

AGRICULTURAL PRODUCTION DYNAMICS UNDER THE INTERACTION OF WATER RESOURCES AND DEMOGRAPHIC PRESSURE: A SPATIAL STUDY OF THE SUSTAINABILITY OF AGRICULTURAL SYSTEMS IN AÏN DEFLA PROVINCE

ديناميكيات الإنتاج الزراعي في ظل تفاعل الموارد المائية والضغط الديموغرافي: دراسة مجالية لاستدامة النظم الزراعية في ولاية عين الدفلى.

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ABSTRACT

This study analyzes the interaction between population growth and the sustainability of agricultural resources in Aïn Defla, emphasizing the role of demographic pressure and water scarcity in reshaping land use. It highlights the transition toward intensive and water-dependent agriculture. The study concludes that the lack of integrated spatial planning accelerates resource degradation and undermines agricultural sustainability and food security.

Keywords: Demographic Pressure; Food Security; Water Scarcity ; Water Stress.

ملخص

تتناول هذه الدراسة إشكالية التفاعل بين النمو الديموغرافي واستدامة الموارد الزراعية في ولاية عين الدفلى، من خلال تحليل التحولات البيئية التي طرأت على أنماط استخدام الأراضي الزراعية تحت تأثير تزايد الضغط السكاني وتنامي العجز في الموارد المائية. وتهدف إلى الكشف عن مدى قدرة الأنظمة الزراعية المحلية على التكيف مع هذه التحديات المتزايدة، في ظل الطلب المتنامي على الغذاء والموارد الطبيعية. وتبرز النتائج اتجاهاً متزايداً نحو تبني أنماط زراعية مكثفة تعتمد بدرجة كبيرة على الري واستغلال الموارد المائية، بدلاً من الزراعة المعاشية التقليدية التي كانت أكثر ارتباطاً بالظروف الطبيعية المحلية. كما تشير الدراسة إلى أن هذا التحول، رغم مساهمته في رفع الإنتاجية الزراعية وتحسين المردود الاقتصادي، يطرح تحديات بيئية تتعلق بتشييد استهلاك المياه والحفاظ على

خصوبة التربة وضمان استدامة الموارد الزراعية على المدى الطويل. ومن ثم، تؤكد الدراسة أهمية تبني سياسات زراعية متكاملة تراعي التوازن بين متطلبات التنمية الزراعية وضمان الاستغلال المستدام للموارد الطبيعية.

الكلمات المفتاحية:

الموارد المائية، الزراعة، النمو الديموغرافي، الامن الغذائي، الإستدامة.

1. INTRODUCTION

Aïn Defla Province, a semi-arid region, is facing growing food security constraints driven by climate change and rapid demographic expansion. Increasing drought frequency, declining rainfall, and rising temperatures have significantly degraded fragile agro-ecosystems, while population growth has intensified pressure on food, water, and agricultural land.

Water availability represents the main limiting factor structuring agricultural production, land use, and territorial productivity. Despite the presence of hydraulic infrastructure, unsustainable water exploitation continues to undermine agricultural resilience. In 2025, the province’s population reached approximately one million, with only 21% of agricultural land under irrigation, highlighting structural vulnerability in water management systems.

Using an integrated geographic approach based on remote sensing, agricultural statistics, and climate data (2008–2025), the study examines spatio-temporal land-use changes, identifies key drivers of agro-ecosystem transformation, and proposes strategies to improve water governance, irrigation efficiency, and territorial resilience in semi-arid contexts.

2. Research Problem (Concise High-Impact Version)

Aïn Defla Province has experienced rapid demographic growth, driving higher food demand and the expansion of cultivated areas, particularly the field crops and horticulture (Directorate of Agricultural Services of Aïn Defla, 2022; General Population and Housing Census, 2025). Simultaneously, recurrent climatic

pressures -including prolonged droughts and irregular rainfall—directly affect the productivity of both irrigated and rained systems (Koudiri et al., 2019; Boudiaf et al., 2018).

Accordingly, the central research question can be formulated as follows: This study examines the extent to which rapid population growth and climatic stress jointly shape the spatial structure of agricultural land use in Aïn Defla Province, with a focus on agricultural production systems. It analyzes how demographic expansion, limited land availability, and climate variability influence the productivity of irrigated crops, cereals, and vegetables, as well as the efficiency of land-use allocation under increasing environmental constraints.

Using an integrated methodology combining agricultural statistics, census data, and remote sensing imagery, the research provides a multi-dimensional assessment of agro-ecosystem dynamics. The findings highlight the growing pressure on land and water resources and assess the system’s capacity to adapt to future climatic variability through more efficient spatial planning and resource management.

2- 1- Methodological Approach and Research Problem:

This study assesses the interaction between demographic growth and climatic variability in reshaping agricultural production systems in Aïn Defla Province over 2008–2025. It focuses on spatial and temporal changes in land use and crop patterns, particularly irrigated agriculture, cereals, and horticulture, under increasing environmental and population pressures.

An integrated approach combining demographic data, agricultural statistics, hydrological information, and remote sensing (Landsat ETM and Landsat 8 OLI) with GIS techniques was used to analyze agro-ecosystem dynamics at the municipal scale.

The results indicate that the combined effects of population pressure and climate stress significantly alter the spatial organization of agriculture, increasing pressure on water and land resources. The study highlights the need for improved land-use

planning and irrigation management to enhance food security and agricultural resilience in semi-arid contexts.

2-2 -Spatial and Temporal Analysis:

The reliance on longitudinal data spanning 2008 to 2025, disaggregated at the municipal level, allows for detailed monitoring of land-use dynamics and spatial transformations of agricultural production (Directorate of Agricultural Services of Aïn Defla, 2022).

2.3- Integration of Demographic and Environmental Variables:

The study explicitly links demographic dynamics (population growth and migration) with constrained water resources and agricultural productivity, representing a robust analytical framework to investigate socio-ecological resilience and territorial food security in a semi-arid context (Boudiaf et al., 2018; Benazzouz et al., 2020).

2-4 - Study Methodology:

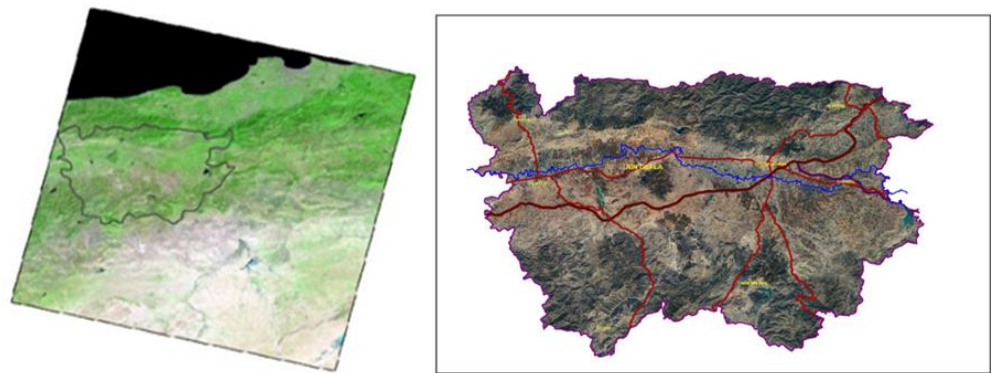
This study relies on a multi-dimensional and integrative methodological framework, combining statistical analytical methods with spatial analysis to study the dynamics of agricultural production and land use in the Wilaya of Ain Defla. Quantitative data were extracted from several reliable sources, including agricultural statistics from the Wilaya's Directorate of Agriculture, demographic data from the Wilaya's Statistics Office, and hydrology and irrigation data from the Wilaya's Directorate of Irrigation and Drainage, as well as from the Hydraulic Basin Agencies (Agence de Bassin Hydrologique), covering the period from 2010 to 2025 (Directorate of Agriculture of Wilaya of Ain Defla, 2025). This multi-source compilation facilitates precise monitoring of agricultural production dynamics. - The study explicitly uses population dynamics and agricultural irrigation to address the research problem presented

3- Study Area – Aïn Defla Province

Aïn Defla Province is located in northern Algeria and is characterized by significant physiographic and environmental diversity. The province is structured into three main natural units:

- a. **Dhahra–Zekkar-Mountain Range (North)**
The northern mountainous zone is marked by steep slopes and complex geomorphology, which make it prone to soil erosion, landslides, and alluvial deposition in lower areas. These geomorphic constraints limit large-scale agriculture, restricting cultivation to small plots or terraces oriented primarily toward subsistence farming.
- b. **Ouarsenis Mountains (South)**
The Ouarsenis Mountains form a natural barrier to the south of the Upper Chélif Plain. The rugged terrain mirrors that of the northern sector, limiting intensive agriculture. Slopes and valleys are highly vulnerable to water erosion, and the mountainous topography imposes challenges for the expansion of infrastructure and irrigation networks.
- c. **Upper Chélif Plain (Central)**
Located between the northern and southern mountain ranges, the Upper Chélif Plain constitutes the most important agricultural area in the province. The plain features fertile soils suitable for cereals, vegetables, and strategic crops. Despite its productivity, the plain is exposed to several environmental hazards, including:
 - ✓ **Soil and water salinization**, affecting crop yields.
 - ✓ **Flooding in low-lying areas**, particularly during periods of intense rainfall.
 - ✓ **Seismic vulnerability**, as the plain has relatively higher earthquake exposure compared to surrounding mountainous regions.The province extends approximately 80 km from east to west in a roughly hexagonal shape. Its marked topographic heterogeneity strongly influences land-use patterns, agricultural practices, irrigation requirements, and strategies for managing natural hazards(Look at Map 1 and Map 2)

Map 1 and 2 :Satellite imagery of the location of Aïn Defla Province from the LANDSAT



Produced by the researcher based on LANDSAT 8 satellite data

Source: Prepared by the researcher based on satellite imagery from Landsat 2024

4- Climate and Hydrology of Aïn Defla Province

Aïn Defla Province is situated within a continental climatic zone characterized by pronounced seasonal contrasts. Summers are hot and dry, resulting in elevated evapotranspiration rates and rendering irrigation indispensable for sustaining crop productivity. Winters are cold and humid, providing favorable conditions for rained agriculture across the plains and mountain slopes.

Annual precipitation in the province ranges between 500 and 600 mm, exhibiting high interannual variability. Recurrent drought events exacerbate water stress, increasing the vulnerability of local agro-ecosystems and placing additional pressure on finite water resources .

The province’s hydrological infrastructure is anchored by a network of major dams, which regulate water availability for agricultural and domestic use. Key structures include: DJlida - Ouled Melouk - Drader - Arib - Oued Cherfa

Recent declines in reservoir levels have underscored the urgency of implementing integrated water management strategies and adopting climate-adaptive agricultural practices. These measures are critical for enhancing water use efficiency, sustaining crop yields, and strengthening the socio-ecological resilience of local farming systems in the face of increasing hydrological constraints.

5- Agricultural Land Structure in Aïn Defla Province

Agricultural land constitutes a significant component of the territorial organization in Aïn Defla province. The total agricultural area amounts to 235,611 hectares, representing 52% of the total provincial surface, of which 181,676 hectares (77% of the total agricultural area) are currently utilized. This high utilization rate reflects - intensive exploitation of available agricultural resources.

The agricultural structure comprises 24,500 farming units, predominantly private holdings. Private farms account for 22,200 units (90% of the total number of farms), covering 183,411 hectares (78% of the total agricultural area), while state-owned farms represent 2,300 units (10% of the total number of farms), with a total area of 52,200 hectares (22% of the total agricultural area). Within the public sector, six pilot farms have been established, covering a total area of 5,407 hectares, to promote targeted production strategies, including dairy production, potato seed, arboriculture, and cereal seed production.

The dynamics of agricultural production in the province are increasingly influenced by demographic growth and recurrent droughts, which exert significant pressure on both land and water resources. These factors particularly affect irrigated crops and vegetables, due to their high dependency on water supply. Additionally, rainfed cereal and vegetable crops experience variability in production caused by shifting rainfall patterns and soil moisture limitations.

Understanding the interactions between land tenure structure, demographic pressures, and climatic factors is essential for planning sustainable agricultural development. The following sections provide a detailed analysis of irrigated crop production, cereal

yields, and vegetable cultivation, highlighting the impact of demographic growth and drought on the spatial distribution and productivity of agricultural land.

6-The Impact of the Natural Environment on Agricultural Activity in Ain Defla Province

A study of the natural environment reveals that the environmental conditions in Ain Defla Province constitute risk factors for the development process, particularly in the agricultural sector. This is primarily because agriculture depends directly on climatic elements such as temperature, rainfall, and humidity, which determine the types of crops suitable for cultivation in the region. In recent years, the area has experienced droughts that have significantly affected agricultural land use, both in terms of production volume and crop types. As a result, there has been a shift in land use patterns toward crops that require less water or can be irrigated using deep wells and dams. However, these water sources have increasingly failed to meet agricultural needs due to declining water levels. For instance, Jlida Dam and Oulad Melouk Dam are now nearly empty, while water levels in Drader Dam, Arib Dam, and Oued Cherfa Dam have also dropped considerably, with the latter holding approximately 103 million cubic meters of water. Consequently, understanding the natural and climatic characteristics of Ain Defla Province is essential for planning and developing the agricultural sector sustainably, by adopting strategies that align with available water resources and climatic variability.

6-1-Climate of Ain Defla Province :

The climate of Ain Defla Province is continental and characterized by its extreme conditions, with hot and dry summers and cold, and humid winters. The upper Cfellif Valley is situated within the 500–600 mm annual rainfall range on the precipitation map. The basin-shaped topography accentuates the continentality of the province, causing cold air to stagnate longer in the valley and making air renewal difficult. The

western opening at Djebel Doui allows the dominant southwest winds to penetrate the region; a phenomenon that negatively affects various crops, especially during bud formation. This directly impacts both the quality and quantity of plant production throughout the valley, particularly fruit trees.

Temperature variations can be significant, reaching up to +20°C. Seasonal temperature differences are considerable, and frost in winter, particularly in spring, limits the cultivation of certain crops. A possible solution could be the use of greenhouses during summer; evapotranspiration is very high, exceeding 50% at midday. Irrigation, thus, becomes essential to sustain crops, especially in the valley floor.

d. The Social and Economic Study of the Wilaya:

1. Population Development and Socio-Economic Impacts in Aïn Defla (1977–2025) reveals the demographic development of Aïn Defla Province, based on successive general population and housing censuses (RGPH), showing a clear shift from rural to urban areas over the past fifty years. The population gradually moved from scattered rural settlements to major urban centers and secondary municipal hubs. This shift has significantly changed the spatial distribution of the population and economic activities throughout the wilaya.

2. Socio-Economic Implications:

1. Rural-Urban Shift: Migration from rural and mountainous areas to urban centers and fertile plains has concentrated the labor force and economic activities, but it also created pressure on urban infrastructure, education, healthcare, and housing. 2. Agricultural Impact: Depopulation of rural areas has led to abandoned agricultural lands, reduced cultivated areas, and disrupted traditional farming systems, increasing the vulnerability of local food production.

Figure 1: Population Growth and Projection in Aïn Defla Province (1977–2025)

Period	Annual Growth Rate (%)	Population Trend	Notes on Socio-Economic Impacts

1977–1987	3.22	Rapid growth	Strong rural communities; expansion of agricultural activities
1987–1998	1.89	Declining rate	Rural out-migration due to security issues; urban concentration
1998–2008	1.5	Moderate growth	Urbanization pressures; abandoned rural lands
2008–2018	1.2	Further slowdown	Increased demand on urban services; strain on labor supply
2018–2025	1.5 (projected)	Gradual increase	Stabilization policies; high youth population; ongoing rural-urban dynamics

- Aïn Defla Province has undergone a sustained demographic transition marked by declining population growth rates (from 3.22% to 1.2%) with a projected moderate recovery (~1.5%), driven primarily by rural out-migration and changing fertility patterns. This shift has resulted in pronounced urban concentration (58.8% urban vs. 16.4% rural in 2025), generating structural rural depopulation, agricultural labor shortages, and increasing pressure on land and production systems.
- Historically, the province experienced significant rural exodus (1987–2005), during which approximately 11,663 families were displaced, accelerating farmland abandonment, land conversion to urban uses, and the erosion of traditional agricultural systems. Despite policy efforts, limited return migration has reinforced long-term spatial imbalances and deepened rural marginalization.
- These demographic dynamics have been compounded by infrastructural constraints, including a housing occupancy rate of 7.3 persons per dwelling, indicating demographic pressure and housing deficits, alongside uneven access to basic services—high electricity coverage (95.7%) contrasted with lower access to gas (32.2%), sanitation (68.6%), and potable water (75%). The health system similarly reflects structural undercapacity relative to population needs.

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- In agricultural terms, although 235,611 hectares are available, only 181,676 hectares are cultivated, with irrigated land limited to 21.3%. Rural depopulation and labor scarcity—particularly in mountainous zones—have increased reliance on mechanization and family labor, raising production costs and reducing system flexibility. Concurrently, urban expansion continues to encroach on fertile agricultural land, altering cropping systems and intensifying competition over scarce resources.
- Overall, the interaction of demographic restructuring, infrastructural disparities, and land-use change is progressively undermining agricultural sustainability and regional food security. These trends highlight the urgency of integrated territorial planning, rural revitalization policies, and improved land–water governance to ensure long-term agro-ecosystem resilience in semi-arid contexts.
- Between 1987 and 2005, Aïn Defla experienced significant rural out-migration, largely driven by security conditions in mountainous and semi-mountainous areas, leading to the displacement of approximately 11,663 families from around 200 rural settlements. This population shift intensified pressure on plains municipalities, which became the main reception areas. The movement had major socio-economic impacts, including widespread abandonment of farmland, disruption of agricultural systems, and a marked decline in rural agricultural activity.
- At the same time, the concentration of displaced populations in urban and peri-urban zones increased demand for basic services such as housing, healthcare, and education. It also contributed to the conversion of agricultural land into urban uses, reducing the available arable land and weakening the agricultural base. Overall, these dynamics significantly altered land-use patterns and rural socio-economic structures, highlighting the need for integrated rural development policies and sustainable land management strategies.

Figure2 : Impact of Urban Sprawl on Agricultural Land

Original Use	Current Us (Output)	Economic & Environmental Impact
Fertile agricultural land	Concrète -blocks résidentiel areas	Loss of productive land for food production
Irrigable plains	Industriel -zones Facilities	Soil permeability deterioration and increased flood risk
Agricultural holdings	Unplanned-Urban expansion	Fragmentation of farmland and difficulties in mechanization

Source: The authors, based on data from the Directorate of Housing, 2024 Report.

To mitigate this economic constraint and reverse the demographic outflow, the government has implemented several development programs aimed at stabilizing rural populations, promoting rural and agricultural activities, and reducing the isolation of these areas. These initiatives fall under the framework of Rural Support Policies, which remain a priority within current social development programs. However, despite these efforts, only about 20% of families have returned to their original rural locations. In absolute terms, only 2,214 families out of 11,663 who had left have returned, while in some depopulated municipalities, areas remain vacant as migrating families have permanently settled in their new destinations.

According to the comprehensive results of the 2008 General Population and Housing Census (RGPH) in Aïn Defla Province, the spatial distribution of the population was as follows: 58.8% resided in primary urban centers, 22.4% in secondary urban centers, and 18.8% in dispersed rural areas. The total number of ordinary and collective households was 122,243, with an average household size of 6.3 individuals. Subsequent census data indicate a slight shift in population distribution: 58.8% in

primary urban centers, 24% in secondary urban centers, and 16.4% in dispersed rural areas, with the total number of households and average household size remaining unchanged.

The total agricultural area (SAT) is estimated at approximately 235,611 hectares, representing 51.8% of the provincial territory. The actual utilized agricultural area (SAU) amounts to 181,676 hectares (77.1% of SAT), while irrigated land (SAI) remains limited at 38,660 hectares, corresponding to only 21.3% of SAU. This pattern of land use reflects a broader global phenomenon known as Rural-Urban Transformation, which reshapes traditional agricultural landscapes, reduces productive land, and restructures the agricultural labor force.

Empirical studies indicate that urban expansion and encroachment on agricultural areas result in substantial losses of cultivated land and declining crop yields, thereby exacerbating food insecurity, particularly in regions experiencing rapid urbanization (Xu et al., 2025; *Science Bulletin*). Furthermore, rural-to-urban migration affects the local agricultural labor supply by attracting the active working-age population away from farming, creating labor shortages closely linked to reductions in cultivated areas and overall production (Ukaro et al., 2018; *Dergipark*). In contexts similar to Aïn Defla, this labor withdrawal contributes to underutilization of arable land and increased reliance on mechanization or family labor, which in turn raises production costs.

Urbanization also intensifies competition for land and labor, driving up input prices and disproportionately affecting smallholder farmers who lack capital and access to modern technologies (Uri System Research). These structural dynamics—including urban expansion, declining rural population density, and labor scarcity—constrain agricultural productivity. They do not only reduce the availability of irrigated and rainfed land but also alter cropping patterns and increase pressure on producers to adapt, often by shifting toward crops with lower labor intensity or higher added value to ensure continuity and profitability.

Studies on global and regional food systems highlight that in the absence of integrated rural development strategies, these trends continue to undermine agricultural sustainability, elevate production costs, and impede efforts to achieve rural food security (see Table 02).

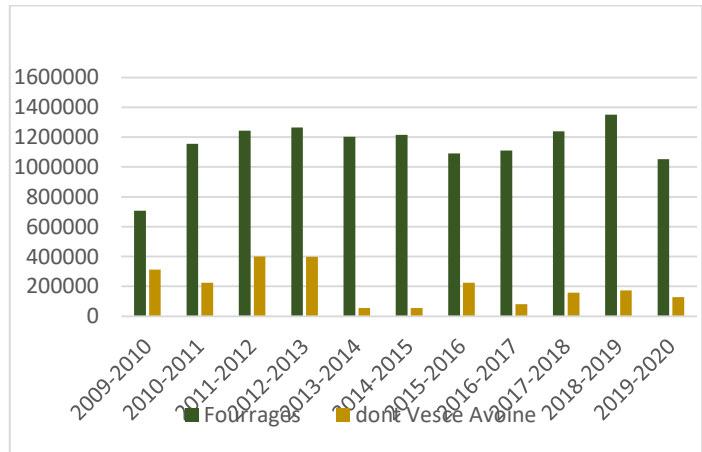
Table 02: Types of Changes and Their Impacts

Type of Change	Geographical / Spatial Impact	Economica Out come
Démographique	Rural-to-urban migration	Loss of skilled agricultural labor
Spatial	Conversion of fertile land into built-up areas	Permanent reduction of productive agricultural land
Production-related	Decline in crop yields and cultivated area	Elevated risk of food insecurity

Source: Authors, based on the data from the Provincial Land-Use Planning Scheme (2024)

Despite the implementation of numerous rural development and agricultural support programs, including technical and logistical assistance for machinery, fertilizers, and financial incentives to promote strategic crops, the sector continues to face structural challenges. In particular, potatoes and wheat have been prioritized under these support schemes, with the state providing direct financial incentives per kilogram of harvested produce. Farmers are often required to store their potatoes until the government or cooperative agencies assess the harvest and determine the purchase price, which can involve significant monetary valuation per kilogram. This mechanism reflects the state’s production support policy, aiming to stabilize income for farmers and encourage investment in strategic crop cultivation. The evolution of agricultural production during the period 2009–2020, as presented in the corresponding table, illustrates the tangible outcomes and limitations of these support interventions.

Figure 03: Evolution of Vegetable Agricultural Production in Aïn Defla Province (2009–2020)



Source: Based on the authors’ analysis of the data presented in Table 01.

Analysis of Table 03 indicates significant fluctuations in both the volume and pace of agricultural production over the period 2009–2020. According to interviews with agricultural technicians and engineers, these variations are primarily attributed to natural and economic factors. Climatic variability, particularly irregular precipitation and pronounced water scarcity, emerges as the dominant determinant affecting crop performance. In addition, agricultural yields have been influenced by the rising cost and variable quality of seeds, as well as increasing input expenses, including fertilizers and other production-related costs.

These findings highlight the vulnerability of local agro-ecosystems to combined climatic and economic pressures. They also underscore the need **for** adaptive management strategies, including improved water resource governance, access to high-quality seeds, and cost-effective input utilization, to stabilize production and ensure territorial food security in Aïn Defla.

6-2- Vegetable Production in Aïn Defla:

Vegetable cultivation in Aïn Defla covers approximately 37,000 hectares, with a total production of about 17,063,400 units and an average yield of 461 units per hectare. Production is spatially concentrated in specific municipalities, reflecting favorable agro-ecological conditions and access to irrigation infrastructure.

Overall, these results highlight the central role of irrigation systems in ensuring production stability under water scarcity conditions. Efficient water management is therefore essential to sustain yields, strengthen agro-ecosystem resilience, and support both food security and rural livelihoods in the province.

This analysis highlights the direct relationship between cultivated area (SAU), irrigated area (SAI), and total available agricultural land (SAT), demonstrating that the sustainability of vegetable production in Aïn Defla is fundamentally contingent upon integrated water resource management, adaptation to demographic pressures, and the agro-ecosystem’s resilience to climatic variability.

Effectively addressing these factors is essential to strengthen territorial food security, preserve rural livelihoods, and mitigate spatial disparities in agricultural productivity across the province. Sustainable management strategies that account for water allocation, labor dynamics, and climatic stress are therefore critical to ensuring both the stability and equity of food production systems within Aïn Defla.

– **Table 3 : Trends in vegetable production**

Crop season	Area	Production	Yield (q/ha)
2010-2015	36351	13259504	365
2015-2016	37476	14607682	390
2016-2017	37500	15694500	419
2020-2025	34385	15271145	444

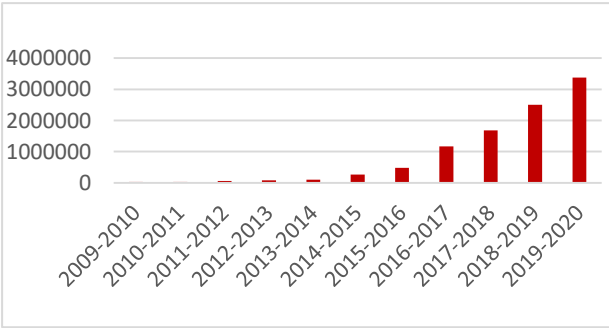
Source: Directorate of Agricultural Services, Aïn Defla Province, Statistics Department, 2025.

Agricultural productivity in Aïn Defla Province is increasingly shaped by the interaction of demographic pressure, rural–urban migration, and recurrent droughts, which jointly reduce labor availability and increase production costs. These

constraints have induced adaptive responses among farmers, including land leasing and partial relocation toward regions with more stable water resources, reflecting the growing vulnerability of local farming systems to climatic variability.

Despite these pressures, the province maintains a strong productive capacity in strategic crops, particularly irrigated vegetables. The sector covers approximately 37,000 hectares and produces over 17 million tons, with high productivity levels driven mainly by potatoes and processing tomatoes. However, this high-output system is highly water-dependent, where even a 10% reduction in water availability can lead to yield losses of 25–35%, highlighting its structural sensitivity to water scarcity; wheat production in Aïn Defla (2010–2020), covering 15,213 hectares with an average yield of 4.3 tons/ha, is mainly rainfed and therefore relatively resilient to irrigation constraints, although it remains influenced by population growth and gradual expansion trends; Overall, the agricultural system is characterized by a structural duality between water-sensitive high-value irrigated crops and more stable cereal production. This pattern reflects significant spatial disparities in productivity driven by uneven water availability and agronomic conditions. Water resources thus represent the main limiting factor of agricultural performance, highlighting the need for integrated water–land management to reduce inequalities, improve efficiency, and ensure long-term food security under increasing climatic and demographic pressures.

Figure 04: Processing tomato



Evolution of Agriculture’s Contribution to GDP (2010–2025)

Between 2010 and 2025, agriculture’s contribution to GDP exhibits only marginal structural change, reflecting a limited transformation of the sector despite short-term fluctuations. The observed variations are primarily driven by macroeconomic conditions rather than endogenous agricultural growth, confirming the weak structural autonomy of the sector.

7- Conclusion

- Agricultural production in Ain Defla is marked by a clear structural duality between high-value but water-dependent irrigated vegetables and more stable rainfed cereals. Although crops such as potatoes and tomatoes generate strong economic returns and position the province as a national production hub, they remain highly vulnerable to water scarcity, climate variability, and demographic pressure.
- Productivity is also characterized by pronounced spatial disparities, mainly driven by uneven water distribution and local agronomic conditions. In contrast, wheat cultivation offers greater resilience but lower economic productivity, reinforcing the trade-off between stability and value within the agricultural system.
- Overall, water availability emerges as the key determinant of agricultural performance, highlighting the need for integrated water–land management, improved irrigation efficiency, and adaptive planning to reduce disparities and enhance the resilience of agro-ecosystems under increasing environmental stress.

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