

Green finance as a mechanism for achieving food security under climate change: The case of Algeria

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Abstract---The agricultural sector represents a fundamental pillar of food security, especially in developing countries such as Algeria. However, it faces increasing climatic challenges, most notably the decline of water resources and land degradation. In this context, green finance has emerged as an innovative mechanism to support the transition towards sustainable and resilient agricultural systems. Green finance refers to the allocation of financial resources to projects that take environmental considerations into account, such as smart agriculture, modern irrigation systems, renewable energy, and the development of drought-resistant seeds. This research paper aims to identify the role of green finance in achieving food security in Algeria. The study concludes that, despite the efforts made by Algeria to achieve sustainable food security, it still suffers from the absence of an environmental orientation in banks' environmental products.

Keywords---Green finance, climate change, food security, agricultural sector, Algeria.

1. INTRODUCTION

The issue of food security has become one of the main global challenges, especially with the increasing population and the impacts of climate change that threaten global agricultural production. Despite the availability of natural and human resources in many countries, agriculture has not yet achieved the targeted increase to meet the growing demand for food. Algeria, like other countries, pays particular attention to this issue, as it has integrated food security within the 2030 Sustainable Development Goals.

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The challenges of achieving food security in Algeria are compounded by difficult environmental and climatic conditions, which require innovative and effective strategies. In this context, the importance of green finance emerges as a modern financing mechanism that not only aims to support the agricultural sector but also focuses specifically on projects that adopt sustainable agricultural practices. These practices reduce environmental impact and contribute to climate change adaptation. Instead of focusing on traditional agricultural investment, green finance provides the opportunity to fund projects such as drip irrigation, organic farming, or the use of renewable energy in farms, thereby enhancing the resilience and adaptability of the agricultural sector to climate challenges.

1.1 Research Problem

From this perspective, the main problem arises: ***How can green finance contribute to strengthening food security in Algeria under climate change?***

1.2 Research Questions

The following sub-questions fall under this main problem:

- ✓ What is the conceptual framework of green finance and food security?
- ✓ What is the impact of climate change on the agricultural sector and food security in Algeria?
- ✓ How is green finance directed towards the agricultural sector in Algeria?

1.3 Research Hypotheses

To answer the sub-questions posed, the following hypotheses can be formulated:

- ✓ Green finance contributes to strengthening Algeria's ability to achieve food security by supporting sustainable agricultural projects that adapt to climate change.
- ✓ Climate change in Algeria negatively affects agricultural productivity and increases the vulnerability of food security.
- ✓ Algeria suffers from a lack of adoption of green finance mechanisms directed at the agricultural sector, which limits opportunities for its development and the achievement of sustainable food security.
- ✓ Developing legislative and institutional frameworks to support green finance can increase investment in sustainable agriculture, positively reflecting on agricultural production and food security.

1.4 Research Objectives

This study aims to achieve two main objectives:

- ✓ To identify and analyze the reality of the Algerian agricultural sector under climate change and review the state's efforts in this field.
- ✓ To propose mechanisms and solutions for the effective use of green finance to address climate change challenges and strengthen sustainable food security in Algeria.

1.5 Previous Studies

- ✓ The study by *Jlaid Nour-Eddine and Lakhdar Rabal (2024)* aimed to examine green finance and its instruments (green bonds, green funds, and green investments) and its role in achieving the transition to a green economy and the Sustainable Development Goals. The study also reviewed the experience of the People's Republic of China as a leading country in this field. It concluded that China's green finance strategy and targeted projects led it to rank first worldwide in issuing green bonds. The study also highlighted the weakness of green finance in Algeria, which relies mainly on the state budget.
- ✓ The study by *Roqayya Haddadou* focused on highlighting the role of green finance as one of the tools of the green economy in achieving sustainable development, in addition to reviewing different sources of green finance and pointing out major eco-friendly projects in Algeria. The study concluded that, despite Algeria's efforts to achieve sustainable development through

green economy mechanisms such as environmental taxes and fees, it still suffers from the absence of an environmental orientation among banks in their financial products.

1.6 Research Methodology

To address the dimensions of the problem and derive results that serve the objectives of the research, the descriptive-analytical method will be adopted to describe and analyze the conceptual framework of green finance and food security, as well as to evaluate the reality of financial policies applied in Algeria to support the agricultural sector. Additionally, the prospective (deductive) method will be used to derive results and reach recommendations by analyzing collected data and proposing a future vision and action mechanisms to enhance the role of green finance in achieving food security in Algeria.

2. THE CONCEPT OF GREEN FINANCE

Green finance is a modern term that aims to direct resources toward projects and investments that take into account the environmental dimension and support sustainable development. It promotes eco-friendly economic activities to address climate change and enhance the resilience of economies, particularly in countries whose food security depends directly on agricultural activity, such as Algeria.

2-1 Definition of Green Finance:

- ✓ The **Organization for Economic Cooperation and Development (OECD)** defined green finance as: *“Financing for economic growth while reducing pollution and greenhouse gas emissions, minimizing waste, and improving the exchange and use of natural resources”*¹.
- ✓ The **German Development Institute** defines it as: *“Financing green investments, whether in the public or private sector, which include various fields such as financing the production of environmental goods and services, providing compensation for environmental losses and mitigating them, prevention measures such as dam maintenance, renewable energy generation, and financing public policies that encourage ecological agriculture and environmental projects”*².

2-2 Objectives of Green Finance

Green finance aims to achieve a set of objectives at the social, economic, and environmental levels, which can be summarized as follows:

- ✓ The conditional linkage between environmental considerations and the financial policies of governments and financial institutions stimulates environmental innovation. This, in turn, positively reflects on achieving social justice and community stability by improving quality of life, providing a clean and safe environment, and ensuring a more equitable distribution of economic and environmental resources³.
- ✓ Reducing poverty rates through the efficient use of natural resources, which enables the implementation of numerous eco-friendly projects that create new job opportunities, particularly in agriculture, energy, and transportation.
- ✓ Encouraging environmentally friendly investments to reduce greenhouse gas emissions and minimize waste. This also includes the effective management of environmental risks within the financial system⁴.
- ✓ Providing and increasing new job opportunities, especially in agriculture, energy, and transportation.
- ✓ Supporting the transition toward sustainable production processes by financing projects that aim to reduce energy and natural resource consumption, as well as limiting industrial waste and greenhouse gas emissions that cause global warming.

3. THE CONCEPT OF FOOD SECURITY AND ITS RELATIONSHIP WITH GREEN FINANCE

3-1 The Concept of Food Security

The definitions of food security have varied due to its great importance for all countries of the world. The most significant definitions include:

- ✓ *“The state in which every individual has access to essential food and can live free from malnutrition. It has become synonymous with national security, strategic security, and social security. Food security is achieved when a country’s food production is commercially organized, and citizens can be guaranteed sufficient food supplies throughout the year, whether in times of prosperity and abundance or during times of crisis”*⁵.
- ✓ The **Organization for Economic Cooperation and Development (OECD)** defines it as: *“Financing that targets economic projects which achieve a balance between financial returns and social and environmental impacts”*⁶.
- ✓

3-2 The Relationship between Food Security and Green Finance

Green finance represents a fundamental investment tool for enhancing food security under climate change. The close and interrelated link between them is clearly manifested in the following:

- ✓ Unlike traditional finance, **green finance links financial activity with environmental protection and climate change mitigation**, making it an important tool to support sustainable agriculture. It helps reduce the negative impact of extreme temperatures on the resilience of grain production in key production and balanced marketing regions. It also plays a crucial corrective role by mitigating the adverse effects of harsh climatic conditions on agricultural productivity, thereby indirectly strengthening food security⁷.
- ✓ **Islamic green finance** contributes to supporting and enhancing food security in the Organization of Islamic Cooperation (OIC) countries by promoting sustainable agriculture, empowering small farmers, and reducing the impacts of climate change. Instruments such as green sukuk, participatory financing, and green productive endowments can channel capital into projects that ensure long-term food security⁸.
- ✓ Green finance enhances farmers’ capacity to adopt **modern agricultural techniques and efficient production inputs** such as improved seeds, fertilizers, and pesticides, which contribute to increasing agricultural productivity and achieving food security⁹.
- ✓ **Reducing agricultural carbon emissions** is one of the most essential elements of agricultural sustainability required for long-term food security. Green finance contributes to this by lowering carbon emission intensity, resulting in less polluting and environmentally damaging production. This, in turn, helps preserve natural resources (soil, water, plant biodiversity), which are fundamental to food security¹⁰.
- ✓ Green finance serves as a **strategic tool to achieve food security**, especially in fragile states exposed to climate change, by funding climate-smart agriculture projects, improving natural resource management, and empowering local communities. It also enhances the productive capacity of local agriculture, reduces dependence on imports, and builds resilient and sustainable food systems.

4. CLIMATE CHANGE AND ITS IMPACT ON AGRICULTURAL PRODUCTION IN ALGERIA

As a result of the combined effect of significant changes and fluctuations in temperature and rainfall as illustrated in Table 01 agricultural yields are exposed to many potential direct and indirect impacts of climate change, affecting both crops and livestock products. It is also worth noting that the agricultural sector in Algeria consumes more than **60% of the available water resources**. Furthermore, the area of irrigated land is expected to increase to exceed **1,560,000 hectares by 2030**¹¹.

4-1 The Impact of Climate Change on Grain Production

Table 01: Annual variation in temperatures and rainfall in Algeria during

Years	2014	2015	2016	2017	2018	2019	2020	2021	2022
Temperature	°19.1	°18.8	°19	°19.1	°18.5	°18.9	°19.3	°19.4	°19.9
Rainfall (mm)	617.5	489.7	644.8	532.3	781.7	526.2	459.3	544.5	428.9

Source: Prepared by the researchers based on: <https://www.meteoblue.com/ar/climate-change>

Table 02: Evolution of Grain Production from 2010–2022 (kg/ha)

Years	2014	2015	2016	2017	2018	2019	2020	2021	2022
Production Quantity	1369	1400	1020	990	1952	1767	1520	1434	1610

Source: World Bank <https://data.albankaldawli.org/indicator/AG.YLD.CREL.KG?locations=DZ>

It is clear from the table that there is a significant variation in grain production in Algeria during the studied period, where it recorded its highest level in 2018 with **1,952 kg/ha**, coinciding with the highest recorded rainfall (**781.7 mm**) and the lowest temperature (**18.5°**) (Table 01) in the same year. In contrast, production reached its lowest level in 2017 with **990 kg/ha**, at a rainfall level of **532.3 mm** and a temperature of **19.1°** (Table 01) in that same year. Accordingly, we conclude that grain production in Algeria largely depends on rainfall.

4-2 The Impact of Climate Change on Livestock

- ✓ Livestock is directly affected by changes in water resources in Algeria, which is considered the second most water-scarce country in Africa after Libya. The exploitation rate of groundwater in the north of the country reaches **90%**¹². Studies show that the percentage of degraded land due to low rainfall ranges between **40% and 48%** in both Biskra and M'sila, and reaches **70%** in Djelfa. In addition, high-quality pastures do not exceed **2%** of the total area¹³.
- ✓ Several studies have confirmed that rising temperatures directly affect daily milk production in western Algeria by **17.6%**¹⁴.
- ✓ The drought of **2007–2008** had a major impact on herders, particularly in Laghouat Province, where **14%** of them lost their herds, while only **26.5%** of farmers (those with more than 50 sheep) managed to preserve most of their herds during the dry year. Meanwhile, **33%** of them managed to preserve fewer than 20 sheep¹⁵.
- ✓ Climatic fluctuations in Algeria force herders in the steppe regions to find alternative sources to continue their activities, particularly regarding animal feed, due to the decline of natural pastures which are no longer able to meet those needs¹⁶.
- ✓ Livestock, especially sheep, has experienced a sharp decline due to ongoing drought and rising feed prices, which have reached the equivalent of more than **USD 1,200**, an amount far exceeding the average monthly income in Algeria. To mitigate the crisis, the government decided to import **one million sheep** to meet the growing demand and avoid price hikes during Eid al-Adha. The following figure illustrates the evolution of the livestock production index in Algeria from **2014–2022**.

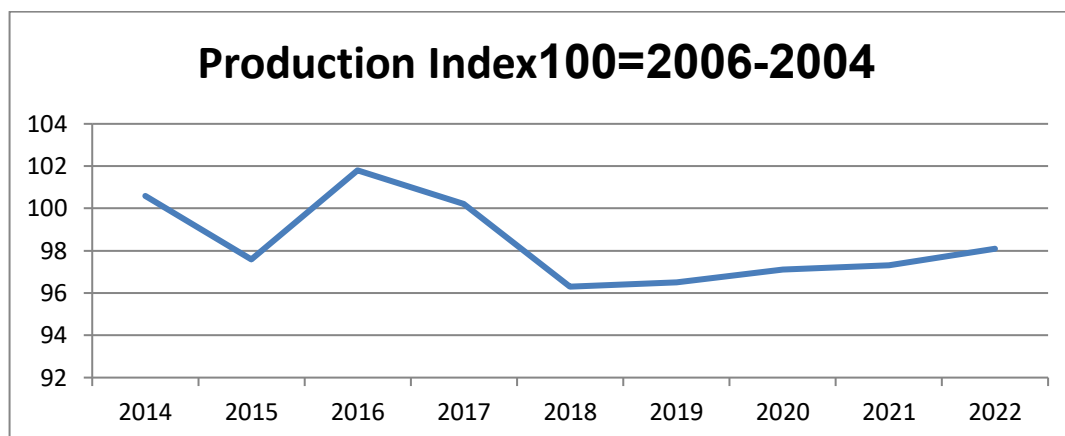


Figure 01: Evolution of the Livestock Production Index in Algeria from 2014–2022

Source: Prepared by the researchers based on data from the World Bank.

<https://data.albankaldawli.org/indicator>

5. MECHANISMS OF GREEN FINANCE TO ADDRESS CLIMATE CHANGE AND STRENGTHEN FOOD SECURITY IN ALGERIA

Green finance constitutes one of the fundamental pillars for achieving sustainable development in Algeria, especially in light of increasing environmental and climatic challenges. Accordingly, Algeria, like other countries around the world, has sought to transition toward a low-carbon economy by activating financing mechanisms that support environmentally oriented projects, particularly in vital sectors such as agriculture, energy, and water. The main mechanisms are as follows:

5-1 Local Mechanisms

- ✓ **Public Expenditure:** For years, Algeria has relied on the state budget to finance and manage infrastructure and agricultural projects. However, these allocations have been very limited, accounting for about **1.18% of GDP**, dropping to **0.84% during 1990–2000** due to the economic and political crisis experienced by Algeria during the same period, when the budget adopted an austerity approach ¹⁷.
- ✓ **Green Taxation:** Green taxation is defined as taxes imposed on polluters who cause environmental damage through their economic activities, either from their polluting products or harmful production techniques. Among the deterrent taxes in Algerian legislation is the tax on polluting or hazardous activities, where the unit amount of the tax is determined according to the provisions of Article 61 of the Finance Law of 2018, which amended Article 117 of Law No. 91-25 of 18 December 1991 ¹⁸.
- ✓ **Environmental Protection Funds:** Due to Algeria's shortcomings in implementing environmental programs, institutions were created to supervise this through financial funds, with the purpose of implementing the national policy for environmental protection and financing green projects to achieve sustainable development ¹⁹.
- ✓ **Financing through the Economic Recovery Support Program:** The Economic Recovery Support Programs gave significant importance to environmental protection. A total of **799 projects** related to environmental protection and urban planning were recorded, which can be summarized as follows ²⁰:
 - Protection of **2.5 million hectares** of steppe lands.
 - Pastoral agriculture covering an area of **60,000 hectares**.
 - Digging of **180 wells** and **330 water points**.
 - Afforestation of **13,000 hectares** and establishment of **1,100 km** of windbreak barriers.
 - Construction and maintenance of **2,360 km** of mountain and rural tracks and roads.

- Development of **10 public dumpsites** and **10 solid waste landfill centers**.
- ✓ **Financing through Local Public Loans and Government Support** ²¹: This mechanism is an important tool adopted by Algeria in its energy transition and green economy strategy. The state, through the Algerian National Bank, covers the financing of the first phase of the **3 GW solar energy program** at a cost of **413 billion DZD (approximately USD 3 billion)**. In addition, private financing contributes through independent power generation projects with a horizon to 2035, where private actors are responsible for the installation, financing, and operation of plants. National financial institutions also provide additional financing directed toward environmentally friendly projects. At the macro level, the state provides both public and private financing to mobilize the resources necessary for the success of energy transition projects, reflecting the political will to accelerate the shift toward a low-carbon economy.

Table 02: Evolution of Electricity Production from Renewable Sources (Excluding Hydropower) (kWh)

Years	2014	2015	2016	2017	2018	2019	2020	2021
Production Quantity	137 330 000	181 520 000	212 500 000	579 110 000	664 660 000	688 040 000	791 710 000	769 110 000

Source: World Bank: <https://data.albankaldawli.org/indicator/AG.YLD.CREL.KG>

From the table, we observe a steady increase in electricity production from renewable sources, which reflects the state's efforts to mitigate climate change through the mechanism of green finance. This has a positive impact on the agricultural sector and consequently contributes to achieving the goal of food security.

- ✓ **Green Banks:** Financial institutions that seek to strike a balance between economic growth and environmental protection by supporting green projects.

5-1 External Mechanisms

As a result of the high costs of financing green projects to protect the environment and achieve sustainable development, Algeria has sought to explore alternative external sources, among which are the following:

- ✓ **Green Climate Fund (GCF):** The Green Climate Fund is the world's leading fund in terms of financing capacity. Algeria benefited from funding of **USD 300,000 in 2019** to finance and implement a national plan against climate change, in addition to funding of **USD 3 million in 2022** to support the National Adaptation Plan, which represents an important step in strengthening the country's capacity to face climate change ²².
- ✓ **International Fund for Agricultural Development (IFAD):** The National Development Fund works on financing initiatives that enhance adaptation to climate change, particularly in rural areas. This support includes the restoration of alfa-grass steppes, the improvement of degraded rangeland management, as well as supporting youth employment in the agricultural sector. Within the framework of its national climate plan, Algeria has committed to reducing greenhouse gas emissions by **7% by 2030**, and to pursuing an energy transition to reduce reliance on hydrocarbons ²³.

6. PROSPECTS OF GREEN FINANCE AS A MECHANISM FOR ACHIEVING SUSTAINABLE FOOD SECURITY IN ALGERIA

Agriculture in Algeria is undergoing a radical transformation, as urban expansion, water scarcity, and climate change require innovative solutions aimed at achieving food security and reducing dependence on agricultural imports through sustainable practices and innovations supported by artificial intelligence. Among these techniques are:

- ✓ **Precision irrigation** using satellite sensor devices and AI-driven analytics to distribute water to the right crop areas at the right time, which is crucial given the arid, drought-prone environment. Sustainable irrigation systems, combined with AI-based weather forecasting, also help reduce the vulnerability of crops to climate fluctuations.
- ✓ **Sensing and monitoring technologies with drones**, which provide real-time assessment of soil health, moisture, and crop vitality. In addition, digital management platforms and blockchain solutions ensure the quality of agricultural products, track resources, and combat fraud in the supply chain.
- ✓ **Solar energy potential**, especially in desert areas, offers Algeria vast opportunities to launch large-scale projects such as the Hassi R'Mel Integrated Solar-Gas Power Plant. These can indirectly supply the agricultural sector with energy (e.g., solar-powered irrigation pumps or agrivoltaic systems).
- ✓ **Use of biochar (activated carbon)** as one of the modern agricultural techniques suitable for desert environments. Produced through the thermal processing of organic materials at temperatures above 400°C in the absence of oxygen, biochar is rich in carbon and provides multiple benefits for agriculture, especially in arid zones. It enhances soil fertility, improves physical properties, increases agricultural yield, and protects plants from certain soil-borne diseases. Furthermore, its carbon-rich structure allows it to remain in soil for thousands of years, making it an effective tool for carbon storage. This contributes to reducing global warming and climate change by lowering atmospheric CO₂ levels ²⁴.
- ✓ **The Green Dam Project and reclamation of arid lands**, one of Algeria's pioneering environmental projects, contributes to enhancing food security by combating desertification, protecting farmland, reducing temperatures, and increasing humidity ²⁵.
- ✓ **Organic farming**, which relies on natural methods and biological techniques to preserve soil fertility, plant health, and ecosystem diversity. Although still in its early stages in Algeria, organic farming offers significant opportunities for strengthening food security.

CONCLUSION

Through our analysis of the research themes, it has become clear that green finance is not limited to the financial dimension alone. Rather, it extends as a strategic tool aimed at achieving food security, ensuring its stability, and guaranteeing its quality—all of which are directly influenced by climate and environmental conditions. Moreover, Algeria possesses real opportunities to employ green finance, particularly in areas such as water-saving irrigation, organic farming, and solar energy. However, this study has also shown that, despite the efforts made by the state to address climate change, these efforts remain insufficient in terms of properly directing financing towards sustainable agriculture. Traditional financing continues to be one of the main obstacles preventing the transition to a green and sustainable agricultural model.

Findings

- ✓ Green finance is an effective tool for achieving sustainable food security by funding agricultural projects based on sustainable and eco-friendly techniques, which help reduce the negative effects of climate change.
- ✓ Algeria faces increasing climatic challenges that have negatively impacted agricultural production and food security.

- ✓ The application of green finance in the Algerian agricultural sector remains limited, as it still relies on traditional mechanisms without systematic orientation towards environmental sustainability.
- ✓ The absence of a clear and comprehensive legal framework that encourages banks and financial institutions to provide green products for the agricultural sector.

Recommendations

- ✓ Establish a legal and regulatory framework that incorporates the concepts and mechanisms of green finance.
- ✓ Strengthen partnerships between the public and private sectors to mobilize sufficient financial resources for funding sustainable agricultural projects, and encourage banks to develop green financial products specifically directed at farmers and investors in sustainable agriculture.
- ✓ Promote scientific research and innovation in the fields of sustainable agriculture and environmental finance, and raise awareness among farmers and agricultural investors about the long-term importance of green finance for agricultural productivity and environmental protection.

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