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Requirements for achieving sustainable agricultural development in Algeria through capitalizing on the Dutch experience

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ABSTRACT

This study aims to highlight the ways through which Algeria can benefit from the strengths of the Dutch agricultural experience, which is considered a leading global model in the agricultural sector. Despite its limited land area and natural resources, the Netherlands has managed to achieve high agricultural productivity and become one of the world's leading exporters of agricultural products. This success is mainly attributed to its reliance on technological innovation, the development of smart agriculture, and the efficient use of energy and water.

The study concludes that Algeria can emulate the Dutch experience in certain technical and technological aspects such as greenhouse farming, the digitalization and governance of the agricultural sector, while adapting other aspects to suit its own needs and capabilities, such as the production of drought-resistant cereals. Achieving this requires the provision of several essential conditions, including the development of agricultural technological infrastructure, investment in energy and natural resource management, as well as a set of institutional and regulatory reforms that support the transition toward a more efficient and sustainable agricultural system.

Keywords: Sustainable Agricultural Development, Dutch Agricultural Experience, Agricultural Technological Innovation, Smart Agriculture, Soilless Agriculture, Agricultural Development in Algeria.

1. INTRODUCTION

Adopting sustainable development models has become an imperative necessity to address various economic and environmental crises. Sustainable agricultural development is a fundamental element in achieving development and ensuring food security. The goal is no longer merely to increase production, but to ensure its continuity for future generations by balancing economic efficiency, social equity, and the preservation of natural resources.

For Algeria, advancing the agricultural sector is a strategic choice for liberation from oil dependency and achieving food security. Despite the available natural and human resources, the path toward sustainability still faces technical and organizational obstacles. This highlights the importance of benefiting from leading international experiences. The Dutch experience is among the most inspiring, as the Netherlands, despite its small geographic area, has become the second-largest exporter of agricultural products in the world thanks to technical innovation and water resource management. However, applying the results of the Dutch experience to the Algerian reality requires identifying the essential requirements that ensure adapting that success to the local environmental context, whether from a technological or institutional perspective.

Based on the above, the following research question can be posed: How can Algeria benefit from the Dutch agricultural experience to develop its agricultural sector while achieving sustainable agricultural development?

To answer this question, the research has been divided into two main sections:

- Section 1: Theoretical Framework of Sustainable Agricultural Development and the Reality of the Agricultural Sector in Algeria.
- Section 2: The Dutch Experience and Its Role in Achieving Sustainable Agricultural Development.

2. Theoretical Framework of Sustainable Agricultural Development and Agricultural Sector Reality in Algeria:

This section will address the general concepts of sustainable agricultural development, with a focus on highlighting the current state of the agricultural sector in Algeria

2.1. Concept of Sustainable Agricultural Development:

Before defining sustainable agricultural development, it should be noted that most references consider the concept of sustainable agricultural development synonymous with sustainable agricultural development, which is the most commonly used terminology, especially in most Arab countries. Therefore, the two terms will be considered interchangeable, representing the development of agricultural and livestock production.

2.1.1. Definition and Characteristics of Sustainable Agricultural Development:

Sustainable agricultural development represents the process of improving productive efficiency in the means of production and marketing of agricultural products. Among its main objectives is diversifying the economic base by increasing and developing the productivity of the agricultural sector, or more precisely, the optimal use of agricultural resources and improving individual incomes through the establishment of specialized farms and creating integration between the agricultural and industrial sectors (Al-Swaidawi, 2020, p. 99).

The definitions of agricultural development have been multiple. It has been defined as the management and maintenance of the natural resource base adapted to technical and institutional change, ensuring the satisfaction of human needs on a continuous basis for both current and future generations by promoting agricultural development in the sectors of agriculture, forestry, and soil conservation, preserving forests, water, and genetic diversity of plants and animals, without harming the natural environment and with social acceptance and economic applicability (Mohammed, 2023, p. 47).

It has also been defined as a vision with dimensions broader than the category of production and consumption, aiming to take into account the environmental aspect and how to manage and preserve it in a manner that meets the needs of the present generation without compromising the ability of future generations to meet their needs. Thus, sustainable agricultural development becomes a process aimed at improving agricultural production in quantity and quality to achieve food security and reduce import dependence, while being concerned with the maintenance of resources and the improvement of their use to ensure the continuity of their production for current and future generations (Al-Swaidawi, 2020, p. 128).

From the previous definitions, the most important characteristics of sustainable agricultural development can be extracted as follows:

- It is characterized by comprehensiveness and integration by linking environmental protection, economic viability, and social equity;
- It is characterized by high efficiency in resource use to reduce waste and achieve maximum possible productivity with minimum resources;
- It is characterized by temporal continuity without damaging the future of the land or the needs of future generations;
- It preserves biological diversity of plants and animals;
- It is considered environmentally friendly as it relies on ecological balance and minimizes chemical pollutants.

2.1.2. Objectives of Sustainable Agricultural Development:

Sustainable agricultural development has many objectives, which can be summarized as follows (Salem, 2011, p. 63):

- Achieving food security for citizens by providing their needs now and in the future;
- Maximizing the agricultural sector's contribution to the formation of gross domestic product;
- Securing the requirements of light processing industries;
- Contributing to raising the standard of living of all members of society.

2.1.3. Elements of Sustainable Agricultural Development:

There are many elements that form the basis of sustainable agricultural development, which can be summarized in the following points (Amira, 2016, p. 136):

- The availability of legislative conditions that support sustainable agricultural development;
- The existence of an appropriate resource base to meet the requirements of sustainable agricultural development;
- The availability of qualified human resources to undertake the responsibilities of sustainable development;
- The necessity of private sector and civil society participation to achieve sustainable agricultural development;
- The provision of required financing to achieve sustainable agricultural development.

2.2. The Agricultural Sector Reality in Algeria and Its Obstacles:

Through this section, the main elements of the agricultural sector will be addressed, as well as its contribution to the total domestic product, in addition to highlighting the main challenges and obstacles facing the development and effectiveness of this sector in achieving sustainable development.

2.2.1. Elements of the Agricultural Sector and Its Contribution to Gross Domestic Product:

Algeria possesses considerable agricultural potential that can be utilized to promote sustainable agricultural development. Through this framework, the extent of the agricultural sector's contribution to increasing the size of gross domestic product will be demonstrated according to the latest statistics.

A. Natural Potential and Distribution of Agricultural Land:

The agricultural sector is considered a main sector in Algeria and a fundamental pillar of the national economy due to its contribution to employment and gross domestic product. According to the ministry's website, it employs approximately 2.6 million agricultural workers, representing more than 74% of the rural labor force and 24% of the national workforce.

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Moreover, it ensures the country's food security by covering more than 74% of national agricultural product needs. Algeria occupies a geographical area of 238,174,100 hectares and is characterized by natural diversity. The total agricultural area is estimated at 48.1 million hectares, with arable agricultural land of approximately 8.6 million hectares, of which 1.47 million hectares are irrigated, while forest areas are estimated at approximately 4.1 million hectares (Algerian Investment Promotion Agency, 2025).

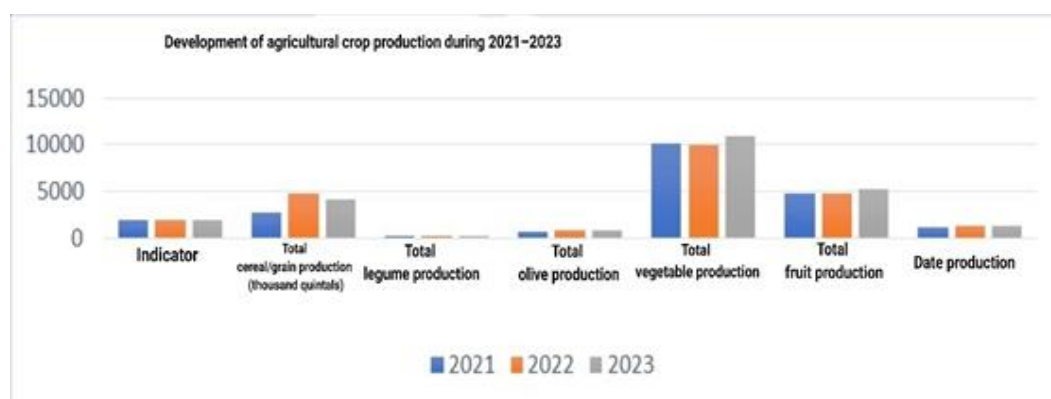
Livestock wealth in Algeria is considered one of the fundamental pillars of food security and the national economy, contributing significantly to gross domestic agricultural product. Livestock in Algeria is concentrated mainly in the steppes and pastoral areas, with sheep constituting the largest share, followed by goats, cattle, and camels in desert areas. The Algerian steppes region is an important supporter of the agricultural sector through achieving integration between agricultural activity and livestock breeding. It covers 25 provinces and occupies an area of 32 million hectares, representing 14% of Algeria's total area, and contains more than 23 million head of sheep and 4 million head of goats, contributing 42% of the added value of the national agricultural sector. The pastoral system faces natural and human challenges, including the exacerbation of drought phenomena and the decline in vegetation cover, as well as overgrazing, which has led to loss of environmental balance and rangeland degradation. Since 2000, public authorities have adopted steppe rehabilitation programs that included protecting pastoral land, improving water and energy infrastructure (Ministry of Agriculture, Rural Development and Fisheries, 2026). For clarification, Tables 1 and Figure 1 below can be presented.

Table 1: Development of Agricultural Production in Algeria during 2021-2023.

Indicator	2021	2022	2023
Total Livestock Count	38,338.51	38,510.80	27,227.61
Total Grain Production (Thousand Tons)	2,783.27	4,717.64	4,207.28
Total Legumes (Thousand Tons)	98.44	100.21	84.54
Total Olive Production (Thousand Tons)	704.62	822.27	925.65
Total Vegetable Production (Thousand Tons)	10,106.68	10,021.24	10,935.46
Total Fruit Production (Thousand Tons)	4,728.366	4,829.287	5,218.49
Date Production (Thousand Tons)	1,178.80	1,287.40	1,324.77
Modern Irrigation Usage	755.12	396.08	396.08

Source: Arab Organization for Agricultural Development, 2025.

Figure 1: Development of agricultural production in Algeria during the period 2021 and 2022.



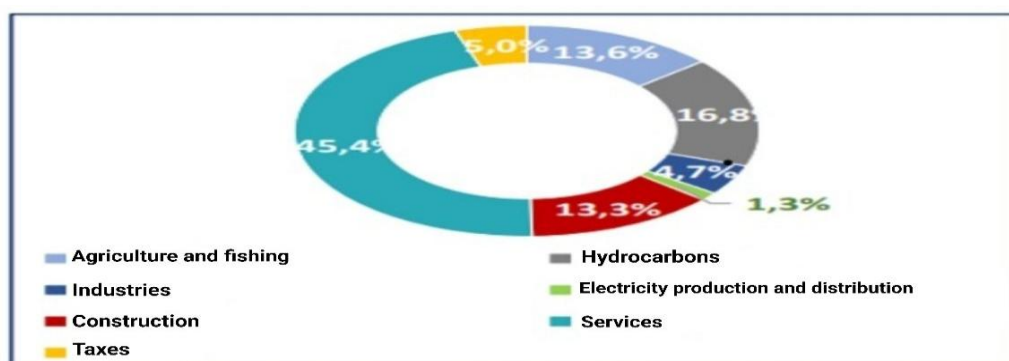
Source: Prepared by the researchers using the data shown in Table 1

From the table and graph above, we observe that vegetables and fruits maintained relatively stable production levels in terms of quantity, with a slight increase recorded in 2023. Cereals experienced significant growth in 2022 compared to 2021, with a slight decline in 2023, but remained higher than 2021 levels. Olive and date production remained relatively stable over the three-year period, with an average of approximately 12 thousand tons. Legume production is the least produced category compared to other crops, with an estimated 85 thousand tons in 2023.

B. Agricultural Sector's Contribution to Gross Domestic Product:

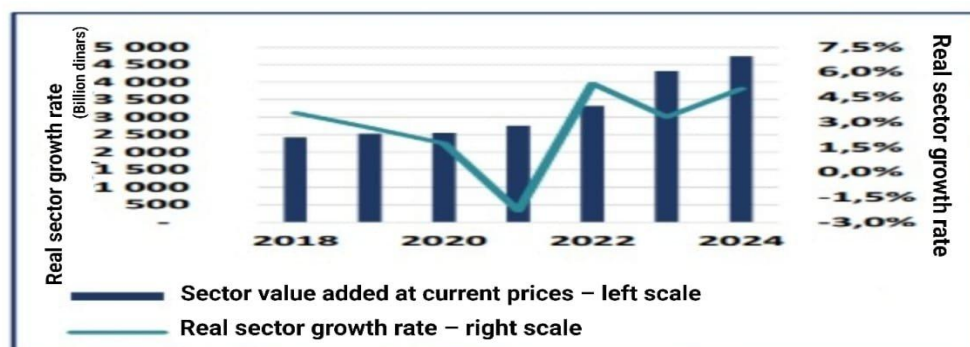
The agricultural sector plays a significant role in increasing gross domestic product in Algeria. According to the annual report of the Central Bank of Algeria, agricultural production growth has shown marked increase. After reaching 2.9% in 2023, it increased to approximately 5.1% in 2024, contributing 0.83 percentage points to overall growth outside hydrocarbons. The sector maintains its second position after the services sector compared to 2023. It should be noted that increased rainfall in 2024 contributed to increased investments in the agricultural sector. This can be illustrated through the following charts:

Figure 2: Main Sectors in Algeria's Gross Domestic Product during 2024



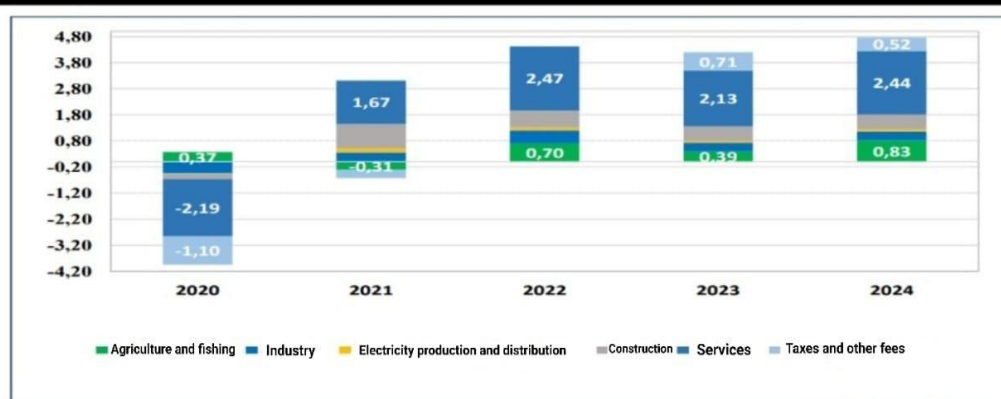
Source: Bank of Algeria, 2025, p24.

Figure3: Growth of the Agricultural Sector in Algeria



source: Bank of Algeria, 2025, p. 25.

Figure 4: Contribution of Major Sectors to Gross Domestic Product Growth outside Hydrocarbons Percentage



Source: Algeria, 2025, p. 25.

From the three figures above, we observe that the relationship between agricultural production growth and total domestic product growth is direct. The more agricultural production grows, the more total domestic product growth increases, as it contributes approximately 13.6%, which is a percentage close to the contribution of the hydrocarbon sector at 16.8%. When it declined in 2021, it had a clear impact on the growth rate of total gross domestic product outside the hydrocarbon sector. This demonstrates its central role in achieving growth outside the hydrocarbon sector and reflects the success of the economic diversification strategy in transforming agriculture from a traditional activity sector into a productivity driver that ensures food sovereignty, supports the national economy, and enables it to create sustainable wealth away from oil market volatility.

2.2.2. Financing Policy for Promoting the Agricultural Sector in Algeria:

Algeria has made considerable efforts to promote the agricultural sector. Among the financing policies it has adopted are two types of loans, according to the 2008 Agricultural Development Law for farmers and livestock breeders, whether individually or organized in cooperatives, groups, associations, unions, agricultural units, or storage warehouses for widely

consumed agricultural products. The content of these loans can be summarized as follows (Ministry of Agriculture, Rural Development and Fisheries, 2026):

First: The Companion Loan (loan Al-Rafiq):

This is a fully subsidized seasonal loan aimed at financing the annual production cycle. The supervisory ministry covers interest at a rate of 0%. The main beneficiaries are farmers and livestock breeders (individual or cooperatives), model farms, and economic institutions. The repayment period ranges from 6 to 24 months. Among its main types are the seasonal loan, designated for acquiring basic inputs (seeds, fertilizers, pesticides, feed), and the Federal loan, directed toward dealers and cooperatives to finance storage activities, industrial transformation (tomatoes, milk, cereals), and export of products such as dates and olive oil.

Second: The Challenge Loan (loan Al-Tahaddi):

This is a long-term investment loan designated for creating new investments or developing and expanding existing ones. It features a progressive interest subsidy system based on project duration. The main beneficiaries include private investors, model farms, and economic institutions concerned with utilizing undeveloped lands.

2.2.3. Obstacles Facing the Agricultural Sector in Algeria:

The agricultural sector in Algeria faces a range of obstacles that can be summarized in the following points:

- Fluctuation of rainfall, especially during recent years in Algeria, and decline in dam and groundwater levels;
- Desertification and soil erosion, which are among the most serious threats caused by sand encroachment in plateau areas and vegetation cover loss due to overgrazing and climate change (Selim, 2019, p. 263);
- Overlap in land ownership patterns (communal lands, private property, state property) leading to legal disputes that impede long-term investment;
- Weak mechanization that improves production returns and lack of innovations directed toward the agricultural sector;
- Shortage of cold storage facilities and warehouses, leading to loss of large quantities of crops;
- Unjustified increase in feed prices and materials used in agricultural production, leading to reduced profit margins for small farmers and loss of interest in investment or sector entry;
- High cost of production equipment and acquisition costs with relative scarcity, especially harvesting machinery.

3. The Dutch Experience and Its Role in Achieving Sustainable Agricultural Development:

The Dutch experience is considered one of the most successful and surprising experiences. This nation did not possess the minimum requirements for advancing its agricultural sector, unlike Algeria with its vast areas and relatively diverse and moderate climate. However, through science, political will, and the convergence of public and private sectors and civil society, it has achieved record-breaking numbers and secured the best positions in agricultural production. Therefore, this section will discuss this successful experience and how lessons can be extracted from it to achieve similar sustainable agricultural development in Algeria.

3.1. Historical Overview of the Dutch Agricultural Experience:

The Netherlands is a small country with high population density and relatively scarce land areas. Consequently, strict regulations were enacted for their implementation (Leila, 2019, p. 9). Its experience began centuries ago when one-fifth of the country was submerged in water. The Dutch built dikes and used windmills to pump water out, creating land from the sea. However, the real transformation came after World War II in the winter of 1944 when food supplies were cut off from the country and more than 20,000 people died of hunger in what became known as the Hunger Winter. From that time onward, there was a unified national goal under the slogan “We will never starve again”. The government transformed agriculture into a national project. Through concentrated efforts and cooperation between universities and changing public mentality, the Netherlands won the second-largest position globally in terms of the value and quantity of agricultural exports, exporting goods worth 140 billion dollars in 2024 (CNN Economics, 2024).

3.2. The Role of Universities and Research Centers in Achieving the Dutch Agricultural Miracle:

Wageningen University is considered the best scientific center specializing in agricultural sciences in the world according to several global indicators. This university encompasses several specializations, including the Department of Animal Sciences. The Netherlands also has a national center for agricultural and food research and development employing more than 6,500 employees and hosting 120,000 students from more than 100 countries worldwide in the fields of healthy food and living environment for governments (Rasha and Boutiba Mourad, 2023, p. 115). The government supports joint initiatives between public and private sectors. Among the prominent research achievements of Wageningen University are the innovation of soilless agriculture technology and the development of modern techniques for banana cultivation in greenhouses. It also conducted research on new grazing patterns and developed advanced agricultural standards for dairy producers within and outside the Netherlands (Qaddash, 2025).

3.3. Fields and Techniques of Agricultural Technology Use in the Netherlands:

The fields of agricultural technology use have diversified due to encouragement of scientific research and the use of artificial intelligence techniques to improve production in quantity and quality in the Netherlands. These can be summarized as follows:

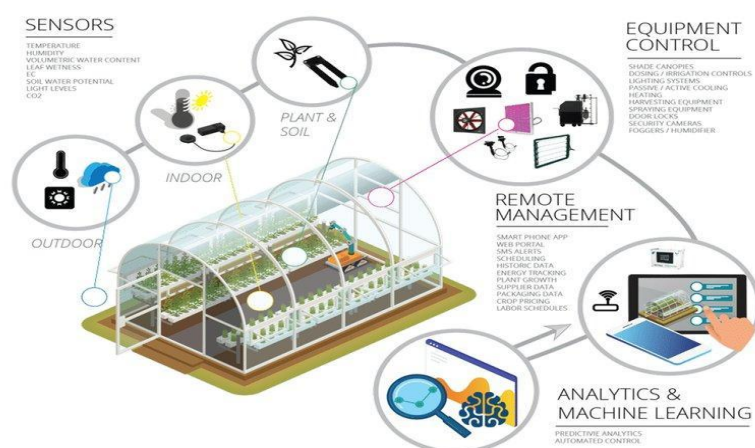
3.3.1. Precision Agriculture:

This is an agricultural system that relies on data collection and analysis for the purpose of managing agricultural fields with extreme precision, treating each field section or individual plant according to its needs, ensuring appropriate fertilizer allocation and directed irrigation, weed control, and thus increasing yields. It also contributes to reducing costs, lowering emissions, and improving compliance with new regulations (Precision Agriculture, 2026).

3.3.2. Smart Greenhouse Agriculture (Horticulture) and Soilless Cultivation:

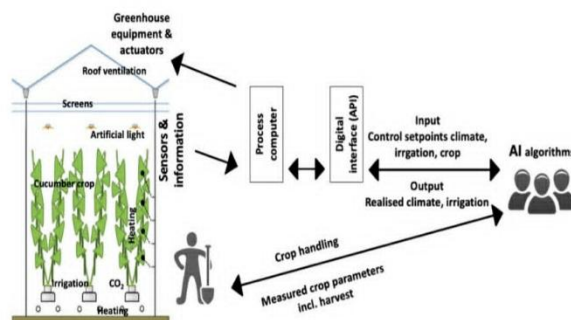
Greenhouse agriculture relies on establishing modern, high-tech greenhouses equipped with actuators to control the internal climate conditions, ensuring good plant growth, while sensors continuously collect data to send it to a control loop (Hemming, 2019, p. 1). This technology aims to achieve efficiency in resource use and produce crops, especially those that cannot be grown in the Dutch climate known for extreme cold. It provides artificial conditions that may be better than natural conditions for cultivating plants such as tomatoes and cucumbers. The following two figures illustrate how plants are cared for under artificial conditions inside greenhouses.

Figure 5: Artificial Conditions for Plant Growth Inside Greenhouses



Source: <https://www.mdpi.com>.

Figure 6: Artificial Conditions for Cucumber Plant Growth Inside Greenhouses



Source: Hemming s, Remote Control of Greenhouse Vegetable Production with Artificial Intelligence—Greenhouse Climate, Irrigation, and Crop Production, 2026, p04.

According to a Wageningen University report, greenhouses in the Netherlands cover approximately 10,000 hectares and contribute more than 30% of agricultural income, reflecting the importance of greenhouse agriculture in terms of productivity ratio, whether in quantity or quality. Soilless agriculture, or hydroponic agriculture, involves growing plants in water instead of soil. There are other forms of soilless cultivation, such as aeroponic agriculture, where plant roots grow in the air and are sprayed with a mist containing nutrients, allowing increased oxygen absorption and accelerating growth (Karim Jaber, 2013, p. 2).

However, In cultivation using inert media, materials such as rock wool and coconut fibers are used to anchor roots, while plants receive nutrients through a precise irrigation system. Almost all greenhouses in the Netherlands use soilless agriculture systems due to their benefits, which include saving up to 50% of water and fertilizers, obtaining abundant and better-quality crops, and allowing farmers to start with disease-free crops. Techniques such as NFT (nutrient film technique) or DFT (deep flow technique) are commonly used in leafy crops, where the nutrient solution continuously circulates. Studies have shown that soilless agriculture systems are viable for recycling nutrient solutions, with a prototype designed to reuse solutions drained from tomato crops for irrigating secondary crops, resulting in a 14% increase in spinach yield and improved nitrogen and phosphorus use efficiency by 50% (Gruda, 2023, p. 2).

3.3.3. Indoor Vertical Agriculture and Seed Development :

Plants are cultivated in tiers, one above the other, inside a controlled, closed environment. Special lights are used to provide plants with necessary light, and all conditions they need are controlled through robots, nutrients, and ambient temperature control. The Netherlands uses this type of agriculture due to its limited land allocated to agricultural areas and to provide more suitable conditions that natural outdoor climate may not provide (Najah, 2025, p. 112). Large Dutch companies such as Enza Zaden annually develop hundreds of new seed varieties in northern Netherlands, maintaining a global seed bank to address diseases, climate changes, and all emergencies (Al-Gharbawy, 2025).

3.3.4. Robots, Smart Machinery, and Digital Twin Technology for Artificial Intelligence:

Robots and automation assist farmers and agricultural companies in reducing labor intensity and increasing production efficiency while achieving more sustainable growth. Robots can be used directly in greenhouses and in fields for tasks such as removing weeds and harvesting broccoli and fruits, as well as self-driving tractors or drones. It should be noted that the market value of agricultural robots and machinery in the Netherlands is 80 million U.S. dollars. In 2025, the Netherlands enacted a digitalization law in agriculture that set standards for deploying digital systems, data security requirements, and equipment approval and operational safety (Shubham, 2025).

The concept of digital twins emerged in product management contexts. In this field, the need arose for a product management system containing all product information throughout its lifecycle, made available to all users. Digital twin technology can be achieved through the Internet of Things, which provides information about plants through a digital model (virtual twin) allowing monitoring, control, and prediction (Verchur, 2022, p. 199) by simulating the agricultural environment and continuously analyzing data.

3.3.5. Digital Agricultural Supply Chains:

The TNO organization (Dutch Organization for Applied Scientific Research) has worked for years to make agriculture more sustainable. Sustainable agriculture (circular agriculture) will only succeed in reality through the cooperation of all parts of the production chain, starting from the farmer, reaching the buyer, then the retailer, and finally the consumer. Thanks to data and technology, all parties can achieve significant gains by digitalizing the largest number of processes in the agricultural production chain. Examples of digital supply chains include the Lokalist platform, a next-generation digital platform that helps Dutch farmers more easily access consumers and local companies with joint financing from the European Agricultural Fund for Rural Development. This project promotes local food systems by making short supply chains more viable, efficient, and professional, thus contributing to the model's role in reducing transport emissions, lowering costs, and increasing transparency throughout the supply chain (European Broadband Competence Offices Network Sup, 2025).

3.4. Lessons Learned from the Dutch Experience:

The Dutch experience has proven to be an integrated experience in terms of strategies and methods used to achieve agricultural development and ensure its sustainability. Lessons that can be extracted from it are as follows:

- Development of agricultural productivity returns despite limited available Dutch land areas through exploiting urban spaces;
- Precise control over plant nutrients and external conditions for growth, which increases productivity;
- Crop production occurs throughout the year without being affected by climatic conditions;
- Ability to predict agricultural problems;
- Achieving food self-sufficiency resulting from the development of plant and animal varieties and seed management.

4. Requirements for Achieving Sustainable Agricultural Development in Algeria Based on the Dutch Experience:

The Dutch experience serves as an ideal and inspiring model for Algeria, particularly in light of increasing climate challenges and water scarcity. Despite Algeria's vast areas and

abundant natural resources, it does not achieve efficiency in resource utilization, which the Netherlands has excelled at by following the principle “maximizing production on minimum land with minimal resources.” To achieve sustainable agricultural development in Algeria and adapt it based on the Dutch model, the following requirements must be met:

4.1. Technical Requirements :

What Algeria needs to reduce resource waste is transitioning from an abundance system to achieving efficiency. The Dutch sustainable experience relied on “precision agriculture” that allows managing fields with extreme precision in responding to plant needs, allocating appropriate fertilizers to each plant in a single field or following these techniques to ensure increasing yields in quantity and quality;

- Modernizing irrigation systems, meaning radical transition from traditional irrigation to smart irrigation and adopting directed drip irrigation systems, using evaporation-resistant techniques especially in desert and semi-arid areas to avoid water scarcity problems;
- Protected and smart agriculture: generalizing advanced plastic greenhouses with automatic humidity and heat control, allowing productivity to increase tenfold compared to open-field agriculture;
- Soil management through using digital sensors to precisely measure soil needs for fertilizers, reducing groundwater contamination with chemicals and preventing waste of funds.

4.2. Institutional Requirements:

This can be achieved through activating the Algerian “golden triangle” because Dutch success was not merely technical but also organizational. In Algeria, the requirement is to build a sturdy bridge between:

- Universities and research institutes such as the National Institute for Agricultural Research to develop locally-sourced seeds resistant to drought and salinity and to find innovative solutions for agricultural development;
- The state by providing banking facilities and directing support exclusively to projects adopting sustainability standards in areas such as water-efficient irrigation and solar energy, etc.;
- Farmers and private sector by encouraging private investment in processing industries near farms to reduce post-harvest losses, educating farmers on modern techniques for drip irrigation, fertilization, and pest control.

4.3. Environmental and Energy Requirements :

- Sustainability requires tilling the land without depleting it by rotating crops annually and measuring soil productivity for crop production each year;
- Integrating renewable energies by exploiting Algeria’s strong solar radiation to power water pumps and cooling systems in warehouses, reducing carbon footprint and costs;
- Water recycling through adopting wastewater treatment technologies and using treated gray water for irrigation, a Dutch specialty that can be transferred to Algeria;

- Integrated pest management by reducing reliance on imported chemical pesticides and replacing them with biological solutions (adopting organic fertilization) to preserve environmental balance.

4.4. Challenges and Barriers to Implementing Agricultural Technology in Algeria:

Implementing sustainable agricultural technology faces a range of challenges that must be addressed for successful execution and achieving desired results. These challenges include:

- Agricultural technology faces adaptation challenges to harsh environmental conditions for agriculture, including large temperature and humidity increases, prolonged sun exposure, and climate fluctuation. Cold severity is no longer confined to cold regions; we are now witnessing snow in deserts and drought with heat increases in rainy and moderate areas. Therefore, equipment must be designed to withstand all these changes;
- Integrating modern technology into traditional agriculture presents challenges, as converting old vehicles to modern ones, for example, requires integrating complex computing equipment into vehicle applications;
- High costs and complexity characterizing precision agriculture such as global positioning systems, drones, and data analysis programs pose challenges for farmers, especially small-scale project owners who struggle to afford these technologies, equipment, programs, and necessary training;
- Legal, ethical, and social barriers related to data ownership, privacy, and security leading to farmer hesitation in adopting techniques such as precision agriculture, necessitating clear guidelines and regulations for data management.

5. CONCLUSION:

In conclusion, replicating the Dutch model in achieving agricultural development does not mean literal imitation but rather adopting the philosophy of efficiency and localizing agricultural and environmental technology in accordance with local environmental conditions. Algeria possesses all the requirements (land, energy, geographic location, and suitable climate) to transform into a food-producing nation and a regional food basket, provided that agricultural innovation and scientific research become its priorities for developing the agricultural sector.

Key Findings :

- Digitalization and technology are the key: The Dutch experience proved that controlling data (climate, soil, water consumption) determines production efficiency and sustainability;
- The study showed that agricultural sector strength lies in linking university outputs, government policies, and farmers;
 - Necessity is the mother of invention: The Dutch experience proved that adaptation to environmental and climate conditions and environmental factors ensures progress and growth and achieving food stability, meaning that innovative solutions are often presented according to countries' needs.

Recommendations:

Based on the above findings, the following recommendations can be presented:

- The necessity of adopting climate-smart agriculture through investing in smart plastic greenhouses and advanced irrigation techniques to reduce water waste, especially in desert and dry areas;
- Establishing technology poles for agricultural development in southern and high plateau regions (as intensive production areas) to develop locally-sourced drought-resistant seeds and provide technological and knowledge support to farmers in those areas;
- Supporting startups in crop monitoring software development and investing in clean energy and its integration into agricultural production;
- Developing supply chains and logistics services by establishing advanced storage and cooling centers near farms and processing industry facilities near farms to reduce losses, lower costs, and protect the environment;
- Promoting agricultural sector governance and providing a regulatory environment encouraging adoption of modern agricultural technologies;
- Attention to animal breeds and breed development, especially those providing abundant production of milk and eggs, and benefiting from their waste through what is known as organic fertilization;
- Establishing relationships with countries like the Netherlands ensuring knowledge and technology transfer, opening the way for agricultural and horticultural development.

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