



Algeria's Agricultural Sector as A Means of Achieving Economic Diversification in The Face of Climate Change

Case Study of GUELMA State



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Merwan DJAHMI*¹, Faouzi SMAALI²

¹ laboratory for digitization and diversification of the Algerian economy, University 8 May 1945 Guelma (Algeria),
djahmi.merwan@univ-guelma.dz

² laboratory for digitization and diversification of the Algerian economy, University 8 May 1945 Guelma (Algeria),
smaali.faouzi@univ-guelma.dz

Abstract

economic slowdown due to the volatility of oil prices in recent years. The Algerian government is trying to diversify its economy. Agriculture is seen as one of the key sectors on which Algeria relies to diversify its economy, achieve food security and reduce agricultural imports.

However, this objective faces the challenges posed by climate change. This study attempts to assess the impact of climate change, such as average rainfall and average temperature, on the agricultural sector in Algeria by studying the water resources sector and the agricultural sector in Guelma State.

The results indicate that climate change is a major obstacle to Algeria's efforts to diversify its economy through the agricultural sector.

Keywords

Climate Change;
Agriculture Sector;
Water Resources;
Economic Diversification.

الكلمات المفتاحية

تغير المناخ ؛
القطاع الفلاحي ؛
الموارد المائية ؛
التنوع الاقتصادي .

القطاع الزراعي في الجزائر كوسيلة لتحقيق التنوع الاقتصادي في مواجهة تغير المناخ «دراسة حالة ولاية قالمة»

ملخص

الجزائر بلد يعتمد على النفط والغاز، ويعاني من تباطؤ اقتصادي بسبب تقلب أسعار النفط في السنوات الأخيرة، تسعى الحكومة الجزائرية إلى تنويع اقتصادها، وتعتبر الفلاحة من أهم القطاعات التي تعتمد عليها الجزائر لتنويع اقتصادها وتحقيق الأمن الغذائي وتقليل الواردات من المنتجات الفلاحية. ومع ذلك فإن هذا الهدف يواجه التحديات التي يفرضها تغير المناخ، تحاول هذه الدراسة تقييم تأثير التغيرات المناخية، مثل متوسط هطول الأمطار ومتوسط درجات الحرارة، على القطاع الفلاحي في الجزائر، من خلال دراسة قطاع الموارد المائية والقطاع الفلاحي في ولاية قالمة. وتشير النتائج إلى أن تغير المناخ يمثل عائقاً كبيراً لجهود الجزائر لتنويع اقتصادها من خلال القطاع الفلاحي.

* Corresponding author. E-mail : djahmi.merwan@univ-guelma.dz

Doi:

I- Introduction:

The Algerian economy remains heavily reliant on the extractive sector, with the oil industry alone contributing to 27% of GDP and serving as the backbone of the Algerian economy. This lack of diversification is particularly evident in exports, with 88.33% of export revenues in 2021 coming from oil and gas, valued at 34.058 billion US dollars. This dominance has impeded the growth of other productive sectors, making it challenging for the country to meet its own needs. In 2021, Algeria imported USD 9.158 billion worth of manufactured goods, which accounted for 24.48% of total imports, and USD 6.498 billion worth of consumer goods, which accounted for 17.37% of total imports. It is worth noting that local industry cannot meet the high demand in the domestic market. Additionally, Algeria is a major importer of agricultural products such as cereals, sugar, dairy products, and meat, accounting for 23.73% of total imports (USD 8.877 billion). (Bank of Algeria, 2022, pp. 87-90)

The extractive industry's frequent shocks have left the Algerian economy in an unstable position. This necessitates transformation and the search for stable alternative sectors to strengthen the country's GDP. The agricultural sector is one of the most important alternatives to the oil industry. It helps achieve socio-economic development, compensates for the possible depletion of oil wealth. Agriculture is a significant part of the Algerian economy, alongside the oil and gas industries. It contributes 11.8% to the country's GDP and employs almost 9.9% of the population. (Desmidt, 2021, p. 9)

Algeria is currently seeking to achieve this goal through several reforms and measures it has taken in the past few years, by lifting restrictions imposed on investment in the agricultural sector and food industries and making it more competitive to increase farm productivity, raise production, and develop the agricultural industry sector. Implement investment in agricultural and water-saving agricultural/irrigation infrastructure. Support the encouragement of young agricultural entrepreneurs. Support reforms to promote economic diversification.

However, achieving this faces the challenge of climate change, as Algeria faces renewed extreme weather events, recurring drought cycles and accelerating desertification, and is particularly vulnerable to the multifaceted impacts of climate change that threaten to undermine its economic and social development. (INDC, 2015, p. 4)

Algeria's population is expected to reach 61 million by 2050 and 71 million by 2100. (Kathryn A., George , David , & Paul , 2022, p. 48) Although not a significant contributor to climate change, Algeria is expected to be among the most affected by its impacts, with the country expected to experience a temperature increase of 2°C by 2050, leading to a decrease in water resources, declining agricultural yields and increased desertification. (IPCC, 2022, p. 3448) Therefore, the transition from an economy based on the hydrocarbon sector to an economy led by productive sectors such as agriculture, while limiting the frequent import of products, in light of climate change represents a major challenge for the Algerian economy.

Through the above, we have formulated the following problems: **What are the effects of climate change on the agricultural sector in Algeria? And does climate change pose an obstacle to Algeria's plans to diversify its economy?**

This study analyses the impact of climate change on the agricultural sector in Algeria, which is a key driver of economic diversification in the country. The case study focuses on Guelma state, which is representative of the entire country. The analysis is based on data from local, national, regional, and international organizations that specialize in climate and future expectations. The study compares this data with the local reality of the agricultural and water resource sectors. As well as studying possible ways to adapt to these impacts and issues that Algeria is currently facing.

II- Climate Change in Algeria:

II.1. Global Situation:

Algeria, the first largest Arab/African country, its geography is a contrast with the mountainous, fertile terrain of the north and the great expanse of arid desert in the south. (Country Reports, 2023)

The climate of Algeria varies by different regions, as the climate of the coastal areas is characterized by heat in summer and cold and rainy for several months in winter, the mountainous interior areas located between the coast and the Sahara enjoy cooler weather, temperatures below freezing for long periods of winter. Spring and autumn are light and pleasant, which makes them usable for planting. The desert has an extreme climate, warm in winter, hot in late spring, summer and early autumn and cool at night all year round. (Country Reports, 2023)

II.1.1. Temperatures:

Temperatures vary in Algeria depending on the region, between day and night, and between summer and winter. In the Sahara Desert, the temperature ranges between more than 50°C at maximum during summer days and less than 0°C at minimum during winter nights. The north benefits from the Mediterranean climate, and winter temperatures range between 8 and 15 °C. It rises to 25°C in May reaching an average of 28°C to 38°C in July and August. In the high plateau region, the summer temperature ranges from 30°C to 38°C and the winter is very cold, sometimes reaching -18°C. (Wikipedia, 2023)

II.1.2. Precipitation:

The north of the country enjoys a Mediterranean climate, where summers are hot and dry and winters are mild, sometimes rainy and snowy. This region is considered the wettest in Algeria, and is characterized by annual precipitation ranging between 400 and 1000 mm of water. In the high plateaus, it ranges between 200 to 400 mm. In the pre-Saharan region, which does not yet correspond to the Sahara itself, the average annual rainfall is between 100 mm and 150 mm. However, the Saharan region sees annual averages fall to less than 10 mm in the drier areas. (Wikipedia, 2023)

However, heavy rains were observed in Algeria in several regions, the resulting floods caused significant losses of crops and property.

Table 1. Climate data in Algiers 1991-2020

Month	jan	feb	march	april	may	june	jul	august	sep	oct	nov	dec	year
Average minimum temperature (°C)	5.9	6.4	7	9	12	15.6	18.5	19.1	17.1	13.7	9.6	7	11.7
Average temperature (°C)	11.3	11.9	12.8	14.7	17.7	21.3	24.6	25.2	23.2	19.4	15.2	12.1	17.4
Average maximum temperature (°C)	16.5	17.3	18.5	20.4	23.5	27	30.6	31.2	29.2	25.1	20.7	17.2	23.1
Precipitation (mm)	80	81.8	73.4	61.1	39.9	16.7	4.6	7.4	34.2	76	96.4	115.2	686.6
Number of days with precipitation	11.4	10.6	9.7	9.1	7.3	2.5	1.5	2.5	5.3	8.6	11.1	12.1	91.7

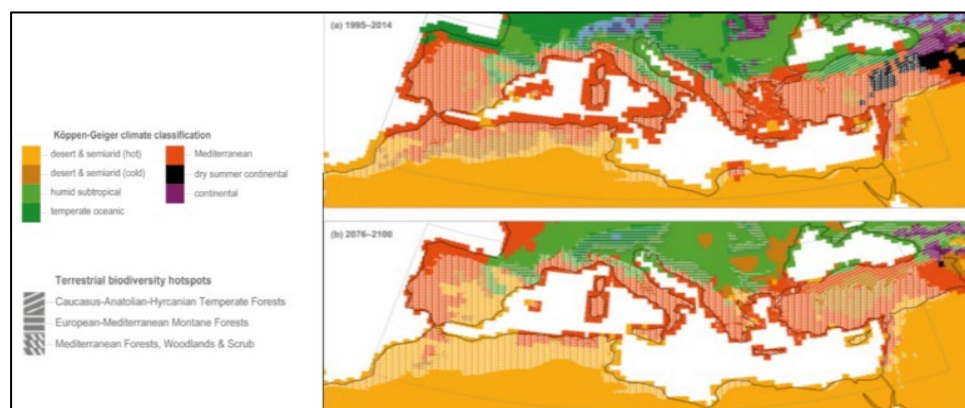
Source: (Climates to travel, 2023)

II.2. Climate Change Projections:

Climate change projections, based on global and regional climate models, show an increase in average temperature and an intensification of extreme heat and drought events across the North African region. This is mainly because temperature and precipitation are projected to change in different directions. Future climate change scenarios predict drying in the Mediterranean region, with countries in the south and east of the basin (including Algeria) being particularly affected. In these regions, drying will be more pronounced during the rainy season, which is the most critical period for replenishing scarce water resources. (Kathryn A., George , David , & Paul , 2022, p. 18)

According to the 2022 report on climate change by The Intergovernmental Panel on Climate Change (IPCC), the Mediterranean basin is expected to experience a temperature increase of 2-3°C by 2050 and 3-5°C by 2100. The report also predicts less frequent but more intense rainfall, as well as more common and longer droughts. These changes in precipitation patterns will directly impact agriculture and water resources. (IPCC, 2022, pp. 3444-3445)

Figure 1. climate and natural terrestrial ecosystems in the Mediterranean Basin according to the Köppen-Geiger climate types



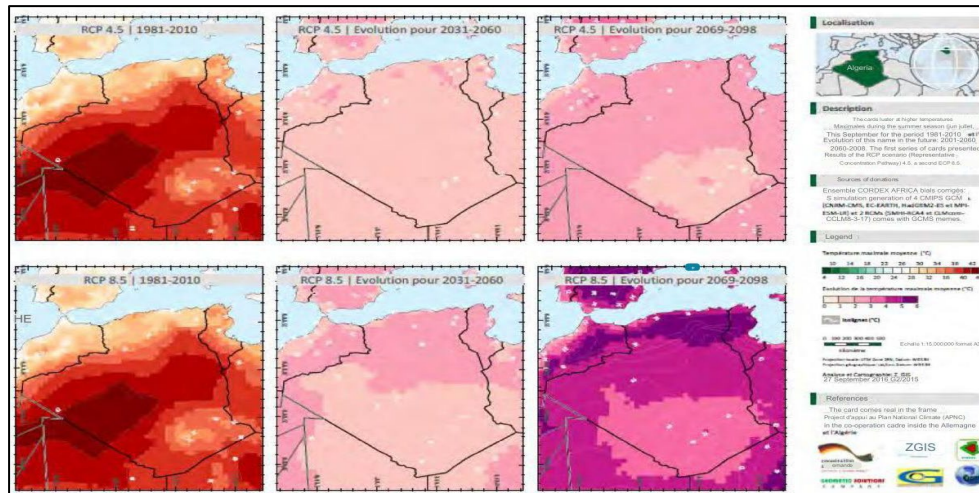
Source: (IPCC, 2022, p. 3442)

Therefore, Algeria's climate will become more severe by 2100. Agriculture, freshwater and terrestrial ecosystems, and heat waves and droughts will all be exacerbated by climate change. These heat waves will also raise the possibility of forest fires. Additionally, there are mixed tendencies of rising and falling river and flash floods.

II.2.1. Temperature Projections:

Climate projections for Algeria indicate that the average temperature will increase significantly by 2031-2060. The map in Figure 2 below shows that the average temperature for the period 1981-2010, as well as its projected evolution in the future (2031-2060 and 2069-2098). The first series of maps presents the results of the optimistic scenario (Representative Concentration Pathway) RCP4.5, while the second presents the catastrophic scenario RCP8.5. (Ministry of The Environment and Renewable Energies, 2018, p. 11)

Figure 2. Projected changes in annual temperature relative to the reference period (1981-2010)

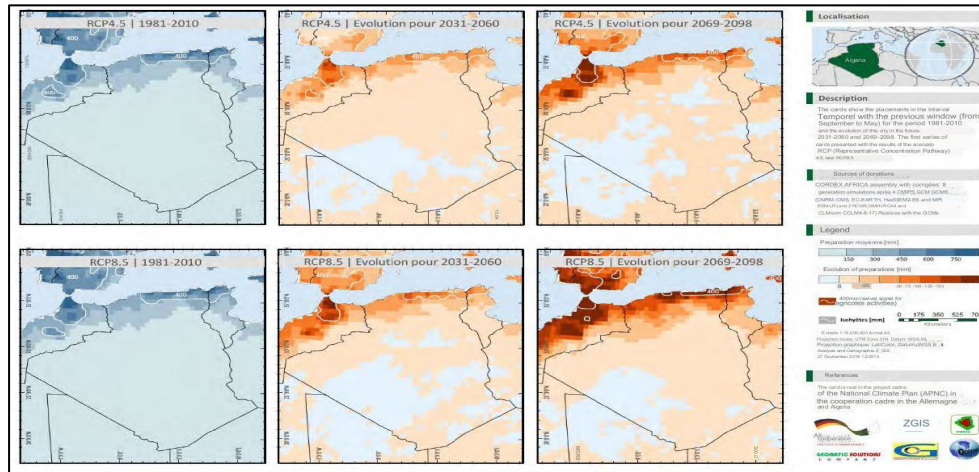


Source: (Ministry of The Environment and Renewable Energies, 2018, p. 11)

II.2.2. Precipitation Projections:

The analysis of precipitation in Algeria indicates that the average cumulative precipitation per year presents a risk of a decrease of 100 mm, which represents a decrease of approximately 15% expected by 2050.

Figure 3. Projected changes in Average precipitation relative to the reference period (1981-2010)



Source: (Ministry of The Environment and Renewable Energies, 2018, p. 10)

This map illustrates the average annual rainfall during the wet season (between September and May) for the years 1981-2010, as well as projected changes for the periods 2031-2060 and 2069-2098. The first set of data shows the results of the optimistic RCP4.5 scenario, which assumes a reduction in greenhouse gases in the atmosphere. The second series presents the RCP8.5 scenario, which is the most catastrophic scenario. In this scenario, gas emissions are not decreasing, which exacerbates climate change and leads to a severe reduction in the current average annual rainfall, particularly in the northern regions of Algeria. (Ministry of The Environment and Renewable Energies, 2018, p. 10)

II.2.3. Drought:

An increase in temperature of around +2°C by 2040-2060 according to the RCP8.5 scenario will lead to an increase in the average number of consecutive dry days per year with a forecast of 235.2 days/year at horizon 2040-2060 compared to 207.9 days/year currently. This will mean that a third of the year will be considered a dry period, as for the number of days where the heat index is >35°C, it is estimated at 59.06 days by 2040-2060. (Cramer, Guiot, & Marin, 2022, pp. 27-28)

II.2.4. Drill lights:

The analysis of the forest index-weather (FIW), used to assess the fire danger, showed a strong variation for the north of Algeria and a decreasing gradient from the south to the north of the country with the highest values for the regions of the interior Center and East. (National meteorological office, 2018, p. 34)

II.3. The Impact of Climate Change in Algeria:

Due to its geographical location, Algeria is highly susceptible to climate changes. A decrease in precipitation and an increase in surface and groundwater withdrawals will cause severe water stress, affecting both drinking water supply and irrigation. A decrease in irrigation water will have a significant impact on agricultural production and the agri-food industry in Algeria. The increase in water withdrawal, coupled with rising temperatures and reduced precipitation, will significantly strain water resources.

Climate change is inevitable and will have significant impacts, posing numerous challenges such as increased temperatures, rainfall, and water scarcity.

II.3.1. The Impact on Agricultural Sector:

Agricultural land covers almost 21% of the total land area, estimated at 49 million hectares. This is distributed as follows: 8.4 million hectares of agricultural area, 33 million hectares used as routes, and 6.6 million hectares of forests and steppes. Irrigated land accounts for 11% of the agricultural area, which is an area of 929,000 hectares. Therefore, Algeria has only 3.5% of the total area of the country as arable and irrigated land. The ratio of available agricultural land per capita decreased significantly from 0.75 ha/cap in 1962 to 0.24 ha/cap in 2008. This loss of farmland is attributed to various factors, including human activities such as industrialization, construction, and pollution, as well as natural phenomena such as desertification, soil erosion, and loss of vegetation cover. Climate change is expected to further exacerbate these issues, leading to a decline in biodiversity and the degradation of soil quality, ultimately resulting in desertification. In the steppe, the impact of climate change is evident in the alteration of the cyclical pattern of drought. In the 1960s, drought occurred once every three years, whereas in the 1970s and 1980s, it occurred twice every five years. Since then, it has increased to seven out of ten years, as of 2018. This change in the cyclic nature of dehydration will lead to: (Touitou & Abul Quasem, 2018, pp. 9-10)

- Decreased crop yields: The negative impact of rising temperatures and shifting rainfall patterns on crop productivity is well-documented. Excessive heat can reduce yields, damage crops, and limit the availability of suitable land for cultivation.
- Pest and disease outbreaks: Climate change promote the survival and spread of pests and diseases that damage crops. Altered climatic conditions create a favorable environment for pests and diseases, resulting in increased crop damage and losses.
- Soil degradation: Soil erosion and degradation are accelerated by higher temperatures and reduced rainfall. This leads to lower soil fertility, reduced moisture retention, and decreased agricultural productivity. Recent climatic fluctuations and drought, which have become more frequent over the past three decades, have accentuated the phenomenon of soil degradation, causing desertification in vulnerable areas such as steppes and high plains.
- Climate change is causing changes to planting seasons, which is disrupting traditional planting and harvesting patterns. This is creating uncertainty for farmers who need to adapt their practices to suit changing climate conditions.
- Livestock productivity is being reduced due to climate change, which is impacting pasture availability, quality, and quantity, affecting livestock production and health. Inadequate forage and water availability can lead to malnutrition and decreased livestock productivity.
- Additionally, limited access to adaptation technologies and resources is exacerbating the negative impacts of climate change on agriculture. Algerian farmers, especially those in rural and marginalized communities, often lack access to the necessary adaptation technologies, financial resources, and information to cope with the effects of climate change.

II.3.2. The Impact on Water Resources:

Algeria's primary vulnerabilities lie in its water and agriculture sectors. The country is predominantly semi-arid to arid from north to south, with a per capita water availability of only 600 M3/inhab/per year. This places Algeria in the category of countries with poor water resources, falling below the shortage threshold set by the World Bank at 1000m3/inhab/per year. Algeria has constructed 71 dams with a total capacity of 7.1 billion M3, which is close to its mobilizable water potential. In the northern region of the country, the rate of groundwater exploitation has reached approximately 90%, which is equivalent to nearly 2 billion cubic metres per year. It is worth noting that some aquifers are already overexploited., this situation has led to: (Touitou & Abul Quasem, 2018, pp. 9-10)

- Water scarcity is a major issue in Algeria due to increased droughts and reduced precipitation caused by climate change. This has made it difficult for farmers to irrigate their crops and sustain agricultural production.
- Additionally, changes in the dam's water levels have occurred due to silt accumulation and decreased surface runoff. Silt is linked to the nature and shape of steep terrain, vegetation fragility, lack of afforestation, and upstream dam urbanization, which reduces dam storage capacity by 2 to 3% annually. Additionally, a decrease in runoff exacerbates the situation as the contribution of runoff to surface water is constantly decreasing. The flow is too low to fill Algeria's existing dams.
- Furthermore, extreme weather events are becoming more frequent. Climate change has resulted in an increase in the frequency and intensity of extreme weather events, such as floods, storms, and heatwaves. These events can cause direct damage to crops, livestock, and infrastructure, further exacerbating the challenges faced by farmers. Scientific studies suggest that torrential rains and storms, like those that swept through different parts of the country, will become more frequent, violent, and dangerous.

III- Climate Change in Guelma State:

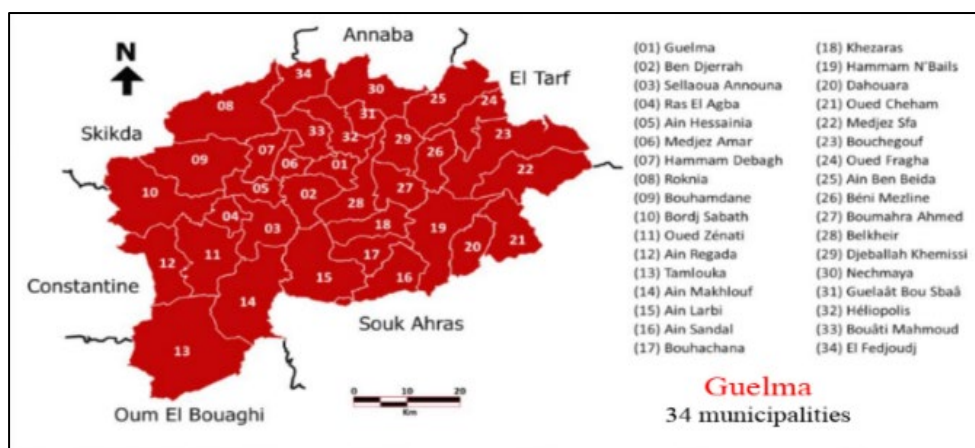
III.1. Presentation of The State:

III.1.1. Geographic Context:

The state of Guelma is located in the northeast of Algeria, bordered to the north by the state of Annaba, to the northeast by the state of El Tarf, to the northwest by the state of Skikda, to the east by Souk Ahras, to the south by Oum El Bouaghi and to the west by Constantine, thus occupying a median position between the north of the country and the high plateaus (Figure 04).

With an area of 3,686.84 ha, the state of Guelma is characterized by a diverse relief, consisting of 37.82% mountains, 27.22% plains and plateaus, 26.29% hills and piedmonts and 8.67 % of its surface area which is considered other land. (Administration of Agricultural Interests of the State of Guelma, 2023)

Figure 4. Guelma State and Neighboring States

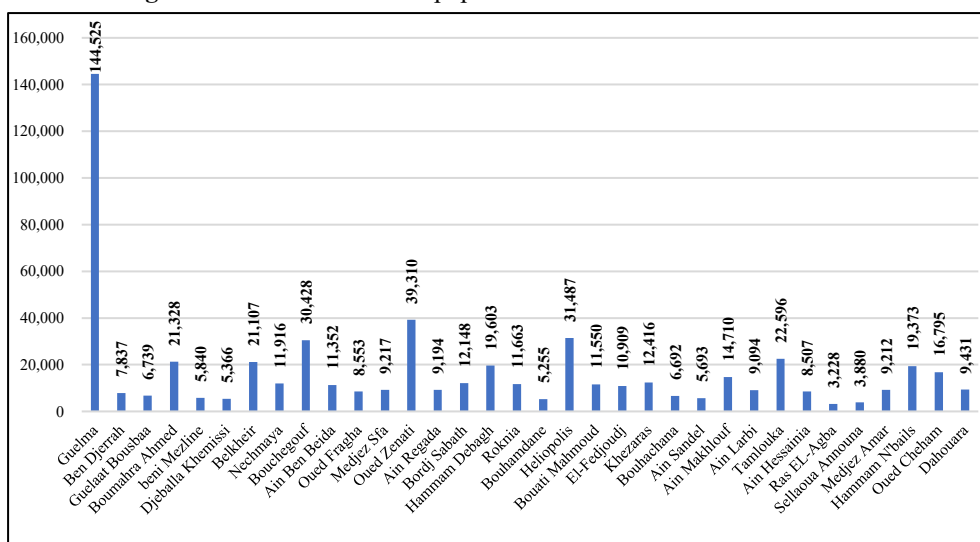


Source: (Administration of Agricultural Interests of the State of Guelma, 2023)

III.1.2. Population:

According to the latest estimates, the population of the state of Guelma reached 576 995 inhabitants in 2022, with an average density of 155 inhabitants/km². Almost three quarters (75,83%) of the population occupy urban areas compared to 24,17% who occupy rural areas (Figure 5).

Figure 5. Distribution of the population of the state of Guelma in 2022.



Source: (Administration of programming and budget follow-up of the State of Guelma, 2023)

III.1.3. Main Sectors of Economic Activity:

A. Commercial activity: The commercial activity constitutes a very important economic base for the development of the state, it has a very significant societal dimension. The state of Guelma benefits from the presence of 40315 businesses including 14362 retail businesses or 35,62%, while service sector represents a rate of 32,16%, the artisanal production including 8568 artisan with rate of 21,25%, the industry and construction sector represent a rate of 9,20%, however import/export and wholesale trade have a very low rate of 2% including in total 710 businesses (Table 02).

Table 2. Distribution of commercial activity by sector until 31/12/2022.

Activity	Retail business	Service	Artisanal production	Industrial and Construction production	Wholesale business	Import	Export	Total
Guelma	14362	12966	8568*	3709	551	122	37	40315
Rate (%)	35.62%	32.16%	21.25%	9.20%	1.37%	0.30%	0.09%	100%

Source: (National Center of the Commercial Register, 2023)

* (Chamber of traditional industries and crafts of the state of Guelma, 2023)

B. Employment: The most relevant socio-economic indicators are those relating to employment. The latest available statistics, which date from 2022, indicate that the working age population represents 58.51% of the total population, and that the unemployment rate is 17%. These same statistics also indicate that the sectors which employ the most are the agriculture, services and Commerce sectors (Table 03). (Administration of employment of State of Guelma, 2023)

Table 3. Distribution of jobs by sector of activity

Sector of Activity	Men	Women	Total	Rate (%)
Administration	14.160	22.454	36.614	15.63%
Construction (BTPH)	23.774	11.980	35.754	15.26%
Agriculture	35.197	10.875	46.072	19.66%
Industry	21.205	9.420	30.625	13.07%
Services	24.043	19.018	43.061	18.38%
Commerce	26.934	15.229	42.163	18.00%
Total	145.313	88.976	234.289	100%

Source: (Administration of employment of State of Guelma, 2023)

Given the agricultural production potential in the state of Guelma, the industrial fabric automatically turned towards the agri-food industry, semolina and flour mills, canneries, dairies and other agri-food production and processing units, employed in 2022 more than 1700 people, and represents one of the most promising employment sectors in the state. (Administration of employment of State of Guelma, 2023)

III.2. Climate Profile of The State:

The territory of the State is characterized by a sub-humid climate in the center and the North and semi-arid towards the South. This climate is mild and rainy in winter and hot in summer. The temperature, which varies from 9.6°C in winter to 10.9°C, in summer is on average 25.9°C. This climate enjoyed by the State is quite favorable to agricultural and livestock activity (Table 4).

Table 4. Monthly average temperatures (°C); average monthly precipitation (mm) Period 1986-2004.

Month	jan	feb	March	april	may	June	Jul	august	sep	oct	nov	dec
T(°C)	9.6	10.1	12.3	14.3	18.9	23.5	26.7	27.6	23.9	19.9	14.3	10.9
P(mm)	93.3	60.8	52.6	64.6	53.4	19.6	3.5	13.6	38.9	42.2	79.5	88.3

Source: (National Meteorological Office-Belkheir station, 2023)

III.2.1. Analysis of Temperature Trends:

The figures in the table 05 below indicate that since 1995 to 2023, extreme temperatures have occurred throughout the year, beyond the average maximum temperatures, we often record extreme temperatures which exceed the average for each month, from January to December.

Table 5. Recent records of notable climate events Period 1995-2023.

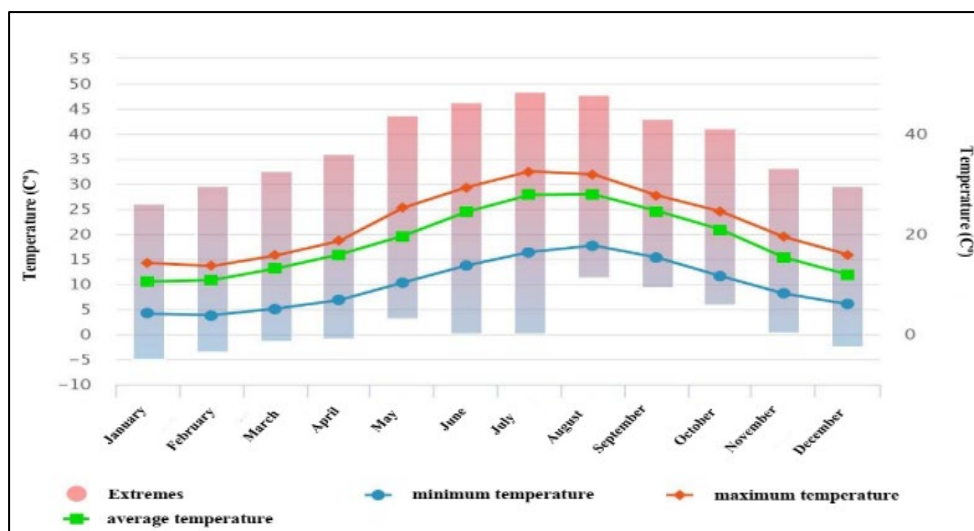
COLD PERIODS						PERIODS OF HEAT					
Coldest days		Coldest months		Coldest years		Hottest days		Warmest months		Warmest years	
-5.1°C	28/01/2005	0°C	10/1995	0°C	1997	48.3°C	10/07/2023	40.9°C	07/2023	27.2°C	2022
-3.6°C	13/02/2012	0°C	03/1997	6.4°C	1996	47.7°C	09/08/2021	39.6°C	08/2012	26.4°C	2017
-3.4°C	07/01/2002	0°C	04/1997	9.7°C	2001	47.3°C	10/08/2021	39.2°C	08/2003	26.3°C	2014
-2.8°C	08/01/2002	0°C	05/1997	11°C	2005	46.7°C	14/08/2008	39.1°C	08/2017	26.3°C	2012
-2.7°C	10/02/2015	0°C	06/1997	11°C	2008	46.6°C	24/07/2009	38.8°C	07/2012	26.2°C	2021
-2.6°C	18/12/2001	0°C	07/1997	11.1°C	2017	46.2°C	24/06/2007	38.5°C	07/2003	26.2°C	2016
-2.6°C	06/01/2002	0°C	08/1997	11.2°C	2004	46.2°C	29/08/2003	38.5°C	07/2009	26.1°C	2006
-2.4°C	09/01/2002	0°C	09/1997	11.2°C	2009	46.1°C	11/08/2021	38.4°C	08/2021	26°C	2020
-2.4°C	19/12/2007	0°C	10/1997	11.3°C	2002	46.1°C	31/07/2017	38.1°C	07/2017	25.8°C	2002
-2.1°C	09/02/2018	0°C	11/1997	11.3°C	2013	46°C	05/08/2012	37.8°C	07/2022	25.7°C	2015
-1.9°C	07/02/2020	0°C	12/1997	11.3°C	2011	46°C	14/07/2012	37.8°C	07/2015	25.7°C	2008
-1.8°C	29/01/2008	0°C	01/1998	11.4°C	2010	46°C	11/07/2017	37.8°C	07/2021	25.5°C	2010
-1.7°C	27/02/2013	0°C	02/1998	11.4°C	2018	46°C	18/07/2005	37.7°C	07/2018	25.3°C	2003
-1.6°C	29/01/2022	0°C	04/1998	11.5°C	2015	46°C	27/06/2006	37.3°C	07/2001	25.3°C	2011
-1.5°C	20/01/2017	0°C	02/1997	11.5°C	2016	46°C	06/07/2001	37.2°C	06/2022	25°C	2013
-1.5°C	26/01/2017	0°C	01/1997	11.5°C	2012	46°C	17/08/2022	37.2°C	08/2004	25°C	2009
-1.5°C	27/03/2002	0°C	05/1998	11.6°C	2020	46°C	23/07/2009	37.2°C	08/2011	24.9°C	2018
-1.5°C	10/02/2008	0°C	11/1998	11.6°C	2014	45.8°C	24/07/2023	37.1°C	08/2007	24.9°C	2004
-1.4°C	25/02/2013	0°C	12/1995	11.8°C	2006	45.6°C	03/07/2014	37.1°C	07/2006	24.8°C	2005
-1.4°C	10/03/2005	0°C	01/1996	12.1°C	2003	45.5°C	03/08/2002	37.1°C	07/2019	1.4°C	1997
-1.4°C	16/02/2009	0°C	02/1996	12.2°C	2022	45.5°C	13/06/1997	37°C	08/2008	0°C	1996
-1.4°C	18/12/2007	0°C	03/1996	12.3°C	2021	45.4°C	12/08/2021	37°C	08/2020		
-1.4°C	23/01/2011	0°C	04/1996			45.4°C	23/07/2023	36.9°C	08/2015		
-1.3°C	27/12/2003	0°C	08/1998			45.3°C	22/07/2023	36.8°C	08/2009		
-1.3°C	16/02/2021	0°C	07/1998			45.3°C	07/07/2023	36.8°C	07/2007		
-1.2°C	20/01/2012	0°C	07/1996			45.2°C	25/06/2007	36.7°C	08/2022		
-1.1°C	26/01/2006	0°C	06/1998			45.1°C	31/07/2021	36.7°C	07/2008		
-1.1°C	08/02/2003	0°C	09/1996			45.1°C	09/07/2023	36.6°C	08/2014		
-1.1°C	13/02/2010	0°C	09/1998			45.1°C	21/08/2020	36.6°C	07/2010		
-1.1°C	04/02/2018	0°C	10/1998			45°C	22/07/2010	36.5°C	08/2001		

Source: (Infoclimat , 2023)

For example, the average maximum temperature for the month of August varies between 36.5 and 39.6°C while during the years 2002, 2003, 2008, 2010, 2012, 2020, 2021 extreme temperatures (beyond the average for the month of August) were recorded and are respectively 45.5°C / 43.3°C / 46.7°C / 44.5°C / 43.6°C / 45.1°C and 47.7°C.

The same observation is made for extreme low temperatures compared to the average minimum temperature. Indeed, extreme low temperatures have been recorded throughout the year since 1995 until 2023 with extreme low temperatures of -5.1°C / -3.6°C / -3.4°C / -2.7°C respectively for January 2005, February 2012, January 2002 and February 2015.

Figure 6. Temperatures in Guelma state from 1995 to 2023



Source: (Infoclimat, 2023)

In summary, the frequency of extreme temperatures indicates that seasonal averages may change with a shift toward very hot summers and very cold winters, as shown in the following figure.

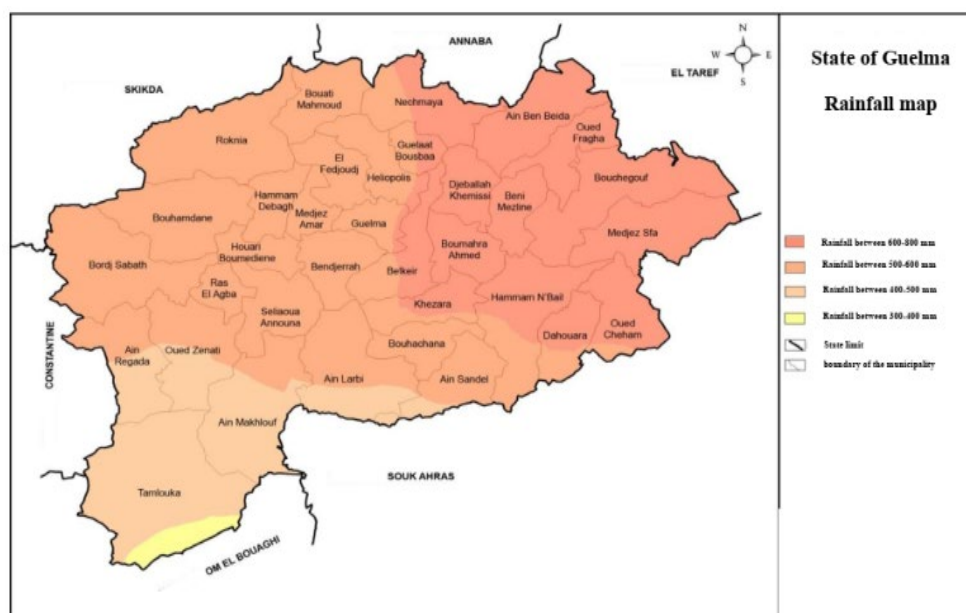
III.2.2. Rainfall:

The average rainfall observed is:

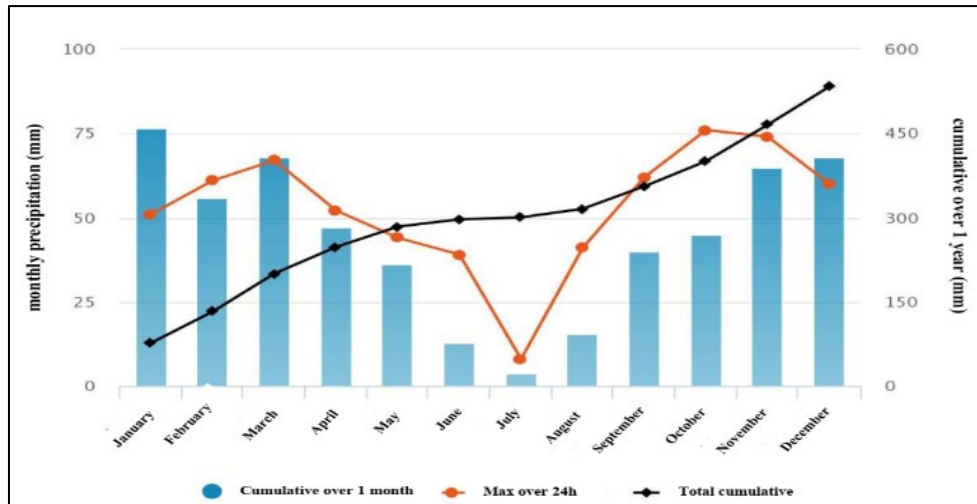
- 654 mm/year at the National Meteorological Office-Belkheir station;
- 627 mm/year at the National Meteorological Office-Ain Larbi station;
- 526 mm/year at the National Meteorological Office-Medjez Amar station.

This rainfall varies from 300 to 400 mm/year in the South to 800 mm/year in the North. Nearly 57% of this rainfall is recorded during the wet season From October to May (Figure 12).

Figure 7. Rainfall map of Guelma state.



Source: (National Meteorological Office-Belkheir station, 2023)

Figure 8. Precipitation over the period 1995 – 2023 in Guelma.

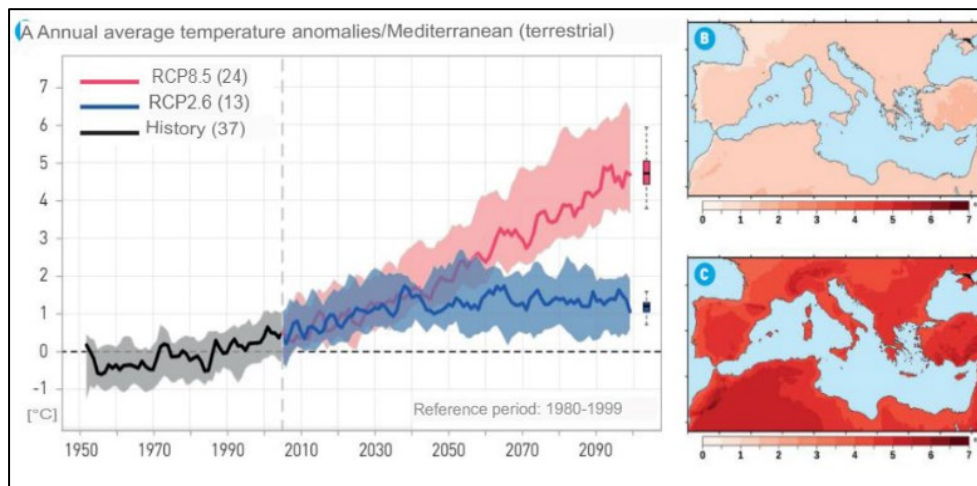
Source: (Infoclimat, 2023)

The analysis of Figure 08 indicates that the maximum precipitation over 24 hours is mainly greater than the average monthly precipitation, which increases the risk of flooding.

III.3. Climate Change Projections:

III.3.1. Temperature Projections:

As we have seen in Figure 03, The average temperature changes in the state will take the same pattern, the climate projections indicate that the average temperature will increase sharply by 2040-2060 (Figure 09).

Figure 9. Projected changes in annual temperature compared to the reference period (1980-1999)

Source: (Cramer, Guiot, & Marin, 2022, p. 11)

Box (a): represents the simulations for the RCP2.6 and RCP8.5 scenarios in the Mediterranean basin (which includes Guelma state). The 2 scenarios show that a minimum increase of 1°C is expected by 2040- 2060 against an increase of 2°C in the pessimistic scenario.

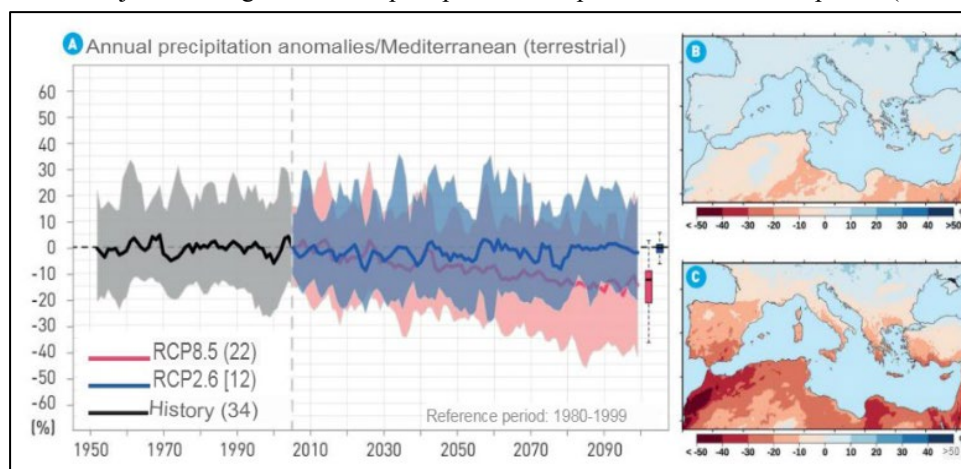
Box (b): represents a map of the simulation of warming at the end of the 21st century (2080- 2099) for RCP2.6. In this optimistic scenario, the temperature increase for the state of Guelma will reach 2°C at the end of the century. This increase remains very high and the risks generated will be very serious.

Box (c): represents a map of the simulation of warming at the end of the 21st century (2080- 2099) for RCP8.5. In this scenario, the temperature increase in the state of Guelma will reach 4 or even 5°C. This scenario is catastrophic for the state and the impacts will be extremely severe.

III.3.2. Precipitation Projections:

The expected changes in the average cumulative rainfall for the state of Guelma will follow the same pattern as the analysis of rainfall for Algeria, which we saw in Figure 04, meaning that the average rainfall in the state is expected to decrease by about 15% By 2050.

Figure 10. Projected changes in annual precipitation compared to the reference period (1980-1999)



Source: (Cramer, Guiot, & Marin, 2022, p. 11)

Future climate projections for the reference period (1980-1999) based on the simulations of scenarios RCP2.6 and RCP8.5 indicate, at the end of the 21st century (2080-2099), a predominant change towards a precipitation regime with greater variability between the years, higher intensity and maximum extremes especially in winter, spring and autumn, less frequent rainfall and longer dry periods especially in summer and in the countries of the south (which includes Guelma state), Which corresponds to forecasts from World Resources Institute that indicate that the state will suffer from high water stress by 2050 (Figure 11).

Figure 11. Risk of water stress in Eastern Algeria by 2050



Source: (Aqueduct, 2023)

therefore, we summarize the expected effects of climate change in the state, they would include the the following climatic factors:

- a rise in temperatures;
- a decrease in total rainfall;
- greater instability in the distribution of precipitation during the year, an increase in the frequency of extreme climatic events. (heavy rain, drought...).

Thus, a substantial increase in temperature with a significant decrease in precipitation and increased evaporation, leading to an increase in water stress and a scarcity of natural resources in general could deeply destabilize key sectors of the state such as agriculture and the agri-food industry.

IV- The Water Resources in The State of Guelma:

IV.1. Hydraulic Potential:

The state of Guelma is located between two hydrographic water basins consisting of several rivers (Figure 12), the most important of which are:

- River Sibus 57,15km.
- River AL-Zenati 52,40 km.
- River Bouhamdane 48,35 km.
- River AL- Cherf 24.13 km

Figure 12. Hydrographic map of Guelma state.



Source: (Administration of Water Resources of the State of Guelma, 2023)

A. Sibus Hydrographic Basin: This basin has an area of 6483 KM² and includes all of the district municipalities: Oued Zenati, Ain Makhoulf, Ain Hessainia, Guelma, Lakhezara, Hammam N'bails, Bouchegouf, and part of Municipalities of Hammam Debagh, Heliopolis and Guelaat Bousbaa, its rainfall rate is 300 To 500 mm/year in normal years. The Sibus Hydrographic Basin is divided into four (4) small basins whose waters flow into main streams: River Sibus, River Bouhamdane, River AL- Cherf and River AL-Maleh. All water streams flow into River Sibous, which flows from the southwest to the northeast, starting from Rivers coming from the high plateaus, passing through River Bouhamdan and River AL- Cherf, to meet with the Medjez Amar to be the main source of River Sibous, and to continue its flow through sloping areas until it finally empties on the Annaba Coast.

B. Constantine Coastal Hydrographic Basin: It is a smaller basin in area than the first and covers: the municipalities of Roknia and Bouati Mahmoud with full coverage, and the municipalities of Nechmaya, Bouhamdane, Majaz Ammar, El-Fedjoudj, Heliopolis and Guelaat Bousbaa with partial coverage, its rainfall reaches 500 mm/year in normal years.

IV.2. Mobilization Capacities:

The quantity of water that can be mobilized in the state of Guelma is estimated at 284.05 million M³. A groundwater mobilization potential of 94.1 million M³ per year, from 1620 operational water points (wells, water sources). A surface water mobilization potential estimated at 189.95 million M³, which mainly comes from the Bouhamdane dam located in the municipal of Hammam Debagh (Table 6).

Table 6. Dams and water barriers across the state of Guelma

Municipal	Designation	Naming	Capacity (million M ³)	Irrigated area (Hectare)
Hammam Debagh	Dam	Bouhamdane	185	9 986
	Water barrier	Rihana -1-	0.065	20
Aïn Makhoulf	Dam	Medjez-Beggar	4	1 000
Nechmaya	Dam	Hdjer Kafta	0.44	600
	Water barrier	Ouad nakhla	0.04	50
	Water barrier	Ledraou	0.03	45
Aïn Ben Beida	Water barrier	Bir chougran	0.025	40
	Water barrier	Sidi mensour	0.025	25

Ain Larbi	Water barrier	Ben mebrouk	0.02	7
Belkheir	Water barrier	Besbassa	0.03	15
	Water barrier	Medraou	0.025	7
Bordj Sabat	Water barrier	Ain bouras	0.025	5
Bouati Mahmoud	Water barrier	Mechouma	0.02	20
Heliopolis	Water barrier	Al goutarat	0.03	20
Medjez Sfa	Water barrier	Medjez Sfa	0.1	80
Oued Fragha	Water barrier	Seltani	0.025	20
	Water barrier	Moumna	0.02	5
Ras El Agba	Water barrier	Ain boutouia	0.03	8
TOTAL			189.95	11 953

Source: (Administration of Water Resources of the State of Guelma, 2023)

The Bouhamdane dam is the only one that is used for agricultural irrigation and provides drinking water to about 40 % of the population of the state, It also supplies most of the local industries with their water requirements. The remaining dams and water barriers are solely used for agricultural irrigation. The state's remaining water needs are met through groundwater. (Administration of Water Resources of the State of Guelma, 2023)

The state relies heavily on this source of water. Any decrease in water levels will have significant social and economic consequences, and could seriously impact water and food security.

IV.3. Irrigation Area (Guelma- Bouchegouf):

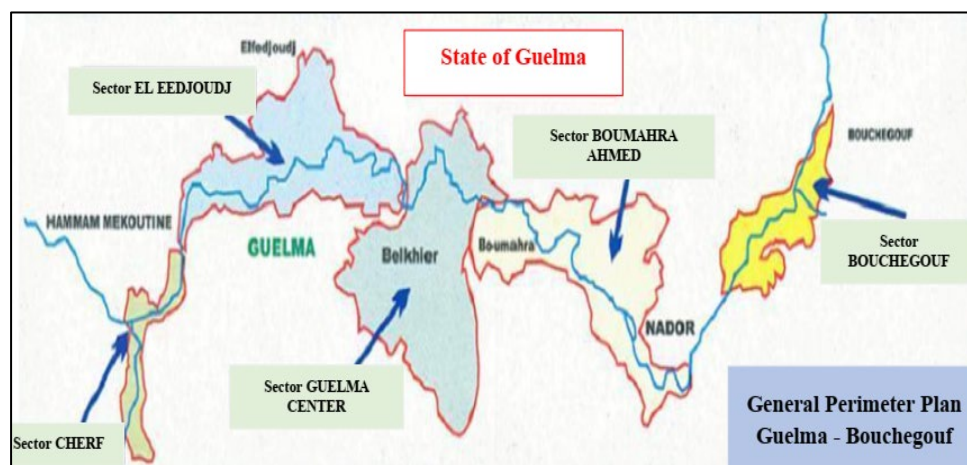
The irrigation perimeter (Guelma- Bouchegouf) was established following a study completed by the Greek company (Tetracts) in 1983. Works began in 1988 and the project was taken over in 1996. It began by covering an area of 50 hectares, expanding to 9250 hectares along the banks of Sibus Rive with a total area that can be covered. It reaches 9986 hectares, divided into 05 sectors: (Administration of Water Resources of the State of Guelma, 2023)

- AL-Cherf sector: 650 hectares;
- AL-Fedjoudj sector: 2355 hectares;
- Guelma sector, central 3500 hectares;
- Boumahra sector: 2600 hectares;
- Bouchegouf sector: 880 hectares.

This ocean extends over a distance of 50 km, starting from the junction of River AL-Cherf and Bouhamdane until the municipality of Bouchegouf on the borders of the state of AL-Tarif (Figure 13).

- The network length is 288 km;
- 05 lifting stations with a total pumping capacity estimated at 5987 L/S;
- 06 tanks with a total capacity estimated at 114.840 M³.

Figure 13. The irrigation perimeter (Guelma- Bouchegouf)



Source: (Administration of Water Resources of the State of Guelma, 2023)

This area is considered the most important irrigation facility in the state, as it is the main supplier of agricultural products of all kinds (seasonal crops, fruit trees, industrial agriculture, and grains).

IV.4. The Agricultural Sector the State of Guelma:

With an essentially agricultural vocation, the state of Guelma has significant potential, namely: (Administration of Agricultural Interests of the State of Guelma, 2023)

- A Total Agricultural Area (T.A.A) of 264 618 ha, or 71.77% of the total area of the state.
- A useful agricultural area (U.A.A) of nearly 187 338 ha, or 50.81% of the total area of the state and 70.80% of the (T.A.A). Thus, the (U.A.A) ratio is nearly 0.36 ha/inhabitant, while that recorded at the national level is 0.3 ha/inhabitant.
- An area of pastures and rangelands of 50 875 ha, or 13.80% of the total area of the state and 19.23% of the T.A.A.
- Unproductive land of 26 405 ha, or 7.16% of the total area of the state and 9.93% of the T.A.A.
- An irrigable area of nearly 17 343 ha, or 9.26% of the U.A.A (it can increase, in the long term, to reach 26 000 ha, or 13.88% of the U.A.A with the total commissioning of the irrigated perimeter and the other development projects, in addition to optimizing the mobilization of surface water).

Table 7. Distribution of agricultural area

T.A.A	U.A.A	Pastures and routes	Unproductive land	Irrigable area
264 618 ha	187 338 ha	50 875 ha	26 405 ha	17 343 ha
100 %	70,80 %	19,23 %	9,93 %	9,26 %

Source: (Administration of Agricultural Interests of the State of Guelma, 2023)

V- The Impact of Climate Change on Guelma State:

V.1. The Impact on Water Resources:

The state of Guelma, like the rest of the country, faces great challenges in the water sector due to the climate changes that Algeria has experienced in recent years, which has resulted in a severe shortage of water sources, whether surface or groundwater, and a significant decrease in the amount of water used, whether for drinking or irrigation, especially in the last three years, as follows: (Administration of Water Resources of the State of Guelma, 2023)

- In 2021, the quantities allocated for drinking water and irrigation were respectively 40.574 million M³ and 36.119 million M³, or nearly 77 million M³, which corresponds to 27.10% of the mobilizable resources.
- In 2022, the quantities allocated for drinking water and irrigation were respectively 24.345 million M³ and 22.528 million M³, or nearly 46 million M³, which corresponds to 16.19% of the mobilizable resources.
- In 2023, the Bouhamdane dam, which is considered the most important source of water in the state, supplies half of the population. With drinking water, which is also used for agricultural irrigation, it almost dried up completely, as the filling rate of the dam on 21/06/2023 reached 10.67%, i.e. an amount estimated at about 9 million M³, where the quantities allocated for drinking water and irrigation were respectively 22.086 million M³ and 8.028 million M³, or nearly 30 million M³, which corresponds to 10.56% of the mobilizable resources.

V.2. The Impact on Agricultural Sector:

Although the state of Guelma has great agricultural potential, the sector faces several challenges. These include the use of traditional farming methods, a lack of innovation, a reluctance among young people to work in agriculture, and a lack of a strong agricultural culture...etc.

Climate change has aggravated the situation, which has led to a significant decrease in agricultural production in the state, as the 2022/2023 agricultural season was arguably one of the most difficult, the irrigated area has declined from 8811 hectares in the 2021/2022 season to 898 hectares in the 2022/2023 season, as shown in the tables below. (Administration of Agricultural Interests of the State of Guelma, 2023)

Table 8. Planting area of cereals and seeds (Achieved results of agricultural season 2022/2023)

Sector	Planting area objective			Planting area achievements			Rate (%)
	Consumer cereals (hectare)	Cereal seeds (hectare)	Overall objective (hectare)	Consumer cereals (hectare)	Cereal seeds (hectare)	Overall objective (hectare)	
Durum wheat	65 100,00	4 900,00	70 000,00	60 852,12	4 068,00	64 920,12	93%
Soft wheat	12 200,00	1 300,00	13 500,00	12 513,69	1 696,50	14 210,19	105%
Barley	9 600,00	400,00	10 000,00	10 486,51	493,00	10 979,51	110%
Oats	450,00	0,00	450,00	405,00	0,00	405,00	90%
Total	87 350,00	6 600,00	93 950,00	84 257,32	6 257,50	90 514,82	96%

Source: (Administration of Agricultural Interests of the State of Guelma, 2023)

The table above shows that the Agriculture administration achieved 96% of their objectives for the planting area. However, it appears that they did not consider the impact of climate change, particularly on the cultivation of cereals and seeds, which is heavily reliant on precipitation.

Table 9. Production of cereals and seeds (Achieved results of agricultural season 2022/2023)

Sector	Production objective			Production achievements			Rate (%)
	Consumer cereals (quintal)	Cereal seeds (quintal)	Overall objective (quintal)	Consumer cereals (quintal)	Cereal seeds (quintal)	Overall objective (quintal)	
Durum wheat	1 300 000,00	100 000,00	1 400 000,00	203 073,52	0,00	203 073,52	15%
Soft wheat	243 000,00	27 000,00	270 000,00	36 655,08	0,00	36 655,08	14%
Barley	194 700,00	5 300,00	200 000,00	27 482,82	0,00	27 482,82	14%
Oats	6 300,00	0,00	6 300,00	1 170,00	0,00	1 170,00	19%
Total	1 744 000,00	132 300,00	1 876 300,00	268 381,42	0,00	268 381,42	14%

Source: (Administration of Agricultural Interests of the State of Guelma, 2023)

The table indicates that the Agriculture administration's production objectives for the planting area were only 14% achieved. As a result, large areas were left unharvested this season, causing significant losses for the farmers.

Table 10. Planting area and Production of vegetables, fruits, animal feed (Achieved results of agricultural season 2022/2023)

Sector	Objective		Achievements		Rate (%)	
	Planting area (hectare)	Production (quintal)	Planting area (hectare)	Production (quintal)	Planting area	Production
Animal feed	0,00	2 291 000,00	30 711,50	1 247 279,00	Unknown	54%
Dried vegetables (chickpeas, lentils...)	6 000,00	96 000,00	5 090,00	25 969,00	85%	27%
Industrial tomato	4 600,00	3 680 000,00	1 665,38	1 092 150,00	36%	30%
Market gardening (consumption potato, seed potatoes, onions, garlic...)	9 000,00	1 755 000,00	6 162,40	761 658,00	68%	43%
Olives	0,00	90 000,00	0,00	73 078,00	Unknown	81%
Citrus fruits	0,00	155 000,00	0,00	148 447,00	Unknown	96%
Fruits of vines	0,00	2 500,00	0,00	2 375,00	Unknown	95%
Apple	0,00	40 000,00	0,00	19 744,00	Unknown	49%
Seeded and hardy grains	0,00	145 000,00	0,00	192 152,00	Unknown	133%
Corn	0,00	50,00	0,00	0,00	Unknown	0%
Rapeseed	0,00	0,00	22,00	100,00	Unknown	Unknown
Sugar beet	0,00	1 000,00	0,00	0,00	Unknown	0%
Total	24 300,00	8 835 550,00	47 309,08	3 935 808,00	195%	45%

Source: (Administration of Agricultural Interests of the State of Guelma, 2023)

Table 10 shows that the Agriculture administration only achieved 45% of their production objectives for various agricultural products. This is because these products rely on irrigation, and the administration did not consider the significant decline in water stocks in the state. Additionally, they lacked control over agricultural programs, as evidenced by their lack of knowledge about many planting areas.

Table 11. Animal production (Achieved results of agricultural season 2022/2023)

Sector	Objective	Measuring unit	Production	Rate (%)
Milk	66 000,00	1000 liter	27 446,00	42%
Red meats	135 000,00	Quintal	51 560,80	38%
White meats	98 000,00	Quintal	61 581,03	63%
Eggs	97 000,00	1000 unit	82 297,44	85%
Honey	3 000,00	Quintal	1 129,45	38%
Wool	7 900,00	Quintal	4 123,00	52%

Source: (Administration of Agricultural Interests of the State of Guelma, 2023)

We note that animal production in general is also affected by climate change as a result of high temperature and lack of pastures, in addition to the decline in animal food production, as well as the lack of water used for watering animals, as none of the objectives set were achieved, which were below the level, especially in the red meat and honey.

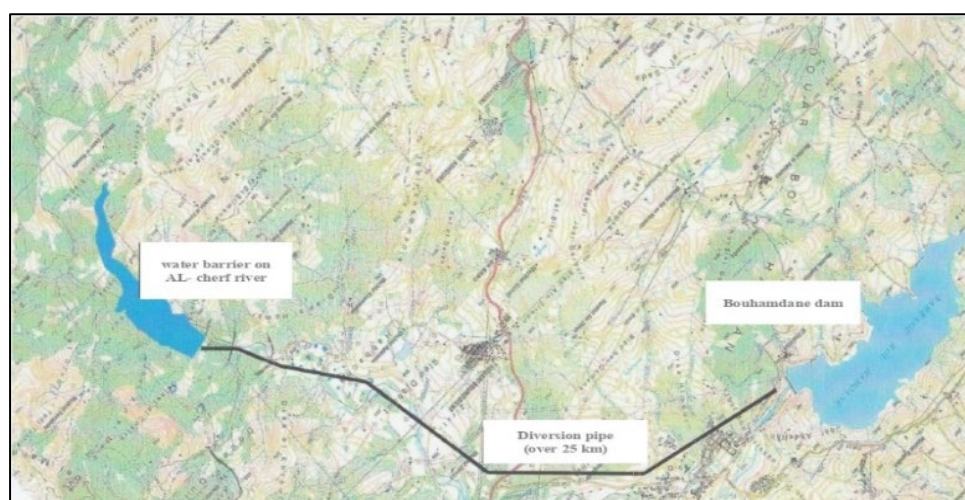
Overall, the results of the 2022/2023 agricultural season indicate a significant decrease in agricultural production in the state of Guelma due to climate change. Additionally, the Agriculture administration's inability to adapt to these changes has exacerbated the situation.

VI- Measures Taken by Local Authorities:

The local authorities in Guelma state are aware of the impact of climate change on water resources and agriculture. They have proposed measures to mitigate these effects to the Ministry of Irrigation, but these have not yet achieved the desired goals. Below, we will review the main reasons for this: (Administration of Water Resources of the State of Guelma, 2023)

- 1- A previous study by the National Dams Agency proposed building a dam in the 'Kedeya Haricha' area with a capacity of 100 million M3. However, a geotechnical study revealed that the proposed land is unsuitable due to its gypsum nature and permeability to water. However, the analysis of the ground layers revealed that it is possible to construct a small water barrier in a different location. This barrier would have a capacity of 50 million M3 and would require the completion of a 25 km pipe to divert the waters of river AL-Cherf to the Bouhamdane dam (Figure 14).

Figure 14. Water diversion project from river AL-Cherf to the Bouhamdane dam



Source: (Administration of Water Resources of the State of Guelma, 2023)

However, the Ministry of Irrigation cancelled the project due to its high cost compared to its economic feasibility.

- 2- Proposal to build 06 water barriers across the state with an amount of 54 Million dinars. These include two barriers in the municipality of Bordj Sabath, a water barrier in the municipality of Bouhamdane, two barriers in the municipality of Bouchegouf and a water barrier in the municipality of Oued Fragha, and this to create irrigated areas estimated at about 3000 hectares, however, this proposal has not yet been approved by the Ministry.
- 3- To establish new irrigation areas in the municipalities of Bouati Mahmoud and Roknia a technical study was prepared to build an irrigation perimeter with an area of 700 hectares at a cost of 25 million dinars from the Zit AL-aanba dam in the state of Skikda, but this proposal requires the approval of the National Dams Agency, which has not yet given its approval.
- 4- Proposal to use the filtered water in the agricultural irrigation from the wastewater filtration station located on the banks of the Sibus river, The capacity of treated water at the station up to 31/05/2023 is 1291977 M³ and the amount of mud is estimated at 81 M³, this treated water is discharged directly into the Sibus river, with almost no pollution.

The Irrigation Minister, during his visit to the state of Guelma on February 14, 2024 revealed that the public authorities have allocated a financial budget of 01 billion dinars to prepare and modernize the station with the aim of increasing the capacity of wastewater filtration and using 60% of the filtered water in the agricultural irrigation.

He also revealed that Guelma has benefited, within the national strategy for wastewater management, from registering a project to complete a second wastewater filtration station that will be settled across the territory of the Oued Zenati municipality, which will allow the protection of the Bouhamdane Dam from pollution, in addition to directing its filtered water towards the agricultural sector in the future. (Algeria Press Service, 2024)

- 5- Due to the wave of drought that the country experienced during the 2022-2023 agricultural season, the Algerian government took it upon itself to compensate the farmers affected by the drought active in the grain division, by supporting them with seeds and fertilizers for free, in the state of Guelma, 4200 affected farmers were counted, while a team of experts will begin conducting expertise and evaluation, releasing the toll of losses and activating the disaster fund. (Guelma State, 2024)

VII- The National Strategy for Climate Change Adaptation:

VII.1. On the Effects of Climate Change and Desertification:

Algeria's National Climate Plan. Its adaptation component includes short and medium-term actions relating to water saving, the adaptation of technical routes, the fight against erosion and desertification, the development of watersheds, the diversification of activities, the safeguarding and extension of forests and transversal measures relating to the improvement of governance by strengthening the capacities of the administration in terms of sensitivity, monitoring and innovative financing, participation and capacity building of communities rural areas to ensure sustainable local management of the natural environment. Building institutional and technical capacities to work in the field of climate change. (Ministry of The Environment and Renewable Energies, 2018, pp. 67-68)

The content of the National Climate Plan was constructed in such a way as to be consistent with Algeria's economic and social strategy and the new economic growth model adopted in 2015 for the period 2020-2035.

Resurrecting the Green Dam project with the aim of expanding it to an area of 4.7 million hectares during the next few years, with the aim of protecting natural resources and combating desertification.

VII.2. In the Agricultural Sector:

In September 2020, the Minister of Agriculture unveiled the Algerian agricultural road map 2020-2024, which aims to organize production areas throughout the region to map agricultural areas by 2030. Creation of small industrial agricultural areas. Developing agricultural centers on the basis of the specific professions for each region, modernizing the irrigation system to reduce water stress, moving towards smart agriculture capable of withstanding climate change and achieving sustainable agriculture that takes into account the environmental situation while maintaining the balance of ecosystems in various regions, encouraging innovation and new technologies, and establishing start-up companies. And using renewable energies, engaging research institutes and academics in the agricultural field to continue developing the seed sector to obtain varieties of agricultural products adapted to the scarcity of water resources, which represents a major obstacle. (Ferrah, 2021, pp. 2-3)

VII.3. In the Water Resources Sector:

Algeria launched an emergency program to support seawater desalination plants by moving towards the completion of 5 new projects. With a production capacity estimated at 1.5 million M³ per day, the number of seawater desalination plants will rise to 19 by 2024, with a total capacity estimated at 3.7 million M³ per day. The National Water Strategy 2021-2030 aims to meet the Algerians' need for drinking water by desalinating seawater by up to 60%. Currently 17% of needs are covered with desalinated water, and it will gradually rise to reach 22% in 2022, 42% in 2024, and 60% in 2030. (Al Jazeera Net correspondents, 2024)

VIII- Conclusions:

The impact of climate change on Algerian agriculture is already evident. Although the future effects are uncertain, they are expected to be significant, even with adaptation policies in place. Climate change puts pressure on countries that rely on agriculture for food security and economic diversification. Projections suggest that the impact of climate change on the national economy will be worse in the medium and long term. This could lead Algeria to...

- Inability to achieve food and water security;
- High food prices;
- Scarcity and water stress;
- High import bill for agricultural products;
- Low investment in the agricultural sector;
- Slow economic growth rates;
- Increased social problems and security risks.

VIII.1. Results:

- The local authorities are unable to adequately address climate change effectively due to the centralization of decisions.
- The chances of success of the national program to mobilize water resources will not be easy, because the water shortage in Algeria is very large and constantly increasing, especially in the north.
- The problem of water shortage will remain acute and dangerous, especially for the agricultural sector, which consumes between 70% and 75% of the country's water capacity.
- Climate change is having a significant impact on Algeria's agricultural sector, hindering the potential for economic diversification and growth of non-oil exports.

VIII.2. Recommendations:

- Strengthen the capacity of local authorities to plan, implement and monitor actions related to climate change mitigation and adaptation.
- Assess all water resources, including surface and underground, traditional and non-traditional, to promote sustainable water management and reduce water usage.
- To adapt to climate change, agricultural calendars need to be adjusted, and varieties and seeds that are suitable for dry climates should be selected. Additionally, implementing climatically intelligent agricultural practices is crucial.
- Implement a mechanism for monitoring and providing early warnings of severe weather conditions. Provide farmers with access to climate information and adaptation resources.
- Develop a monitoring program for climate-sensitive diseases and strengthen pest and disease control measures.
- Adapt to climate change by fighting desertification and land degradation, improving soil conservation techniques, and promoting sustainable land management.
- The organizational structure of the Ministry of Irrigation and its affiliated institutions in Algeria should be reviewed. This should be done in parallel with the activation of the set of Water Studies and achievements, and the strengthening of the capacity of institutions concerned with climate change. The goals should be clear and the budget should be substantial.
- A water and desalination Research Center should be established, along with a regulatory body for water services. International cooperation in this sector should also be improved.

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