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Climate Change and Desertification in Algeria: Assessment of Response Policies

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Abstract

Climate change is increasingly intensifying desertification processes in Algeria through rising temperatures, declining precipitation, recurrent droughts, vegetation degradation, soil erosion, and growing pressure on surface and groundwater resources. This study provides a narrative policy review of the relationship between climate change and desertification in Algeria and examines the main national response policies adopted to reduce environmental vulnerability and strengthen adaptation capacity. The analysis focuses on key policy areas, including afforestation programs, Green Dam rehabilitation, forest and pastoral protection, seawater desalination, wastewater treatment and reuse, water-saving measures, and sustainable groundwater management. Rather than merely describing these initiatives, the study assesses their relevance, implementation challenges, and potential contribution to climate adaptation, water security, and land-degradation control. The findings indicate that Algeria has introduced several important measures to address climate-related desertification; however, their effectiveness remains constrained by fragmented governance, limited monitoring, regional disparities, insufficient data transparency, and weak integration between climate, water, agricultural, and land-use policies. The study highlights the need for a more evidence-based, regionally differentiated, and integrated adaptation framework supported by measurable indicators, improved institutional coordination, and stronger alignment with international frameworks such as land degradation neutrality and sustainable water-resource management.
Keywords: Climate change; desertification; Algeria; environmental governance; water resources; climate adaptation; land degradation.

1. Introduction

Climate change has become one of the most critical environmental challenges facing the world today because of its direct impacts on ecosystems, biodiversity, water resources, agriculture, food security, and sustainable development (Djilali, 2024) [1]. Dry and semi-arid regions are particularly vulnerable to climatic disturbances due to increasing temperatures, declining rainfall, recurrent droughts,

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vegetation degradation, soil erosion, and growing pressure on natural resources. In this context, desertification has emerged as a major environmental and socio-economic threat, especially in African countries where fragile ecosystems are highly exposed to climatic variability and unsustainable land-use practices (Talbi & Samira, 2024) [2].

Algeria is among the countries most exposed to these environmental risks because of its vast desert territory, fragile steppe ecosystems, limited water resources, and dependence on climate-sensitive sectors such as agriculture and pastoral activities. Recent climatic changes have accelerated environmental degradation processes through vegetation decline, land degradation, water scarcity, and increasing drought severity, particularly in steppe and Saharan regions (Fiq Zaânoun & Mohamed Hadaid, 2023) [3]. However, desertification in Algeria cannot be explained solely by climatic factors. Human activities such as overgrazing, deforestation, irrational agricultural practices, groundwater overexploitation, industrial expansion, and weak environmental governance also contribute significantly to ecological imbalance and land degradation.

To confront these challenges, Algeria has implemented several environmental and climate-related policies aimed at reducing environmental vulnerability and strengthening adaptation capacity. These measures include afforestation programs, rehabilitation of the Green Dam project, forest and pastoral protection, land-restoration initiatives, renewable energy development, seawater desalination, wastewater treatment and reuse, sustainable groundwater management, and water-saving strategies (Bouchouit & Firouz, 2019) [4]. Legislative and institutional reforms have also been introduced to strengthen environmental governance and support sustainable development objectives (Henanoua & Aouatif, 2023) [5].

Several studies have analyzed the impacts of climate change and desertification in Algeria from different scientific perspectives. Triche and Obeid [6] emphasized the importance of modeling desertification and wind erosion in southern Algeria, while Bousbaine (2015) [7] highlighted the negative impacts of climate change on sustainable development through increasing pressure on water, agricultural, and energy resources. Similarly, Ghashwa [8] demonstrated that climatic disturbances have altered rainfall patterns and intensified drought severity in inland and desert areas, thereby accelerating desertification processes and environmental degradation.

Climate-related risks are not limited to terrestrial ecosystems but also affect coastal and marine environments. Ibrahimi (2023) [9] stressed the importance of environmental policies and legal frameworks for protecting marine ecosystems against climate-related threats such as sea-level rise and coastal pollution. In parallel, Algeria has strengthened renewable energy and green-economy strategies as part of its mitigation and adaptation policies. Nekaa, Tayleb, and Ahmed (2024) [10] underlined the role of renewable energy policies in reducing greenhouse gas emissions and improving climate resilience, while Badri and Abdelaziz (2025) [11]

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emphasized the contribution of economic intelligence and green-economy strategies to sustainable environmental management and investment.

Governmental policies related to combating desertification and drought have also received increasing attention. Djaidjaa and Habiballah (2025) [12] examined national programs implemented between 2008 and 2020 to rehabilitate steppe areas, strengthen afforestation, and improve water-resource management. Bouarab and Massouda (2022) [13] analyzed climate data for the period 1980–2020 and confirmed significant changes in temperature and rainfall patterns in Algeria. Matales (2012) [14] further demonstrated that climate change has important implications for global energy markets and energy-transition policies, while Laamiri, Akil, and Tinhinane (2025) [15] highlighted Algeria's efforts to improve adaptation through renewable energy development, environmental legislation, and sustainable development programs.

Desert regions in Algeria also possess important economic, social, environmental, and tourism potential. Issa, Maazouzi, Ben Terbah, and Ben Terbah (2019) [16] explained that desert ecotourism can contribute to sustainable local development while preserving environmental and cultural heritage. Similarly, Bellah, Ben El Habib, and Zoubida (2021) [18] highlighted the importance of ecotourism as a sustainable alternative capable of diversifying economic activities beyond dependence on hydrocarbons. Khalifa (2015) [17] analyzed social and urban transformations in Algerian desert cities, whereas Lemhant and Benmisi (2021) [19] and Lemhant and Ali (2021) [20] emphasized the environmental risks generated by industrial pollution and inadequate urban planning in desert urban agglomerations.

Environmental adaptation also requires stronger environmental awareness and institutional coordination. Bayoud (2015) [21] highlighted the role of social institutions in promoting environmental culture and responsible environmental behavior. Achachi, Hamdouche, and Ryad (2021) [22] further explained that sustainable development in Algeria depends on balancing economic growth with environmental protection and natural-resource preservation. In this context, Belfadel (2024) [23] showed that Algeria has adopted several water-adaptation strategies, including seawater desalination, wastewater reuse, improved irrigation systems, and water-saving measures to strengthen water security. Kadoudou and Djamila (2021) [24] also stressed the importance of local authorities in implementing environmental policies and sustainable development programs at the regional level.

Environmental policy has progressively evolved in Algeria under the influence of both domestic pressures and international environmental commitments. Bouskar and Harouri [25], Kateb and Malika [26], Laberche (2017) [27], and Sakhri, Kibech, and Abdelkarim (2013) [28] demonstrated that Algerian environmental policy is shaped by demographic growth, urban expansion, industrialization, climate change, and international environmental agreements related to biodiversity, desertification, and climate governance. However, these studies also indicate that environmental-policy implementation remains constrained by governance fragmentation,

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insufficient monitoring mechanisms, limited institutional coordination, and weak environmental enforcement.

Water security represents one of the most strategic challenges facing Algeria under conditions of climate change and increasing water demand. According to the Algerian Meteorological Office [36] and the Ministry of Water Resources [41], declining rainfall rates, recurrent droughts, and excessive groundwater exploitation have intensified pressure on water resources. Frimeche (2020) [33] argued that achieving water security requires integrated water-resource management based on diversification of water sources, infrastructure development, and sustainable governance. Messaadia, El Wafi, and Tayeb (2022) [34] confirmed that future water security in Algeria depends not only on water availability but also on institutional efficiency, climate adaptation, and public awareness. Similarly, El Kotbi (2025) [35] emphasized the importance of strengthening water legislation to protect water resources from depletion and pollution.

Governmental institutions also contribute to environmental sustainability through educational and environmental programs. The Ministry of National Education [37] emphasized the importance of environmental education, while the Ministry of Agriculture and Rural Development [38] highlighted the role of afforestation and vegetation protection in combating desertification. The Ministry of Environment and Quality of Life [39], the Ministry of Industry [40], and the Ministry of Interior, Local Authorities and Territorial Planning [42] also stressed the importance of environmental governance, pollution reduction, industrial monitoring, and local participation in sustainable development policies. International organizations and institutional reports further support these perspectives. The Food and Agriculture Organization (FAO) [43] emphasized the relationship between climate change, land degradation, and water scarcity in dry regions. Meteoblue climate data [44] confirmed significant climatic changes in Algeria between 1978 and 2022, including increasing temperatures and rainfall variability. Bouarab and Fethallah (2022) [45] also demonstrated the negative effects of climate change on agricultural productivity in Algeria. According to Kattab (2023) [46], Algeria experienced a significant decline in rainfall during recent decades, increasing pressure on water resources and agricultural systems. Official data from the Office National des Statistiques (ONS) [47], the Algerian Ministry of Hydraulics [48], the World Health Organization (WHO) [49], and Dorabaltea Company [50] further highlight the importance of wastewater treatment, sustainable water management, sanitation systems, and water-resource infrastructure for strengthening environmental resilience and adaptation capacity.

Despite the growing body of literature on climate change, desertification, environmental governance, and water security in Algeria, many previous studies remain descriptive and fragmented. Most research focuses on isolated sectors such as water management, renewable energy, tourism, or environmental legislation, while limited attention has been given to evaluating the effectiveness of national response policies in an integrated manner. Furthermore, several studies rely heavily on descriptive analyses without establishing clear analytical frameworks,

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measurable indicators, or regionally differentiated assessments of policy effectiveness.

Therefore, this study aims to analyze the relationship between climate change and desertification in Algeria and to assess the effectiveness and limitations of national response policies. The study adopts a narrative policy-review approach based on environmental governance and climate-adaptation perspectives. It examines the interaction between climatic drivers, anthropogenic pressures, institutional responses, and sustainable development policies in order to evaluate Algeria's capacity to reduce environmental vulnerability, strengthen water security, and improve adaptation to climate risks. The study also highlights the need for integrated, evidence-based, and regionally differentiated environmental strategies aligned with international frameworks related to sustainable development, climate adaptation, integrated water-resource management, and land degradation neutrality.

2. Climate Change in Algeria

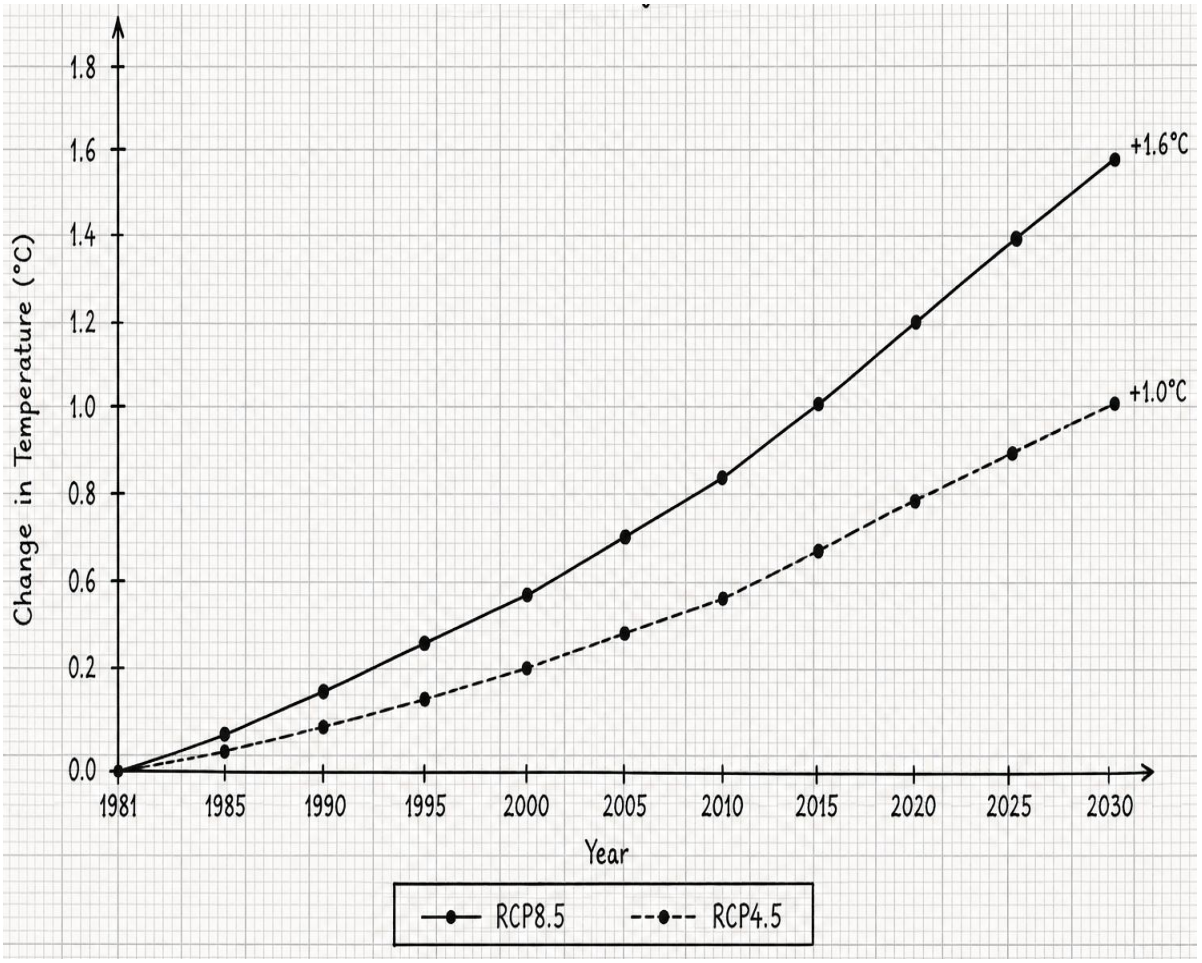


Figure 1. Projected Temperature Change in Algeria (1981–2030) under RCP4.5 and RCP8.5 Scenarios.

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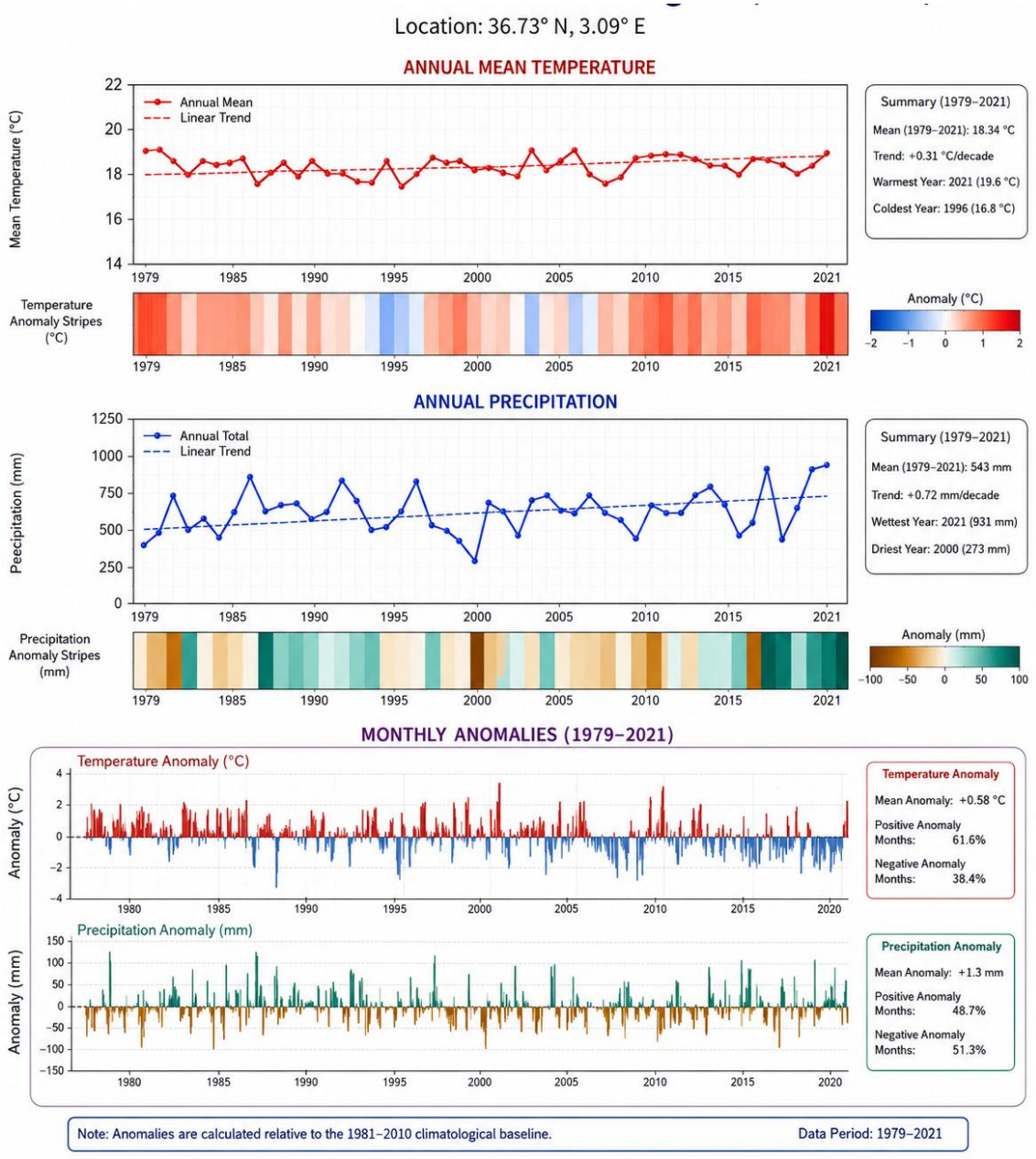


Figure 2. Global statistical analysis of temperature and precipitation trends and anomalies in Algeria (1979–2021).

Figure 1 shows the projected increase in temperature in Algeria between 1981 and 2030 under the RCP4.5 and RCP8.5 scenarios. The figure indicates a clear upward trend, with a stronger rise under RCP8.5, reaching about +1.6°C by 2030, compared with nearly +1.0°C under RCP4.5. This confirms that higher greenhouse gas emissions may intensify warming in Algeria, particularly after 2000. Such warming can increase drought frequency, water stress, agricultural vulnerability, and desertification risks in arid and semi-arid regions.

Figure 2 presents a global statistical analysis of temperature and precipitation trends and anomalies in Algeria during 1979–2021. It shows that annual

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temperature generally follows an increasing tendency, while precipitation remains highly variable from year to year. The anomaly stripes and monthly anomaly graphs reveal repeated warm periods and irregular rainfall distribution. This variability confirms that Algeria is exposed not only to gradual warming but also to unstable rainfall patterns, which may intensify soil degradation, vegetation loss, groundwater pressure, and agricultural instability. Therefore, the two figures together support the need for stronger climate adaptation policies, improved water-resource management, and regionally differentiated strategies to reduce desertification and climate vulnerability.

3. Desertification in Algeria

Table 1. Projected Changes in Precipitation in Algeria during 1981–2030 under RCP8.5 and RCP4.5 Scenarios.

PERIOD	RCP8.5		RCP4.5	
	CHANGE (%)	TREND	CHANGE (%)	TREND
1981–2010 (Reference)	0 % –	Reference period	0 % –	Reference period
2011–2015	-5 % ↓	Slight decrease	-3 % ↓	Slight decrease
2016–2020	-10 % ↓	Moderate decrease	-6 % ↓	Moderate decrease
2021–2025	-17 % ↓	Significant decrease	-12 % ↓	Significant decrease
2026–2030	-25 % ↓↓	Severe decrease	-18 % ↓	Strong decrease

Table 01 presents the projected evolution of precipitation in Algeria between 1981 and 2030 under two climate scenarios: RCP8.5 and RCP4.5. The numerical results indicate a progressive decrease in rainfall amounts over time, reflecting the growing impacts of climate change on water availability and environmental stability in Algeria.Under the RCP8.5 scenario, precipitation is expected to decrease from -5% during the period 2011–2015 to nearly -25% by 2026–2030. This trend demonstrates a severe reduction in rainfall associated with high greenhouse gas emissions and accelerated climate warming. In comparison, the RCP4.5 scenario shows a less pronounced decline, ranging from -3% to approximately -18% over the same period. Although the decrease remains lower than in the RCP8.5 scenario, it still represents a significant climatic challenge for the country.The downward arrows presented in the table illustrate the intensity of rainfall reduction. A single downward arrow indicates a slight decrease, while double downward arrows represent severe decreases in precipitation. The results clearly reveal that the intensity of drought conditions is expected to increase progressively toward 2030, particularly under the pessimistic RCP8.5 scenario.These projected reductions in precipitation may have serious consequences for Algeria's natural and socio-economic systems. Reduced rainfall contributes directly to water scarcity, soil degradation, declining agricultural

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productivity, and the expansion of desertification processes, especially in arid and semi-arid regions. Moreover, lower precipitation rates may increase pressure on groundwater resources and intensify competition over water use among agricultural, industrial, and domestic sectors.The table also highlights the importance of adopting effective climate adaptation and mitigation strategies. Strengthening water resource management, improving irrigation efficiency, promoting drought-resistant crops, expanding reforestation programs, and investing in renewable energy are essential measures to reduce the vulnerability of Algeria to future climatic risks.Overall, Table 01 confirms that precipitation decline represents one of the major environmental threats facing Algeria during the coming decades. The comparison between RCP8.5 and RCP4.5 further demonstrates that reducing greenhouse gas emissions could significantly limit the severity of future climatic impacts and contribute to achieving more sustainable environmental conditions.

4. Desert Environment in Algeria

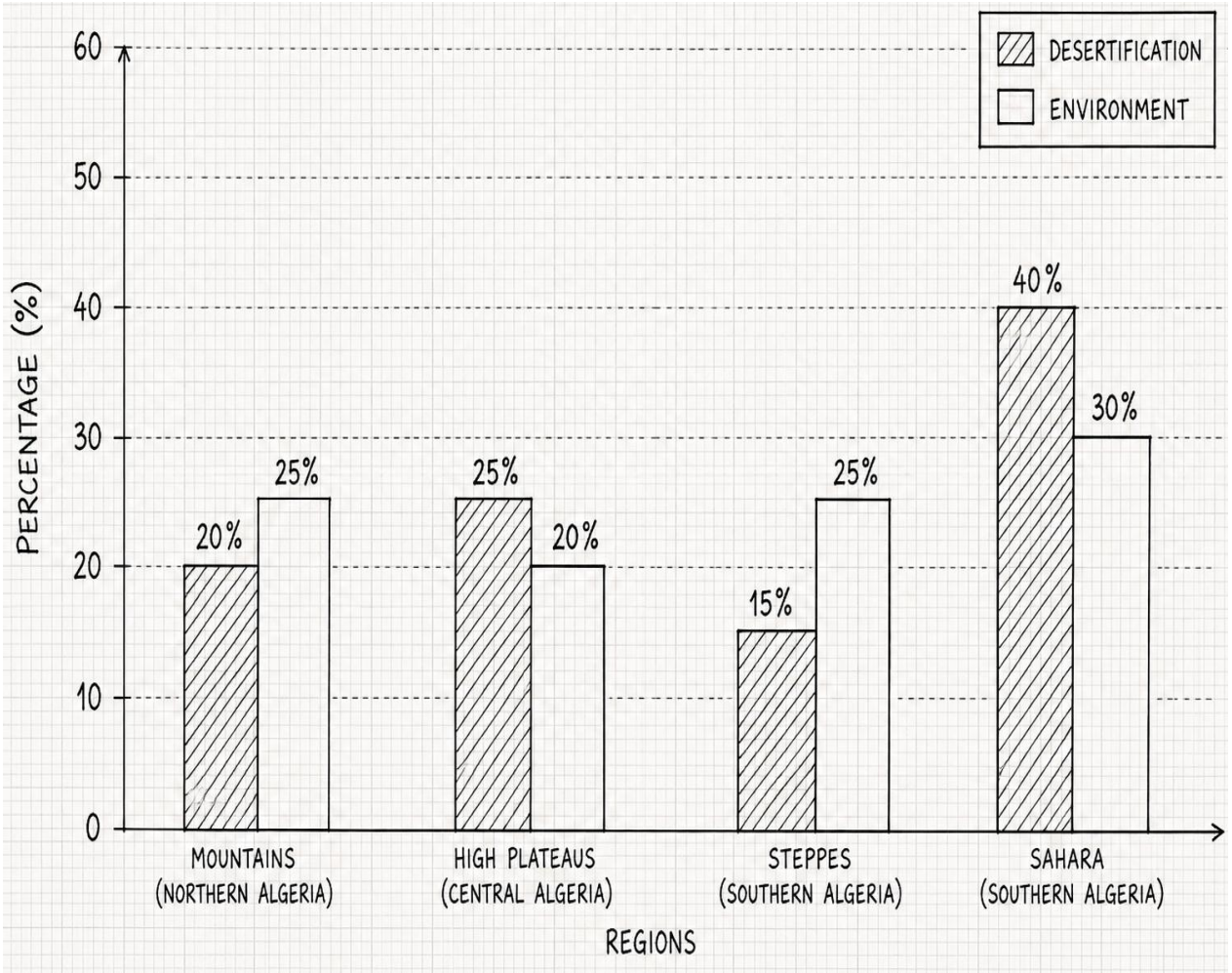


Figure 3. Projected Temperature Change in Algeria (1981–2030) under RCP4.5 and RCP8.5 Scenarios.

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Figure 03 presents a comparative analysis of environmental vulnerability and desertification intensity across the main geographical regions of Algeria, namely the Mountains, High Plateaus, Steppes, and Sahara. The histogram reveals significant regional disparities in both environmental conditions and desertification processes, reflecting the combined influence of climatic variability, water scarcity, vegetation degradation, and human pressures.

The results indicate that the Sahara region records the highest level of desertification, reaching approximately 40%, while the environmental vulnerability indicator approaches 30%. These findings confirm that southern Algeria is the region most exposed to climatic stress, prolonged drought, soil degradation, and desert expansion. The harsh climatic conditions of the Sahara, characterized by very low rainfall, high temperatures, limited vegetation cover, and fragile ecosystems, significantly increase environmental vulnerability. In addition, excessive groundwater exploitation and growing pressure on water resources further intensify environmental degradation in this region.

The Steppe region also exhibits high environmental sensitivity. The environmental vulnerability indicator reaches nearly 25%, whereas desertification is estimated at approximately 15%. This situation reflects the transitional ecological nature of steppe ecosystems, which are highly vulnerable to climatic fluctuations and anthropogenic pressures such as overgrazing, deforestation, and unsustainable land use. Although the desertification rate remains lower than that observed in the Sahara, the Steppe region faces increasing environmental risks that may accelerate land degradation if preventive and restoration measures are not strengthened.

In the High Plateaus region, the desertification indicator reaches approximately 25%, while environmental vulnerability is close to 20%. These values indicate moderate but significant environmental pressure associated with declining rainfall, soil erosion, agricultural stress, and increasing climatic variability. Because the High Plateaus constitute one of Algeria's most important agricultural regions, environmental degradation in this area may directly affect agricultural productivity, food security, and rural socio-economic stability.

By contrast, the Mountain regions of northern Algeria show relatively lower desertification levels, estimated at around 20%, while environmental conditions remain comparatively more stable, with an environmental indicator close to 25%. Higher rainfall rates, denser vegetation cover, and more favorable climatic conditions contribute to limiting environmental degradation in these northern regions. Nevertheless, mountain ecosystems remain exposed to environmental pressures related to urban expansion, forest fires, soil erosion, and climate variability.

Overall, Figure 03 demonstrates that environmental vulnerability and desertification intensity increase progressively from northern to southern Algeria. The histogram highlights the strong relationship between climatic conditions, water availability, vegetation cover, and regional environmental degradation. These findings emphasize the importance of implementing regionally differentiated environmental policies adapted to the specific characteristics of each area. Such policies should

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include sustainable land management, reforestation and afforestation programs, rational water-resource management, groundwater protection, drought-adaptation strategies, and stronger environmental awareness programs to reduce the impacts of climate change and desertification in Algeria.

5. Environmental Adaptation in Algeria

Table 2. Major Environmental and Afforestation Initiatives in Algeria for Combating Desertification and Supporting Sustainable Development.

YEAR / PERIOD	PROJECT OR INITIATIVE	KEY FIGURES / TARGETS	MAIN OBJECTIVE	
1970	Launch of the Great Green Belt Project	Around **1,500 km** of shelterbelt	Protect the first ecological green belt in Algeria against desertification	
1970 – 1990	First phase of the Great Green Belt	Planting **thousands** of hectares of trees and forest species	Establish and protect soil and green areas, and promote reforestation	
2020 – 2020	Anti-desertification and sand encroachment policies	Afforestation and rehabilitation programs on **thousands** of hectares	Reduce land degradation and desertification and combat sand encroachment	
2021	Reforestation and afforestation campaigns	Planting about **1 million** trees in some campaigns	Restore degraded vegetation cover and support vulnerable areas	
2022	Afforestation campaigns in different provinces	Planting **millions** of seedlings of various species	Support biodiversity and increase green spaces	
2023	Resumption of the Great Green Belt	Expanding green spaces and promoting the culture of afforestation	Adapt to climate change and promote sustainable management of natural resources	
2024	Massive and nationwide afforestation campaigns	Planting about **5 million** trees in one day	Restore degraded areas and combat wildfires and protect vegetation cover	
2030 (Future goals)	Future objectives for afforestation and combating desertification	Expanding afforestation to **millions** of trees, including trees and bacteria	Strengthen sustainable development and protect the environment for future generations	

Table 02 summarizes the main environmental initiatives and afforestation programs implemented in Algeria between 1970 and 2030 to combat desertification, protect natural resources, restore degraded ecosystems, and strengthen climate adaptation. It shows that Algeria's environmental policy has evolved progressively from large-scale afforestation projects toward broader strategies integrating land restoration, biodiversity protection, water-resource management, and sustainable development.

The first major initiative was the launch of the Great Green Belt Project in 1970. This project aimed to create an ecological barrier of approximately 1,500 km in order to limit desert encroachment, stabilize soils, protect steppe and agricultural areas, and

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reduce the advance of arid conditions toward northern regions. During the period 1970–1990, the first phase focused mainly on planting trees and shrubs, improving vegetation cover, and reducing wind erosion in vulnerable areas.

In recent years, Algeria has reinforced its environmental response through rehabilitation and reforestation programs covering large degraded areas. The campaigns organized in 2021 and 2022, including the planting of nearly one million trees and several million seedlings, reflect a renewed national effort to restore ecosystems, increase vegetation cover, improve biodiversity, and reduce land degradation. These initiatives are particularly important in steppe and semi-arid areas, where desertification is intensified by drought, overgrazing, soil erosion, and pressure on water resources.

In 2023, the rehabilitation of the Great Green Belt was strengthened as part of Algeria's climate adaptation strategy. This phase represents a shift from simple tree planting toward a more integrated restoration approach, linking afforestation with soil conservation, pastoral management, biodiversity protection, and sustainable land use. The large-scale afforestation campaigns launched in 2024, including the planting of approximately five million trees in one day, further illustrate the increasing political and institutional commitment to ecological restoration and environmental protection.

The objectives projected for 2030 focus on expanding afforestation programs, increasing vegetation cover, reducing desertification risks, improving ecosystem resilience, and supporting sustainable development in vulnerable regions. However, the effectiveness of these initiatives depends not only on the number of planted trees but also on survival rates, species selection, irrigation availability, soil suitability, local community participation, monitoring mechanisms, and long-term maintenance. Therefore, Table 02 should not be interpreted merely as a list of afforestation actions, but as an indicator of Algeria's gradual transition toward a more integrated environmental and climate-adaptation policy.

Overall, Table 02 demonstrates that Algeria has adopted long-term environmental policies combining afforestation, ecosystem restoration, biodiversity conservation, land rehabilitation, and climate adaptation. Nevertheless, to respond to the reviewers' concerns, these programs must be evaluated through measurable indicators such as planted area, tree survival rate, restored hectares, reduction of soil erosion, improvement of vegetation cover, institutional coordination, and regional impact. Such an evaluation is essential to determine whether these initiatives effectively reduce desertification and strengthen environmental resilience in Algeria.

6. Environmental Policies in Algeria

Table 3. Evolution of Environmental Indicators in Algeria during 2010–2024.

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Year	Renewable Energy Share (%)	Waste Recycling Rate (%)	Afforested Area (Thousand ha)	Air Quality Index (AQI)
2010	2.7	4	600	80
2012	3.2	5	650	76
2014	4.1	7	720	71
2016	6.7	9	820	66
2018	9.8	12	950	60
2020	13.5	16	1,050	54
2022	17.2	20	1,200	48
2024	22.6	27	1,400	42

7. Water Security in Algeria

Table 03 presents the evolution of key environmental indicators in Algeria between 2010 and 2024, namely the share of renewable energy, waste recycling rates, afforested areas, and the Air Quality Index (AQI). These indicators provide a general overview of Algeria's environmental progress and its efforts to strengthen sustainable development, reduce pollution, and improve climate-adaptation capacity.

The share of renewable energy increased from 2.7% in 2010 to 22.6% in 2024. This evolution reflects Algeria's growing orientation toward clean energy and the gradual diversification of its energy mix. It also indicates an effort to reduce dependence on fossil fuels, limit greenhouse gas emissions, and support climate-mitigation objectives.

Waste recycling also improved, rising from 4% in 2010 to 27% in 2024. This progress suggests a gradual strengthening of waste-management policies, environmental awareness, and circular-economy practices. However, the effectiveness of this progress depends on collection systems, sorting infrastructure, recycling capacity, and local implementation mechanisms.

Afforested areas increased from 600 thousand hectares in 2010 to about 1,400 thousand hectares in 2024. This expansion reflects the importance of afforestation and ecological restoration programs in combating desertification, protecting biodiversity, stabilizing soils, and restoring degraded ecosystems. Nevertheless, the real impact of these programs should be assessed using measurable indicators

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such as tree survival rate, restored land area, vegetation-cover improvement, and long-term maintenance.

The Air Quality Index improved from 80 in 2010 to 42 in 2024, since lower AQI values indicate better air quality. This trend may reflect the combined effects of pollution-control measures, renewable-energy development, urban greening, and improved environmental management. However, this indicator requires clear data sources, measurement locations, and calculation methods to confirm the reliability of the observed improvement.

Overall, Table 03 indicates positive progress in Algeria's environmental management between 2010 and 2024. However, in order to meet scientific and methodological requirements, these results should not be presented only as descriptive trends. They must be supported by verified data sources, clear units, calculation methods, and, where possible, trend analysis. The table therefore highlights both Algeria's environmental progress and the need for stronger monitoring, transparent data, regional comparison, and evidence-based evaluation of policy effectiveness.

Table 4. Evolution of Environmental Indicators in Algeria during 2010–2024.

Indicator	Current Situation (2025)	2030 Target / Outlook
Number of Large Dams	81 dams	86 dams
Water Storage Capacity	8 billion m^3	12 billion m^3
New Dams	0	5 dams
Number of Seawater Desalination Plants	19 plants	25 plants
Daily Desalination Production Capacity	3.7 million m^3/day	5.5 million m^3/day
Drinking Water Coverage from Desalination	42%	60%
Number of Wastewater Treatment Plants	211 plants	250 plants
Wastewater Treatment Capacity	1.0 billion m^3/year	1.4 billion m^3/year

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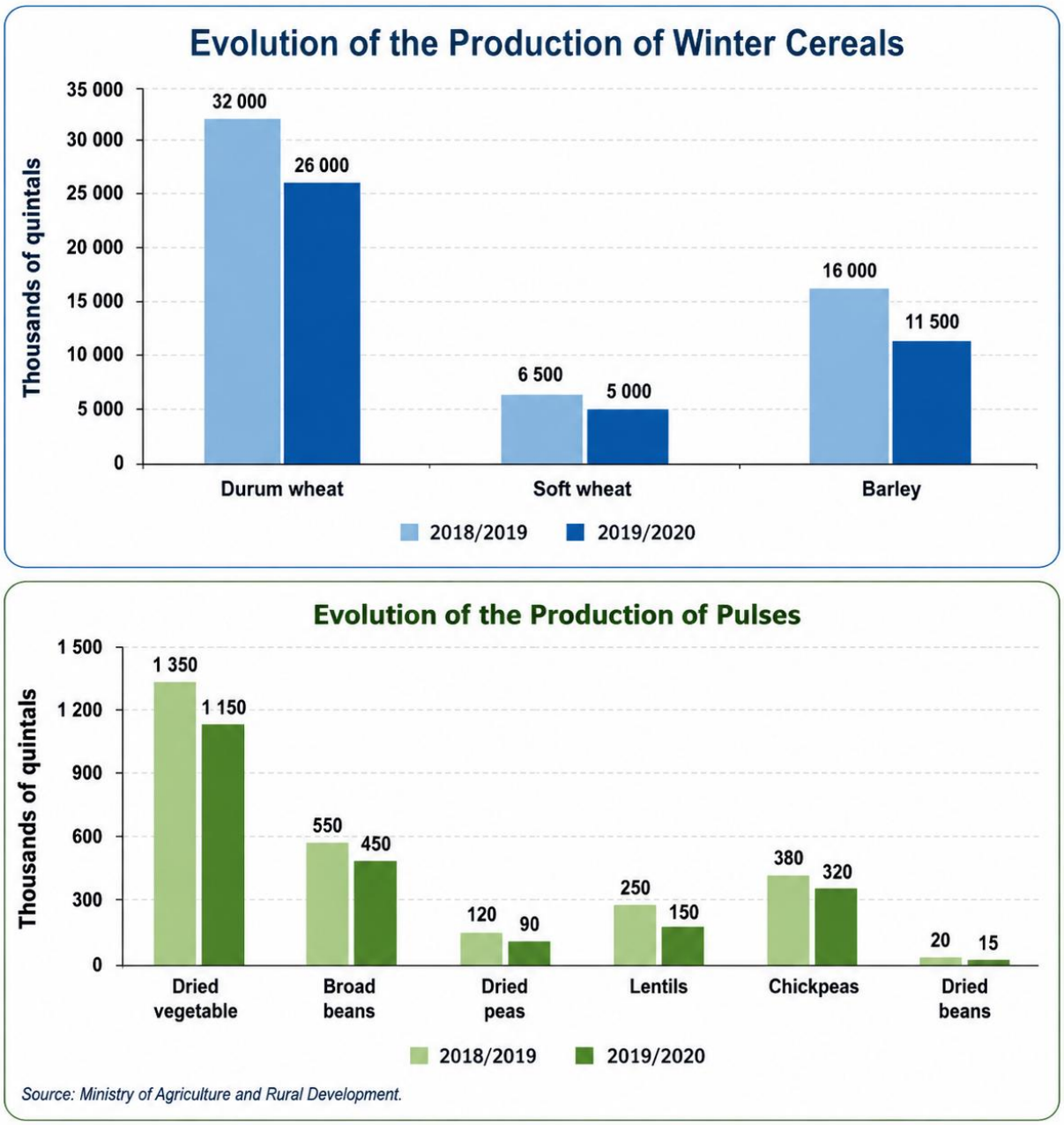


Figure 4. Evolution of winter cereal and pulse production in Algeria during the agricultural seasons 2018/2019 and 2019/2020.

Figure 4 illustrates the evolution of agricultural production for winter cereals and pulses in Algeria during the 2018/2019 and 2019/2020 agricultural seasons. The graph shows a general decline in production for most agricultural products between the two seasons, reflecting the increasing vulnerability of Algerian agriculture to climatic variability and water stress.

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For winter cereals, durum wheat recorded the highest production in both seasons, although production decreased from approximately 32,000 thousand quintals in 2018/2019 to about 26,000 thousand quintals in 2019/2020. Barley production also declined significantly, while soft wheat showed a moderate reduction. These decreases may be associated with reduced rainfall, recurrent droughts, rising temperatures, and increasing pressure on water resources, particularly in semi-arid and steppe regions where cereal production strongly depends on climatic conditions.

Similarly, pulse production experienced noticeable fluctuations. Dried vegetables, broad beans, lentils, chickpeas, and dried peas generally recorded lower production levels during 2019/2020 compared with the previous season. This trend confirms the sensitivity of rain-fed agriculture to climate variability and irregular precipitation patterns in Algeria.

The figure also highlights the importance of strengthening climate adaptation policies in the agricultural sector through improved irrigation systems, drought-resistant crops, sustainable water-resource management, soil conservation, and modernization of agricultural practices. Furthermore, supporting food security in Algeria requires integrated environmental and agricultural policies capable of reducing the impacts of climate change and desertification on agricultural productivity.



Figure 5. Domestic water cycle and sustainable water-management solutions for agricultural areas.

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5. Conclusion

Climate change has become a major environmental and strategic challenge for Algeria, particularly because it accelerates desertification in arid and semi-arid regions. Rising temperatures, irregular rainfall, recurrent droughts, soil degradation, vegetation loss, and increasing pressure on surface and groundwater resources have intensified environmental vulnerability and created serious risks for agriculture, biodiversity, food security, and socio-economic stability.

The analysis shows that desertification in Algeria results from the interaction between climatic and anthropogenic drivers. Climatic factors include drought, rainfall decline, heat stress, and water scarcity, while human drivers include overgrazing, deforestation, unsustainable agricultural practices, urban expansion, industrial pressure, and excessive groundwater exploitation. Therefore, desertification should not be interpreted as a purely climatic phenomenon, but as a multidimensional process shaped by environmental, social, economic, and institutional factors.

The review of national response policies indicates that Algeria has adopted several important measures, including the rehabilitation of the Great Green Dam, afforestation campaigns, forest and pastoral protection, renewable energy development, seawater desalination, wastewater treatment and reuse, dam construction, and water-saving programs. These initiatives demonstrate a clear national commitment to climate adaptation and environmental protection. However, their effectiveness remains uneven because many programs still require stronger monitoring systems, measurable indicators, regional evaluation, long-term maintenance, and transparent data on implementation outcomes.

A major finding of this study is that Algeria's environmental policies need to move from general description toward evidence-based evaluation. Future assessments should measure policy performance using concrete indicators such as restored hectares, tree survival rates, vegetation-cover improvement, reduction of soil erosion, groundwater recovery, wastewater reuse volumes, renewable-energy contribution, and regional vulnerability reduction. Without such indicators, it remains difficult to determine whether existing policies have effectively reduced desertification or improved adaptation capacity.

The study also highlights the importance of regional differentiation. The Sahara, steppes, high plateaus, mountains, and coastal areas do not face the same environmental pressures and therefore require different adaptation priorities. In Saharan regions, water scarcity and groundwater protection should be prioritized. In steppe areas, overgrazing control, rangeland restoration, and vegetation recovery are essential. In the high plateaus, sustainable agriculture and soil conservation are priorities, while mountain and coastal regions require erosion control, forest-fire prevention, and protection of coastal ecosystems.

Environmental governance remains a central condition for successful adaptation. Stronger institutional coordination, local authority involvement, scientific monitoring, transparent data sharing, environmental education, and civil-society participation

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are necessary to improve policy implementation. Algeria's environmental legislation and international commitments provide an important foundation, but their impact depends on effective enforcement, intersectoral cooperation, and continuous evaluation.

In conclusion, combating desertification and adapting to climate change in Algeria require an integrated, evidence-based, and regionally differentiated approach. National strategies should combine environmental protection, sustainable land management, rational water-resource use, ecological restoration, renewable energy development, and social participation. Strengthening monitoring systems, improving policy evaluation, and aligning national actions with international frameworks such as land degradation neutrality, integrated water-resource management, and climate adaptation are essential to improve environmental resilience and ensure sustainable development for present and future generations.

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