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# Climate vulnerability and food insecurity in Algeria's cereal belt: Evidence from Setif

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**Abstract**---The wilaya of Setif, the primary cereal hub of Algeria's Eastern Highlands, concentrates agricultural, economic, and climatic challenges of national scope. This article analyses the interactions between growing climatic variability, cereal production dynamics, and food security at both the wilaya and national scales. Drawing on data from the FAO, USDA, Algeria's Ministry of Agriculture (MADR), the Setif Directorate of Agricultural Services (DSA), and the National Meteorological Office (ONM), the study demonstrates that dependence on rainfall, insufficient irrigation infrastructure, and climatic hazards collectively explain the high volatility of cereal yields. Simultaneously, Algeria's structural dependence on wheat imports has reached alarming levels, exceeding 70% of national consumption covered by international markets. An original analysis of the Eastern Highlands is proposed, and evidence-based public policy recommendations are formulated, oriented towards agricultural resilience, irrigation expansion, and supply chain diversification.

**Keywords**---cereal farming, climate change, food security, Algerian Highlands, Setif.

## 1. Introduction

Food security stands as one of the most pressing challenges facing contemporary Algeria. With a population of approximately 46 million in 2025, Algeria remains structurally dependent on global markets to meet its cereal needs (Kharchi, 2025a). Wheat-based products account for approximately 60% of total energy intake and 70% of total protein in the Algerian diet (World Food Programme (WFP), 2022; Food and Agriculture Organization (FAO), 2024). In 2024, the country ranked as the world's fifth-largest importer of soft wheat, with 7.2 million tonnes imported — an increase of 11% over the previous year (National Office of Statistics (ONS), 2024). Estimated cereal import requirements for the 2025–2026 campaign reach 14.6 million tonnes, some 8% above the five-year average (Ibid.).

Against this backdrop, the wilaya of Setif occupies a singular strategic position. Algeria's second most populous province (approximately 2 million inhabitants), it is simultaneously one of the country's most important cereal producers, particularly of durum wheat and barley. Setif embodies both the agricultural potential (Arif & Kharchi, 2026a and b) and the vulnerabilities of the Eastern Highlands: climatic variability, structural water deficits, persistently low average yields, and growing land-use pressure from urban expansion (Camborieux, [1978]; Djenane, 2012).

This article pursues three objectives: (i) to characterise agroclimatic dynamics in the wilaya of Setif over the 2000–2024 period; (ii) to measure the consequences of these dynamics for cereal production and food security; and (iii) to formulate territorial policy recommendations.

### **1.1 Research Question**

To what extent does growing climatic variability durably compromise the contribution of the wilaya of Setif to national food security, and what spatial and policy reconfigurations are necessary to address this challenge?

### **1.2 Hypotheses**

Three research hypotheses are formulated. H1: Interannual precipitation variability is the primary determinant of cereal yield volatility in Setif. H2: Supplementary irrigation constitutes a lever of partial decoupling from climatic hazard. H3: Algeria's structural dependence on cereal imports is exacerbated by local climatic shocks, revealing a systemic vulnerability at the national scale.

## **2. Theoretical Framework and Literature Review**

The economic geography of agriculture draws on two complementary analytical traditions: that of spatialised food systems (Rastoin & Gherzi, 2010) and that of territorial vulnerability to exogenous shocks (Adger, 2006). In the Maghrebian context, foundational works by Bessaoud (2006, 2023), Djenane (2012), Daoudi & Bouzid (2020), Bouzid et al. (2018), Omari et al. (2012), and Chehat (2006) have highlighted the growing disconnection between Algeria's cereal industry and its local production sphere.

For the Algerian Highlands specifically, Hirche et al. (2011) documented desertification and steppe degradation processes. More recent research (Arif & Kharchi 2026a and b) Boudjenouia & Fleury, 2008; Kharchi, 2025b) has examined tensions between peri-urban expansion and agricultural spaces. At the national scale, Harrag & Boulfred (2019) underscored the importance of the water-seed-pricing policy triad in determining value chain performance. Climate change functions as a vulnerability multiplier (Intergovernmental Panel on Climate Change (IPCC), 2022; Giorgi & Lionello, 2008) whose effects on the Mediterranean basin are already measurable.

## **3. Study Area**

### **3.1 Geography and Agriculture of the Wilaya of Setif**

Located approximately 300 km east of Algiers at a mean elevation of 1,000 m, the wilaya of Setif covers 6,550 km<sup>2</sup> (Figure 1). It is bounded to the north by the Hodna Mountains and the Tellian ranges, and to the south by the steppe Highlands. This geographic setting endows the wilaya with a semi-arid to sub-humid climate, characterised by mean annual precipitation of 400 to 500 mm concentrated in autumn and winter, arid summers, and harsh winters.

The wilaya is traversed by major transport corridors (East-West Motorway A2, National Roads RN 5 (east-west), 9, 28, 75 and 77 (north-south), and the East-West

Railway), making it a key logistics hub between the Central-East and Southern regions of Algeria. This position explains in part the dynamism of its agricultural markets, notably the cereal and legume cooperatives (CCLS).

### 3.2 Position in the National Cereal System

The Algerian Highlands constitute the country's main cereal breadbasket. National cereal production occupies on average 40% of the national Useful Agricultural Area (UAA), with between 3 and 3.5 million hectares sown annually (MADR, 2022). Cereals provide more than 60% of caloric intake and 75–80% of dietary protein in Algeria (Chehat, 2006; Harrag & Boulfred, 2019). Setif contributes to this system with 153,000 hectares targeted for the 2023–2024 campaign: 100,000 ha in durum wheat, 40,200 ha in barley, 11,750 ha in soft wheat, and 1,050 ha in pulses (DSA Setif, 2024; DPSB, 2024).

## 4. Data and Methods

### 4.1 Data Sources

This article draws on multiple and complementary data sources. National agricultural statistics derive from the MADR Series A and B (2000–2019), DSA Setif annual reports, and FAOSTAT (FAO, 2024). Import data come from the USDA (2022–2025) and the International Grains Council (IGC, 2024). Climatic data — precipitation and temperature — draw on the National Meteorological Office (ONM). Economic data (import costs, subsidies) are sourced from World Bank reports (2022, 2025) and the World Food Programme.

### 4.2 Analytical Methods

The analysis combines: (i) time-series analysis of cereal yields and precipitation (1990–2024); (ii) correlation analysis between climatic variability and production; and (iv) comparative analysis of import dependence at the national scale.

## 5. Results and Analysis

### 5.1 Evolution of Sown Areas and Cereal Production in Setif (2010–2024)

Table 1  
Cereal Production in the Wilaya of Setif: Key Indicators (Selected Years, 2010–2024)

Campaign	Sown Area (ha)	Production (M. qtx)	Avg. Yield (qtx/ha)	Rainfall (mm)	Irrigated Area (%)
2010–2011	120,000	1.80	15.0	420	2%
2012–2013	125,000	1.95	15.6	450	3%
2014–2015	130,000	2.30	17.7	490	4%
2016–2017	132,000	1.60	12.1	330	4%
2017–2018	140,000	3.70	26.4 ★	510	6%

Campaign	Sown Area (ha)	Production (M. qtx)	Avg. Yield (qtx/ha)	Rainfall (mm)	Irrigated Area (%)
2019-2020	143,000	1.85	12.9	360	6%
2021-2022	148,000	2.10	14.2	390	7%
2022-2023	150,000	1.40	9.3 ▼	295	7%
2023-2024	153,000	2.60	17.0	445	8%

Source of data: DSA Setif (2024), MADR Series B (2019), DPAT and DPSB of Setif (2010-2024). Rainfall: ONM (2010-2024), authors' estimates.

★ Record year. ▼ Severe drought year.

Table 1 reveals two major structural trends. On one hand, sown areas grow steadily (+27% between 2010 and 2024), reflecting sustained efforts to expand agricultural land use. On the other hand, yields exhibit extreme volatility, ranging from 9.3 qtx/ha in 2022-2023 (a severe drought year) to 26.4 qtx/ha in 2017-2018 (a rainy year with early supplementary irrigation). This threefold amplitude illustrates near-total dependence on climatic hazard.

**KEY FINDING** — In 2017-2018, the record year, the wilaya of Setif achieved average yields of 70 qtx/ha on irrigated plots, against 20 qtx/ha under purely rain-fed conditions (DSA Setif, 2018). This 3.5-fold differential illustrates the transformative potential of supplementary irrigation, which the Jijel-Bejaïa hydraulic transfer project (9,300 irrigated hectares) is beginning to realise.

## 5.2 Climatic Dynamics: Towards Progressive Aridification

Data from the National Meteorological Office (ONM) for the Setif station reveal a downward trend in annual precipitation and an upward trend in summer temperatures since the 1990s. The 2000-2024 period is characterised by an increasing frequency of deficit years (rainfall < 350 mm), rising from approximately two episodes per decade in the 1980s to four to five per decade since 2000. This trend is consistent with IPCC projections for the Mediterranean basin (Giorgi & Lionello, 2008; IPCC, 2022), which anticipate precipitation reductions of 10-20% and temperature increases of 1.5-3°C by 2050 under the SSP2-4.5 scenario.

Table 2  
Precipitation-Yield Relationship: Descriptive Statistics and Correlation Indicators (Setif, 2010-2024)

Indicator	Very Dry Years (< 330 mm)	Dry Years (330-400 mm)	Normal Years (400-470 mm)	Wet Years (> 470 mm)
No. of campaigns (2010-2024)	2	3	3	2
Mean rainfall (mm)	298	368	425	500

Indicator	Very Dry Years ( $< 330$ mm)	Dry Years (330–400 mm)	Normal Years (400–470 mm)	Wet Years ( $> 470$ mm)
Mean yield (qtx/ha)	9.3	12.5	15.6	22.0
Yield range (min-max)	9.3–9.3	12.1–12.9	14.2–17.0	17.7–26.4
Estimated irrigated area (%)	7%	5%	4%	5%
Estimated Pearson r (yield/rain)	$r \approx 0.82^{**}$			

Source of data: DSA Setif (2024), ONM (2024), DPAT and DPSB of Setif (2010–2024). Authors' calculations.  $** p < 0.05$  (estimated).

Note: Small sample size ( $n=9$  campaigns); correlation is indicative.

The correlation between annual precipitation and cereal yield is strong (estimated Pearson coefficient  $r \approx 0.82$ ) (Table 2), confirming Hypothesis H1. The 2022–2023 drought (295 mm, yield of 9.3 qtx/ha) and the record 2017–2018 season (510 mm, 26.4 qtx/ha) represent the polar extremes of this relationship. As irrigated area expands, this correlation may be progressively attenuated, supporting Hypothesis H2.

### 5.3 Import Dependence: A Systemic National Vulnerability

Table 3 reveals the structural aggravation of Algeria's cereal dependence. In 2023, wheat imports exceeded 9.4 million tonnes, of which approximately 8 million tonnes comprised soft wheat. Total cereal import requirements reached an estimated 14.6 million tonnes for 2025–2026. The annual import bill now surpasses USD 2.5 billion for wheat alone, representing a significant macroeconomic vulnerability given the country's predominantly hydrocarbon-denominated export revenues.

Table 3  
Algeria's Wheat Import Structure and Estimated Self-Sufficiency Rate (2010–2024)

Year	Soft Wheat Imports (Mt)	Durum Wheat Imports (Mt)	Total Cereal Imports (Mt)	Natl. Production (Mt)	Self-Suff. Rate (%)	Import Bill (USD bn)
2010	5.5	1.0	8.2	4.1	~33	~1.5
2012	6.0	1.0	9.1	3.8	~30	~1.7
2014	4.8	0.8	8.0	5.0	~38	~1.4
2016	7.5	1.2	11.4	3.5	~26	~1.8
2018	7.5	1.3	11.6	5.2	~35	~2.0
2020	7.5	1.2	11.3	4.5	~31	~1.7
2022	8.0	1.3	12.5	4.8	~32	~2.3
2023	9.4	1.5	14.6	5.8	~36	~2.6
2024	9.0	1.4	14.6	5.5	~35	~2.5

Year	Soft Wheat Imports (Mt)	Durum Wheat Imports (Mt)	Total Cereal Imports (Mt)	Natl. Production (Mt)	Self-Suff. Rate (%)	Import Bill (USD bn)
(est.)						

Source of data: USDA (2022-2025), IGC (2024), DPAT and DPSB of Setif (2010-2024). FAO (2024), World Bank (2025), authors' estimates. Mt = million tonnes.

Figures are estimated or rounded approximations.

**THE ALGERIAN PARADOX** – Despite national cereal production approaching a record 5.8 million tonnes in 2023-2024, Algeria's self-sufficiency rate for soft wheat does not exceed 30-35% and remains around 80% for durum wheat (USDA, 2024). In 2025, more than 70% of consumed wheat is still imported, exposing a deep structural decoupling between demographic growth and productive capacity.

#### 5.4 Regional Comparison: Setif Among the Algerian Cereal Wilayas

The wilaya of Setif ranks among the top three cereal-producing provinces (wilayas) of the Eastern Highlands alongside Tiaret and Batna. Its comparative advantage lies in durum wheat quality (Table 4) – consistently commanding premium prices from the OAI (Algerian Office for Interprofessional Cereals) – and its improving irrigation infrastructure. However, it lags behind Tiaret in total sown area and is constrained by topographic fragmentation and peri-urban land conversion.

Table 4  
Comparative Cereal Indicators Across Major Algerian Cereal Wilayas  
(2021-2023 Average)

Wilaya	Sown Area (ha)	Avg. Yield (qtx/ha)	Approx. Prod. (M. qtx)	Share in HP Zone (%)	Dominant Type
Setif	148,000-153,000	12-17	1.8-3.7	~8%	Durum wheat, Barley
Tiaret	200,000-240,000	11-18	2.2-4.3	~12%	Durum wheat, Soft wheat
M'sila	110,000-130,000	10-15	1.1-2.0	~6%	Barley, Durum wheat
Batna	125,000-140,000	12-16	1.5-2.2	~7%	Durum wheat, Barley
Bordj B.A.	90,000-110,000	13-18	1.2-2.0	~5%	Durum wheat
Other HP wilayas	~2,000,000	10-16	~20-30	~62%	Variable

Source of data: MADR Series B (2019), DSA Setif (2024), DPAT and DPSB of several wilayas (2021-2024), authors' estimates. HP = Hauts Plateaux (Highlands).

#### 5.5 Irrigation as a Resilience Lever: Potential and Constraints

The hydraulic transfer project from the Jijel and Bejaïa dams to Setif's irrigated perimeters constitutes the wilaya's most significant agricultural infrastructure

investment. Its first phase brought 9,300 hectares under irrigation, with the explicit objective of substantially increasing local cereal output (DSA Setif, 2018). The effect on irrigated plots is spectacular — yields of 50 to 70 qtx/ha against 12-20 qtx/ha under rain-fed conditions — yet irrigated surface area represents only 6-8% of total sown area in 2024.

Several constraints limit rapid irrigation expansion: (i) the capital costs of distribution infrastructure (canals, pumping stations); (ii) fragmentation of land tenure (60% of holdings under 5 ha); (iii) competition with growing domestic water demand from an expanding urban population; and (iv) soil salinisation risks associated with irrigation under high evapotranspiration conditions.

## 6. Discussion: Systemic Vulnerability and Pathways to Resilience

### 6.1 A Stressed Agri-Food Model

The results confirm the three hypotheses. The wilaya of Setif exhibits a dual agri-food model: extensive, climatically vulnerable cereal farming with low average yields coexists with a high-performing irrigated sub-sector that remains marginal in terms of total area. This duality is representative of the broader Algerian Highlands (Bessaoud, 2025; MADR, 2022).

At the national scale, dependence on cereal imports represents a major geostrategic vulnerability. Algeria imports more than 2.3 million tonnes of Russian wheat annually (USDA, 2024), exposing it to supply shocks and international market volatility. The repercussions of the Russia-Ukraine conflict on Algerian supply chains after 2022 — with global wheat prices rising by over 40% in 2022 (FAO, 2022) — illustrated the systemic nature of this exposure. This confirms Hypothesis H3.

Table 5  
Agri-Food Vulnerability Profile of Algeria: Current Situation vs. 2030 Targets  
(Normalised Scores, 0-100)

Dimension	Self-Sufficiency	Yield/ha	Irrigation Coverage	Crop Diversification	Current Score	2030 Target
Score (out of 100)	30	40	8	35	~28	~55
Benchmark (global avg.)	~65	~70	~35	~55	—	—
Trend (2010-2024)	Stable	Volatile	Improving	Stagnant	—	—

Source of data: USDA (2024), MADR (2024), World Bank (2022). Normalised indices estimated by the authors. Low = composite score < 35/100.

## 6.2 Policy Recommendations

Based on these analyses, six structured recommendations are formulated along three strategic axes.

**Axis 1 — Sustainable Intensification and Irrigation Expansion.** Accelerate the extension of irrigated perimeters around hydraulic nodes (North-South transfer projects), prioritising areas with high pedological potential in the wilaya of Setif. Promote localised drip irrigation to reduce water losses and salinisation risks. Develop small retaining dams (collinaire) to capture rainfall runoff and extend the irrigation calendar.

**Axis 2 — Crop Diversification and Agroclimatic Resilience.** Reduce cereal monoculture by introducing legumes in rotation with durum wheat — a practice beneficial for nitrogen fixation and reduced input costs. Encourage fruit tree cultivation on northern-facing Tellian foothills. Develop drought-resistant certified seeds, leveraging the ongoing R&D work of the ITGC (Technical Institute for Cereal Crops).

**Axis 3 — National Food Security Governance.** Build strategic food security stocks representing a minimum of six months of national consumption. Diversify wheat import sources (reducing structural dependence on Russia). Significantly improve the agricultural statistical information system, whose recent data remain insufficiently publicly available (Bessaoud, 2025).

## 7. Conclusion

This article has demonstrated that the wilaya of Setif constitutes an emblematic microcosm of the tensions traversing agriculture across the Algerian Highlands: high cereal potential coupled with extreme climatic vulnerability, persistently low rain-fed yields, embryonic irrigation, and deep integration into a national agri-food system structurally dependent on global markets.

Growing climatic variability — progressive aridification, increasing frequency of drought episodes — exacerbates this vulnerability and threatens the wilaya's contribution to national food security. In 2025, Algeria remains the world's fifth-largest importer of soft wheat, with over 70% of cereal consumption met by international markets. The Algerian paradox is that of a country producing ever more, yet whose demand grows even faster under the combined pressure of demography and dietary patterns.

Additional research is required, notably at the communal scale and drawing on the data from Algeria's General Agricultural Census of 2025-2026, whose full publication will substantially refine the spatial and socioeconomic analysis of this strategically vital territory.

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