pages/News12842020.aspx. Accessed on 15/07/2025.

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