

## Strategic Integration of Green Innovation in Algeria: Pathways to Sustainable Economic Transformation

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### Abstract

*This paper examines Algeria's efforts toward sustainable development through green innovation. It reviews key initiatives in renewable energy, sustainable agriculture, and green infrastructure. The study assesses their impact on emission reduction, energy efficiency, and green job creation. It highlights persistent challenges such as technological gaps and limited funding. Weak private-sector involvement also hinders progress. The paper emphasizes the need for policy coherence and strategic investment in innovation. Strengthening governance and building expertise are essential for a successful ecological transition.*

**Keywords:** Innovation, green innovation, green economy, green projects, sustainable development.

### الإدماج الاستراتيجي للابتكار الأخضر في الجزائر: مسارات التحول الاقتصادي المستدام

#### ملخص

تناول هذا البحث مسار الجزائر نحو تحقيق التنمية المستدامة من خلال دمج الابتكار الأخضر ضمن التخطيط الاقتصادي الوطني. ويراجع أبرز الإجراءات المتخذة في مجالات الطاقة المتجددة، والزراعة المستدامة، والبنية التحتية الخضراء، اعتماداً على مصادر متعددة تشمل السياسات العمومية والهياكل المؤسسية. يقيس التحليل مدى إسهام هذه المبادرات في بلوغ الأهداف البيئية، مثل تقليص الانبعاثات، وتحسين كفاءة استخدام الطاقة، وتوليد فرص العمل في الاقتصاد الأخضر. كما يكشف عن التحديات المستمرة، بما في ذلك القصور التكنولوجي، ونقص التمويل، وضعف انخراط القطاع الخاص. ويؤكد البحث على الحاجة الملحة إلى تنسيق السياسات وتوجيه الاستثمارات بشكل استراتيجي نحو الابتكار. ويوصي بتعزيز منظومات الحوكمة وتنمية الكفاءات المحلية، باعتبارها خطوات أساسية لدفع مسار التحول البيئي في الجزائر.

**الكلمات المفتاحية:** ابتكار، ابتكار أخضر، اقتصاد أخضر، مشاريع خضراء، تنمية مستدامة.

**Introduction:**

Algeria, whose economy has long been centered on hydrocarbon exports, is currently navigating substantial economic and ecological challenges that underscore the urgency of adopting a more diversified and sustainable development trajectory. In light of global climate imperatives and the rapid evolution of clean energy technologies, the country faces both obstacles and new prospects. Within this context, Algeria has progressively integrated green innovation—understood as the creation and diffusion of environmentally conscious technologies and systems<sup>(1)</sup> into its broadest economic planning as a means to ensure environmental protection and economic resilience over the long term.

In response to these imperatives, national authorities have initiated strategic programs aiming at scaling up renewable energy generation, modernizing agricultural methods with sustainable practices, and investing in low-carbon infrastructure. The country's vast renewable resources, particularly in solar energy, provide Algeria with a competitive advantage in the transition toward a greener economy. Policy initiatives<sup>(2)</sup> have, thus, focused on emission reduction, on climate adaptation, and on industrial practice promotion, aligned with environmental standards.

Nonetheless, Algeria's green transition remains hindered by a number of structural limitations. These include restricted access to advanced technologies, limited financial resources, and regulatory frameworks that are not yet fully adapted to sustainability goals. Moreover, as global development increasingly pivots toward low-carbon economies, private sector engagement becomes indispensable in accelerating innovation and sustainable industrial transformation. Identifying the nature and extent of these limitations is fundamental to designing effective, context-sensitive policy responses.

Despite its significant renewable energy potential—especially in solar power—Algeria continues to depend heavily on fossil fuels, which represent more than 95% of its export earnings and nearly 60% of public revenues<sup>(3)</sup>. This reliance renders the economy vulnerable to volatility in global energy markets and hampers the effective implementation of green economic strategies. Although several policy initiatives have been launched in support of sustainability, their actual impact has been weakened by administrative inefficiencies, regulatory fragmentation, and funding gaps.

This study, therefore, seeks to answer the major research question: How can Algeria effectively navigate its transition to a green economy through innovation while overcoming the structural and systemic challenges it currently faces? The answer to this question will offer valuable insights for the formulation of policy tools and investment frameworks capable of supporting the country's sustainable economic transformation.

This research is structured around four main objectives:

- To analyze Algeria's approach to green innovation, particularly in the domains of renewable energy, sustainable agriculture, and eco-industrial sectors;
- To evaluate the performance of national strategies in promoting green innovation and in fostering inclusive and sustainable growth;
- To identify persistent challenge which inhibit the country's ecological transition with a focus on technological, financial, and institutional barriers;
- To propose actionable strategies, to enhance the national capacity for green innovation and to support the shift toward an environmentally sustainable economy.

Additionally, the study aims to examine how Algeria's sustainability ambitions can be more effectively embedded within its broadest economic agenda. Through this lens, the research contributes to the ongoing scholarly and policy discourse on sustainable development in emerging economies.

**1- Methodology:**

To address these objectives, the study adopts a mixed-method approach, combining both qualitative and quantitative analyses to ensure a holistic understanding of Algeria's green innovation dynamics.

**- Qualitative Components:**

Policy Analysis: A critical examination of core national strategies, including the National Renewable Energy Program and the Green Algeria Strategy;

Case Studies: In-depth evaluation of emblematic green innovation projects, such as the HassiR'Mel solar power plant and the Biskra sustainable agriculture initiative;

**- Quantitative Components:**

Statistical Analysis: Compilation and interpretation of key metrics on renewable energy capacity, emission reduction, and employment trends in green sectors. The analysis also explores the way green innovation has impacted the national energy mixture and the diversification patterns over the past decade.

**-Data Sources:**

Primary Sources: Official documents from relevant governmental institutions, such as the Ministry of Energy and the Ministry of Agriculture .field studies conducted by national and international research bodies;

Secondary Sources: Academic publications on green innovation and sustainable development, as well as analytical reports from global institutions like IRENA, UNEP, and the World Bank.

**2- Theoretical Frame: Ecological Modernization Theory (EMT) and Green Innovation in Algeria:**

The Ecological Modernization Theory (EMT) offers a robust analytical lens for exploring the way modern societies can reconcile economic development with environmental protection. Rather than viewing industrial progress as inherently harmful to ecosystems, EMT asserts that environmental sustainability can be achieved through strategic technological innovations, regulatory reforms, and market incentives<sup>(4)</sup>. It proposes that modern industrial systems, when restructured through ecological principles, can generate both economic and environmental gains.

In the Algerian context, EMT serves as a relevant framework to understand the country's evolving energy and environmental strategies. As part of its response to global sustainability challenges, Algeria has embraced the integration of renewable energy—particularly solar power—into its energy portfolio. This transition aligns with EMT's emphasis on technological modernization and institutional adaptation. Policies such as the National Renewable Energy Program reflect Algeria's ambition to decouple economic growth from ecological harm by diversifying its energy sources and to promote cleaner technologies. A notable example illustrating this transition is the HassiR'Mel hybrid solar-gas power plant, which incorporates renewable energy into the national grid and exemplifies how innovation can drive both environmental and economic performance<sup>(5)</sup>.

Likewise, the National Renewable Energy Program (NREP) seeks to expand solar and wind capacity, promoting a shift toward a low-carbon economy while stimulating investment in green sectors. These initiatives underscore EMT's core proposition that technological progress, guided by effective governance, can catalyze ecological transformation.

Beyond energy, Algeria's broader policy orientation suggests an increasing institutional commitment to ecological modernization. The country's strategic focus on clean energy infrastructure and sustainable practices marks a transition from fossil fuel dependency toward a knowledge-based, innovation-led economy. However, persistent challenges—including technological limitations, funding shortages, and policy fragmentation—must be addressed to fully realize EMT's transformative potential<sup>(6)</sup>. This calls for enhanced research investment, international partnerships, and capacity-building to support Algeria's green innovation trajectory.

In sum, EMT provides a comprehensive foundation for analyzing Algeria's sustainability strategies. By emphasizing the synergy between innovation and environmental governance, this theory helps contextualize Algeria's renewable energy initiatives within a broader vision of sustainable economic transformation in North Africa.

### **3- Conceptual Framework:**

#### **- Green Innovation:**

Green innovation encompasses the development and application of novel technologies and practices aiming at minimizing ecological footprints while advancing sustainable development goals<sup>(7)</sup>. In Algeria, this concept underpins various policy efforts to reform the energy sector, to foster sustainable agriculture, and to promote low-emission infrastructure. As the country seeks to reduce its reliance on hydrocarbons, green innovation becomes a strategic tool for mitigating emissions, for enhancing energy efficiency, and for building economic resilience<sup>(8)</sup>.

#### **- Green Economy:**

The green economy paradigm integrates economic progress with environmental stewardship and social equity. For Algeria, transitioning toward a green economy implies reconfiguring financial, regulatory, and institutional systems to incentivize eco-friendly investment and innovation. Such a shift requires enhancing public-private cooperation, creating green jobs, and investing in sectors like renewable energy, sustainable mobility, and waste reduction—thereby fostering inclusive and sustainable growth.

#### **- Green Projects:**

Green projects are initiatives deliberately designed to support ecological objectives, such as improving resource efficiency and reducing annually by 2030<sup>(9)</sup>.

These projections underscore the program's strategic role in shaping Algeria's ecological transition and transforming its energy landscape.

### **4- Algeria's Strategy and Efforts in Green Innovation**

#### **4-1- Algeria's Progress towards a Sustainable Green Economy:**

Algeria's movement toward establishing a sustainable green economy forms a crucial element of its overarching long-term development agenda. Confronted with increasing environmental and socio-economic challenges, the country has made deliberate strides through comprehensive green innovation policies designed to diversify its economic base, reduce environmental harm, and tackle pressing issues such as energy dependence, water scarcity, and desertification. These efforts are structured around national strategies that focus on priority sectors including renewable energy, sustainable agriculture, and environmentally friendly industrial practices. This section offers an in-depth exploration of Algeria's green innovation approaches, their practical application, and key projects that contribute to both ecological sustainability and economic resilience.

##### **4-1-1- National Strategies for Green Innovation:**

Algeria's dedication to fostering green innovation is demonstrated through the development and implementation of multiple national strategies aimed at accelerating the renewable energy transition, at promoting sustainable farming methods, and at advancing low-carbon industrial development. These policies address critical issues such as climate change mitigation, energy security, and economic diversification simultaneously<sup>(10)</sup>.

##### **-National Renewable Energy Program (NREP) 2011–2030:**

Initiated in 2011, the National Renewable Energy Program (NREP) stands as a cornerstone in Algeria's sustainable energy transition. The program seeks to rebalance the country's energy portfolio by emphasizing renewable sources such as solar, wind, and hydropower, leveraging Algeria's abundant solar potential<sup>(11)</sup>.

Primary objectives include:

Reaching an installed renewable energy capacity of 22 GW by 2030, accounting for approximately 27% of the national energy mix<sup>(12)</sup>.

Developing solar energy infrastructure targeting 13,000 MW, which would constitute over 60% of the renewable energy capacity.

Expanding wind energy capacity to 500 MW by 2025.

Supporting research and developing efforts to enhance energy efficiency and sustainability in renewable technologies.

**Anticipated impact:**

The NREP's implementation is expected to substantially decrease Algeria's reliance on fossil fuels while reducing greenhouse gas emissions by an estimated 10 million tons of CO<sub>2</sub> annually by 2030. These projections underscore the program's strategic role in shaping Algeria's ecological transition and transforming its energy landscape.

**4-1-2- Green Algeria 2025 Strategy:**

The Green Algeria 2025 Strategy was formulated in response to critical environmental issues including desertification, land degradation, and water scarcity. This comprehensive initiative integrates measures such as reforestation, land rehabilitation, and the implementation of water-efficient agricultural practices to support ecosystem restoration and sustainable resource management<sup>(13)</sup>.

**Key Focus Areas:**

**Sustainable Agriculture:** The strategy promotes organic farming methods, water-saving irrigation technologies, and the cultivation of drought-tolerant crops, aiming to improve resilience against climate variability<sup>(14)</sup>.

**Afforestation and Reforestation:** Efforts involve extensive tree-planting campaigns and land reclamation projects intended to counteract soil erosion and enhance biodiversity conservation.

**Water Conservation:** Initiatives focus on optimizing agricultural water use, particularly in arid regions, through the deployment of desalination plants and wastewater recycling systems.

**Anticipated Outcomes by 2025:**

Rehabilitation of over 2 million hectares of degraded land.

Planting more than 100 million trees to improve soil health and boost carbon sequestration<sup>(15)</sup>.

A reduction in soil erosion and desertification rates by approximately 15%, facilitating long-term land restoration.

**-National Climate Change Adaptation Plan (2018) :**

In recognition of growing climate-related risks, Algeria introduced the National Climate Change Adaptation Plan (NCCAP) in 2018. This plan aims to bolster resilience across vital sectors such as agriculture, water management, and infrastructure. The NCCAP emphasizes adaptive agricultural techniques, enhanced water governance, and urban planning reforms designed to mitigate the impacts of climate<sup>(16)</sup>.

**Focus Areas:**

**Climate-Resilient Agriculture:** Adoption of climate-smart farming, crop diversification, and efficient irrigation technologies to sustain agricultural productivity under changing climate conditions.

**Water Management:** Expansion of desalination infrastructure and improvement of water distribution networks to secure water availability in drought-prone areas.

**Urban and Infrastructure Resilience:** Reinforcement of urban planning policies to increase preparedness against heat waves, flooding, and extreme weather events.

**Expected Impacts:**

Reduction in Algeria's overall vulnerability to climate change.

Enhanced water access and quality, decreasing dependency on traditional water sources.

Increased sustainability in agriculture by balancing productivity and environmental stewardship.

Improved disaster preparedness and urban resilience against climate hazards.

Algeria's green innovation policies are integral to its sustainable development vision. By capitalizing on renewable energy resources, investing in reforestation, and embracing climate-resilient strategies, the country aims to establish itself as a regional leader in sustainability. Nevertheless, obstacles such as financing gaps, technological shortcomings, and climate-related risks remain. Sustained international partnerships, policy refinement, and investments in green technology research will be crucial for realizing Algeria's sustainability ambitions.

#### 4-2- Algeria's Green Innovation Projects:

Algeria has initiated several ambitious projects designed to facilitate its transition toward a sustainable, low-carbon economy. These projects prioritize renewable energy generation, sustainable agriculture, and eco-friendly industrial processes. The overarching goals include diversifying the energy mix, reducing fossil fuel dependency, combating environmental degradation, and promoting long-term socio-economic stability. This section reviews major green innovation projects, emphasizing their technological features, anticipated benefits, and strategic importance.

##### 4-2-1- HassiR'Mel Hybrid Power Plant:

###### Overview:

Situated in Laghouat province, the HassiR'Mel hybrid power plant is among Algeria's most innovative renewable energy facilities. Operational since 2011, it represents a pioneering integration of solar energy with conventional gas-fired electricity generation, enhancing overall system efficiency while cutting greenhouse gas emissions<sup>(17)</sup>.

###### Technological Details:

- Type: Solar-thermal hybrid power plant
- Capacity: 150 MW (including 25 MW of concentrated solar power and 125 MW from gas turbines)
- Technology: Parabolic trough collectors produce thermal energy, which supplements the combined-cycle gas turbine (CCGT) system
- Efficiency Improvements: Hybridization boosts plant efficiency by approximately 5–10% compared to standalone gas plants
- Environmental and Economic Benefits:

Annual CO<sub>2</sub> emission reductions of approximately 120,000 tons

Significant savings in natural gas consumption, enhancing long-term energy security

Serves as a replicable model for future hybrid power facilities in Algeria and the broader North African region

**Table N°1: Energy Contribution of the HassiR'Mel Hybrid Power Plant**

Energy Source	Capacity (MW)	Contribution to National Grid
Solar Power	25	16.7%
Natural Gas	125	83.3%
Total	150	100%

Source: International Renewable Energy Agency 2021.

##### 4-2-2- Biskra Sustainable Agriculture Project:

###### Overview:

The Biskra region, often referred to as the "food basket of Algeria," is a vital agricultural area that faces significant challenges such as water scarcity and soil degradation. To address these issues, the Biskra Sustainable Agriculture Project was initiated with the goal of promoting water-efficient irrigation methods, greenhouse farming, and sustainable agricultural practices specifically adapted to Algeria's arid climate conditions<sup>(18)</sup>.

###### Technological Components:

- Irrigation System: Implementation of advanced drip irrigation technology that minimizes water loss by delivering water directly to the plant root zones, thereby optimizing water use efficiency.
- Greenhouse Farming: Utilization of climate-controlled greenhouses to enable year-round cultivation, protecting crops from extreme weather and improving productivity.
- Use of Desalinated Water: Incorporation of treated wastewater and desalinated water sources to supplement irrigation needs, reducing reliance on conventional freshwater supplies.
- Environmental and Economic Outcomes:

- **Water Conservation:** Achieves up to a 50% reduction in water usage compared to traditional irrigation techniques, significantly conserving water resources.
- **Increased Crop Yields:** Enhances agricultural productivity by approximately 30%, which contributes to lowering Algeria's dependence on food imports.
- **Soil Restoration:** Adoption of soil conservation methods to mitigate desertification and restore soil fertility, thus supporting long-term agricultural sustainability.

**Table N°2: Impact of Biskra Sustainable Agriculture Project**

Metric	Before Project	After Project
Water Consumption Reduction	0%	50%
Crop Yield Increase	0%	30%

Source: Ministry of Agriculture, Algeria, 2022.

#### 4-2-3- Tamanrasset Solar Energy Initiative:

##### Overview:

The southern region of Algeria, particularly Tamanrasset, enjoys exceptionally high solar radiation levels, making it an ideal location for large-scale solar energy projects. The Tamanrasset Solar Energy Initiative aims to provide clean, decentralized energy to rural and off-grid communities, thereby, addressing energy access issues and promoting environmental sustainability<sup>(19)</sup>.

##### Technological Features:

- **Type:** Photovoltaic (PV) solar power plant.
- **Capacity:** Initially designed for 100 MW, with potential plans for future expansion.
- **Grid Integration:** Engineered to supply electricity directly to isolated communities, significantly reducing their dependence on costly and polluting diesel generators.
- **Environmental and Economic Benefits:**
  - **CO<sub>2</sub> Emissions Reduction:** The project is expected to prevent the emission of more than 200,000 tons of CO<sub>2</sub> annually, contributing substantially to Algeria's efforts in greenhouse gas mitigation.
  - **Improved Energy Access:** By enabling electrification of rural areas, the initiative improves quality of life and stimulates economic development.
  - **Cost Efficiency:** The decreased reliance on diesel fuel leads to lower electricity generation costs, benefiting remote and underserved populations.

**TableN°3: Tamanrasset Solar Energy Initiative Overview**

Aspect	Details
Installed Capacity	100MW
Beneficiaries	Rural Communities
Contribution to National Goal	Significant

Source: Ministry of Energy, Algeria, 2021.

#### 4-2-4- Ouargla Green Industry Project:

##### Overview:

The industrial sector in Algeria, especially cement manufacturing, constitutes a major source of CO<sub>2</sub> emissions. The Ouargla Green Industry Project aims to mitigate the environmental impact of cement production by implementing sustainable and energy-efficient technologies and practices<sup>(20)</sup>.

##### Technological Aspects:

- **Alternative Materials:** Incorporation of industrial by-products such as fly ash and slag as partial replacements for clinker, reducing raw material consumption.

- **Energy Efficiency:** Adoption of waste heat recovery systems and enhancements in kiln efficiency to minimize energy use.
- **Carbon Capture Potential:** Exploration of future integration with Carbon Capture and Storage (CCS) technologies to further reduce emissions.
- **Environmental and Economic Impact:**
- **CO<sub>2</sub> Emission Reduction:** The project targets a 30% reduction in carbon emissions, establishing a model for sustainable practices within other industrial sectors in Algeria.
- **Cost Reduction:** Lower dependence on imported raw materials results in decreased production costs.
- **Sustainability Promotion:** Encourages circular economy principles in the construction industry, fostering resource efficiency and waste minimization. construction sector.

**Table N°4: Overview of the Ouargla Green Industry Project**

Project Name	Sector	Technology/Innovation	CO <sub>2</sub> Reduction	Status
Ouargla Green Industry	Industry	Low-carbon cement production using alternative materials	30% reduction in CO <sub>2</sub> emissions	Ongoing

Source: International Renewable Energy Agency (IRENA, 2021)

#### 4-2-5- In Salah Carbon Capture and Storage (CCS) Project:

##### Overview:

The In Salah Carbon Capture and Storage (CCS) Project is recognized as one of the most advanced carbon sequestration initiatives on the African continent. It is designed to capture carbon dioxide (CO<sub>2</sub>) emissions resulting from natural gas production and permanently store them underground, thereby preventing their release into the atmosphere.

##### Technological Aspects:

- **Process:** CO<sub>2</sub> is extracted from natural gas at processing facilities and injected into deep geological formations.
- **Storage Depth:** Approximately 1,800 meters underground within a depleted gas reservoir.
- **Monitoring:** Utilizes state-of-the-art seismic imaging and geochemical monitoring systems to ensure the integrity and safety of long-term CO<sub>2</sub> storage.
- **Environmental and Economic Impact:**
- **CO<sub>2</sub> Sequestration:** The project is capable of capturing and storing around 1 million tons of CO<sub>2</sub> annually.
- **Climate Change Mitigation:** Contributes significantly to reducing Algeria's carbon footprint and supports the country's international climate obligations under the Paris Agreement.
- **Knowledge Transfer:** Functions as a pioneering model for future CCS initiatives across Africa and the broader Middle East and North Africa (MENA) region.

**Table N° 5: In Salah CCS Project Key Metrics**

Factor	Value
Annual CO <sub>2</sub> Stored	1 Million Tons
Technology Used	Geological Storage
Environmental Benefit	Reduction in Greenhouse Gases

Source: International Renewable Energy Agency (IRENA, 2021)

Carbon Storage Process in the In Salah CCS Project (Source: BP, 2020)

#### 5- SWOT Analysis of Algeria's Green Innovation Landscape:

A SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis provides a comprehensive evaluation of Algeria's green innovation environment, offering insights into



the nation's capabilities and limitations in transitioning toward sustainable development. This analytical framework is particularly valuable for policymakers, researchers, and investors aiming to assess Algeria's strategic position in the evolving global green economy.

#### Strengths

Algeria is endowed with substantial natural resources, especially solar and wind energy, which provide a solid foundation for large-scale renewable energy development<sup>(21)</sup>. The Algerian government has shown consistent commitment to environmental sustainability through national policies and programs that promote the reduction of carbon emissions and the deployment of clean energy technologies.

Public awareness of environmental challenges is growing, further fostering social support for green initiatives. Additionally, Algeria benefits from partnerships with international organizations, such as the African Development Bank and the United Nations Development Programme, which provide technical and financial assistance to strengthen the country's green innovation<sup>(22)</sup>.

#### Weaknesses:

Despite these strengths, Algeria faces several structural and operational limitations. One of the most significant challenges is the technological gap—many renewable energy systems rely on imported technologies, which increases project costs<sup>(23)</sup>. Furthermore, the absence of a unified and long-term green policy framework undermines the coherence and efficiency of sustainability programs.

Private-sector involvement in green innovation remains minimal, largely due to regulatory uncertainties, inadequate incentives, and limited access to green financing mechanisms<sup>(24)</sup>. These factors hinder the scalability and sustainability of many environmentally focused initiatives.

#### Opportunities:

Numerous opportunities could propel Algeria's green transformation. The growing global demand for renewable energy presents Algeria with the potential to become a key regional hub for solar and wind energy production. Strengthening domestic research and development in green technologies would not only reduce technological dependency but also stimulate local innovation.

The instability of international fossil fuel markets has further underscored the importance of diversifying the national energy portfolio to improve energy security<sup>(25)</sup>. Additionally, investments in sustainable infrastructure, such as public transportation, energy-efficient buildings, and clean energy systems, could create thousands of jobs and support broader economic diversification and social inclusion.

#### Threats

Several external and internal threats could hinder Algeria's green innovation trajectory. Regional geopolitical instability and security concerns may deter long-term foreign investment in renewable energy projects<sup>(26)</sup>. On the domestic front, the high upfront costs associated with green technologies and resistance to technological change within traditional industries pose significant barriers.

Moreover, persistent environmental degradation—driven by unsustainable land use practices, deforestation, and ongoing dependence on fossil fuels—intensifies Algeria's vulnerability to climate change impacts such as desertification, droughts, and extreme weather events<sup>(27)</sup>.

**Table N°6: SWOT Analysis of Algeria's Green Innovation Landscape**

<b>Strengths</b>  Abundant natural resources (e.g., solar power, wind) High dependency on fossil fuels Government support for green policies Growing awareness of sustainability International partnerships and support	<b>Weaknesses</b>  Technological gaps and reliance on imports Fragmented policy implementation Limited private-sector involvement
<b>Opportunities</b>  Expanding international renewable energy markets Development of local green technologies Volatility in global energy prices Potential for job creation in green sectors Increased investment in sustainable infrastructure	<b>Threats</b>  Geopolitical instability and security risks Slow adoption of green technologies by industries Environmental degradation due to non-sustainable practices

**Source:** Researcher

Algeria's green innovation landscape reflects a multifaceted balance of strengths, weaknesses, opportunities, and threats. Although the country holds considerable potential to emerge as a regional leader in renewable energy and sustainable development, overcoming technological dependencies and policy fragmentation remains critical. Targeted investments in research and development, the establishment of a coherent and integrated policy framework, and the active engagement of the private sector are essential steps toward reinforcing Algeria's capacity to transition to a resilient and environmentally sustainable economy.

#### **Conclusion, Results, and Recommendations:**

Algeria has achieved substantial progress in the field of green innovation, particularly within renewable energy and sustainable agriculture. Several large-scale initiatives underscore the nation's commitment to environmentally responsible development and economic resilience.

The HassiR'Mel Hybrid Power Plant stands out as a landmark project. By combining solar and natural gas technologies, it generates over 150 MW of clean energy, reinforcing the national energy grid while reducing reliance on fossil fuels. Its success highlights the country's potential to implement hybrid energy systems that are especially suitable for semi-arid environments, offering scalable and replicable models for similar regions.

In the agricultural domain, the Biskra Agricultural Project has transformed farming practices in arid areas through the integration of efficient irrigation technologies such as drip systems, hydroponics, and advanced soil monitoring. These innovations have enhanced agricultural productivity while conserving water resources—an essential consideration in Algeria's dry climate. The use of drought-resistant crops and climate-adaptive techniques has further strengthened food security and long-term sustainability.

Moreover, the Tamanrasset Solar Energy Initiative marks a significant stride toward expanding access to clean electricity in remote regions. By deploying photovoltaic infrastructure combined with energy storage technologies, the project ensures continuous power supply, supports local economic development, and aligns with national renewable energy targets. It also contributes to job creation and emission reduction, thereby enhancing living conditions and environmental outcomes.

Collectively, these initiatives reflect Algeria's growing leadership in green innovation and serve as foundational models for future sustainable development across the region.

#### Ongoing Challenges

-Despite these promising developments, Algeria continues to face structural, financial, and policy-related challenges that hinder the full realization of its green innovation potential.

#### -Financial Constraints

The high costs associated with renewable energy projects, combined with limited private-sector engagement, have slowed the expansion of sustainable initiatives. While international donors and development institutions have provided some support, Algeria needs to diversify its funding mechanisms. Encouraging private investment through green bonds, fiscal incentives, and carbon finance could help close the financing gap and accelerate green technology adoption.

-Technological Dependence A critical limitation lies in Algeria's dependence on imported renewable technologies. The absence of a robust domestic innovation ecosystem hampers the development of context-specific solutions. Strengthening national R&D capabilities and fostering technology transfer partnerships with more advanced economies are essential steps toward reducing this dependency. The establishment of green innovation hubs and incubators could further nurture local expertise.

#### -Policy Coordination and Implementation

Although comprehensive environmental policies exist, fragmented responsibilities and bureaucratic inefficiencies impede effective implementation. A lack of coordination among governmental bodies often results in project delays and regulatory bottlenecks. Streamlining policy frameworks and establishing a centralized green energy task force would greatly improve coherence and operational efficiency.

#### Recommendations

To consolidate progress and overcome existing obstacles, the following strategic recommendations are proposed:

-Strengthen R&D Capabilities: Establish specialized research centers in renewable energy and sustainability to foster local innovation.

-Promote Public-Private Partnerships (PPPs): Introduce policy incentives and investment frameworks to attract private-sector participation in green projects.

-Diversify Funding Mechanisms: Develop financial instruments such as green bonds, carbon credits, and climate financing to support large-scale initiatives.

-Enhance Policy Coordination: Create an integrated regulatory framework and a dedicated inter-agency task force to streamline project execution.

-Expand Technical and Vocational Training: Adapting educational curricula to align with the needs of green sectors and equipping the workforce with relevant skills.

-Boost Local Manufacturing: Encourage domestic production of renewable energy components through subsidies, industrial support policies, and joint ventures.

-Raise Public Awareness: Launch nationwide campaigns and educational programs to promote environmental responsibility and sustainable lifestyles.

-Modernize Energy Infrastructure: Invest in smart grid systems and energy storage technologies to improve energy reliability and manage intermittency.

-Support Sustainable Agriculture: Provide farmers with access to innovative water-saving tools, resilient crop varieties, and financial support for eco-friendly practices.

-Foster International Cooperation: Strengthen partnerships with global institutions to facilitate knowledge exchange, capacity building, and technology transfer.

In conclusion, even though Algeria has made significant progress in promoting green innovation, particularly in the areas of renewable energy and sustainable agriculture, continuing on this progress requires addressing major structural challenges. A comprehensive strategy that enhances local technological capacity, that stimulates private-sector engagement, and that improves policy implementation will be pivotal for a successful green transition.

Furthermore, investing in human capital through education and professional training will be essential to build a resilient, inclusive, and environmentally sustainable Algerian economy.

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