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By:
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TOPIC:

Combined effect of climate change and anthropogenic pressure on plant biodiversity in the Ain Temouchent region, case of El Amria

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بسم الله الرحمن الرحيم

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Dedication

To my dear parents,

May God grant you health, long life, and peace. Thank you for your unconditional love, your prayers, your sacrifices, and your unwavering presence in my life.

To my brothers and sisters:

Souhila, Omar, Nihad and Fares Abdelillah,

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To all those I love, also chatgbt

And who hold a special place in my heart, thank you for being there, near or far. This work is also dedicated to you.

IKRELEF Amina Ferial

SCAN ME

الملخص:

تهدف هذه الدراسة إلى تقييم الآثار المُجتمعة لتغير المناخ والضغوط البشرية على التنوع البيولوجي النباتي في منطقة عين تموشنت، وتحديدًا في بلدية العامرية. وقد اعتمدنا المنهج البيئي النباتي، من خلال إجراء مسوحات نباتية على مساحات متجانسة. وعلى نطاق ثابت، دُرست 11 موقعًا باستخدام طريقة التربيع. أما على المستوى الخرائطي، فقد أجرينا تحليلًا زمنيًا لاستخدام الأراضي بين عامي 2015 و2025. وقد كشفت النتائج عن تراجع في بعض أنواع النباتات وتدهور في الموائل الطبيعية، مرتبطًا بالأنشطة الزراعية غير المخطط لها والتوسع العمراني. إضافةً إلى ذلك، أثّرت التغيرات المناخية، بما في ذلك ارتفاع درجات الحرارة وانخفاض هطول الأمطار، على التوزيع النباتي.

توصي الدراسة بضرورة تبني تدابير لحماية الغطاء النباتي وتعزيز الزراعة المستدامة للحفاظ على التوازن البيئي في المنطقة.

الكلمات المفتاحية :

تغير المناخ، التنشئة البشرية، علم البيئة النباتية، العامرية، عين تموشنت، التنوع النباتي , رسم خراءط.

Résumé

Cette étude vise à évaluer les effets combinés du changement climatique et de la pression anthropique sur la biodiversité végétale dans la région d'Aïn Témouchent, plus précisément dans la commune d'El Amria. L'approche phytoécologique a été adoptée, en réalisant des relevés floristiques sur des espaces homogènes. À l'échelle stationnaire, 11 sites ont été étudiés par application de la méthode des quadrats. Au niveau cartographique, nous avons réalisé une analyse diachronique de l'occupation du sol entre les années 2015 et 2025.Le résultat on révèlent une régression de certaines espèces végétales et une dégradation des habitats naturels, en lien avec les activités agricoles non planifiées et l'extension urbaine. Par ailleurs, les variations climatiques, notamment la hausse des températures et la baisse des précipitations, ont impacté la distribution floristique. L'étude recommande la mise en place de stratégies de gestion durable pour préserver la biodiversité végétale et les écosystèmes locaux.

Mots-clés **:**
changements climatiques ,anthropisation , phytoecologie , el Amria , Ain Temouchent , phytodiversité , cartographie

Abstract

This study aims to assess the combined effects of climate change and anthropogenic pressure on plant biodiversity in the Aïn Témouchent region, more precisely in the commune of El Amria. The phytoecological approach was adopted, by carrying out floristic surveys on homogeneous spaces. At the stationary scale, 11 sites were studied by applying the quadrat method. On the cartographic level, we carried out a diachronic analysis of land use between the years 2015 and 2025. The results revealed a regression of certain plant species and a degradation of natural habitats, linked to unplanned agricultural activities and urban expansion. In addition, climatic variations, including rising temperatures and falling rainfall, have impacted floristic distribution. The study recommends the implementation of sustainable management strategies to preserve plant biodiversity and local ecosystems.

Keywords:
climate change, anthropization, phytoecology, el Amria, Ain Temouchent, phytodiversity, mapping .

List of abbreviation

A.N.A.T : National Agency for Land Use Planning

CO_2 : Carbon Dioxide

CH_4:Methane

DNA :Deoxyribonucleic Acid(

DSA : Directorate of Agricultural Services

GPS :Global Positioning System

H_2O : Water

IUCN : International Union for Conservation of Nature

IPCC : Intergovernmental Panel on Climate Change

LULC : Land Use and Land Cover

MATE :Ministry of Spatial Planning and Environment

N_2O : Nitrous Oxide

O_2 : Oxygen

ONS : Office national of statistic

Pop R.G.P.H :General Census of Population and Housing

UNFCCC : United Nations Framework Convention on Climate Change

WMO : World Meteorological Organization

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General Introduction

General introduction :

The concept of biodiversity, a contraction of "biological diversity," is relatively new, meaning the variety of the living world. It refers to the variety and diversity of all living beings—animals, plants, and microscopic—on Earth, as well as all the interactions that occur between species and their environments **(Rovillé and Wafra, 2010).**

So plant biodiversity represents a key indicator of ecosystem health. It plays a vital role in maintaining ecological balance, agricultural production, and climate regulation. However, this biodiversity is increasingly threatened by two major factors: climate change and human activities. The interaction between these two phenomena accelerates habitat degradation, alters species distribution, and threatens ecological stability at different scales.

The Aïn Témouchent region, more specifically the municipality of El Amria, perfectly illustrates this issue. Located in a semi-arid Mediterranean climate zone, it is experiencing both significant climate change and increasing anthropogenic pressure linked to agriculture, urbanization, and the exploitation of natural resources. In this context, it is becoming necessary to analyze the evolution of plant biodiversity in order to better understand the combined impacts of these factors and propose avenues for adaptation.

The main objective of this thesis is to assess the combined effects of climate change and anthropogenic pressures on plant biodiversity in the El Amria region. More specifically, the aim is to:

- Characterize the floristic components of the study sites;
- Analyze changes in land use in recent years using mapping data;
- Assess the pressure exerted by human activities (urbanization, agriculture, grazing, etc.);
- Identify the ecological responses of plant species to climatic and human stresses;
- And finally, formulate recommendations for the sustainable management and conservation of local flora.

To meet these objectives, the work is structured into five chapters:

- ❖ Chapter 1: bibliographyque summery

This chapter presents the fundamental theoretical concepts related to biodiversity, climate change, anthropogenic pressure, and their interactions on plant ecosystems. It provides the scientific framework for the study

- ❖ Chapter 2: Presentation of the Study Area

This chapter describes the El Amria region from its geographical, climatic, pedological, and socioeconomic perspectives, highlighting the specific characteristics of the study area and the factors of ecological disturbance.

- ❖ Chapter 3: Materials and Methods

It details the methodology used for the floristic inventory (quadrat method), the survey periods and frequencies, the data collection tools, and the software used for mapping and spatial analysis.

- ❖ Chapter 4: Anthropogenic Pressure and Land Use Dynamics

Using a diachronic analysis of land use maps (2015–2025), this chapter examines the evolution of agricultural, urban, and natural areas and assesses their impact on floral habitats.

- ❖ Chapter 5: Impacts of Climate Variability on phytobiodiversity

This final chapter explores the consequences of climate change on local flora, highlighting sensitive, resistant, and indicator species, and comparing observed trends across different sites.

Through this structured approach, this work aims to provide an integrated ecological understanding of the current situation of plant biodiversity in El Amria, taking into account the multiple pressures exerted on the territory.

The results obtained may contribute to the implementation of sustainable management measures adapted to regional specificities.

CHAPITER 1 Bibliographic summary

I. Chapiter 1 bibliographic summary

I.1 General introduction on plant biodiversity:

I.1.1 Definition of biodiversity :

The word "biodiversity" first appeared in 1988 in a publication by American entomologist Edward O. Wilson at the American National Forum on Biological Diversity. The word biodiversity was considered more effective in terms of communication than biological diversity (**Chevassus-au-Louis, 2008).**

Among a large number of definitions that have been proposed, we will cite the following:

− Definition 1: The Rio de Janeiro Convention on Environment and Development in 1992 provided a common definition: "biodiversity is defined as the diversity of genes, species, ecosystems and ecological processes" **(Lévêque & Mounolou, 2008).**

− Definition 2: In its simplest form, biodiversity represents life on Earth. Biodiversity can therefore be defined as the variety of living species contained in all terrestrial and aquatic ecosystems currently found on the planet (**Blondel, 2006).**

− Definition 3: The term biodiversity is defined by the variability of living organisms from all sources, including, among others, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part (**Gaston & Spicer, 1998).**

− Definition 4: Biodiversity is defined as useful nature, that is, the set of species or genes that humans use for their benefit, whether they come from the natural environment or from domestication. This concept refers to the variety of life forms including plants, animals and microorganisms, the genes they contain and the ecosystems they form **(Ramade, 2009).**

− Definition 5: "The most striking feature of the earth is life and the most striking feature of life is its diversity" **(Tilman et al., 2006).**

There are three levels of organization of biological diversity: genes, species, and ecosystems **(Leveque and Mounolon, 2008).**

I.1.1.1 Genetic Diversity:

This corresponds to the genetic variability between individuals of the same species. There are three main approaches to quantifying genetic variability: the phenotypic approach, enzymatic variability analysis, and direct analysis of genetic variability (DNA sequencing) **(Parizeau, 2001).**

Genetic diversity of carrots and cauliflower: root color determined by the presence of carotenoid and anthocyanin pigments.

Figure 1: examples of genetic diversity in some vegetables (pientrest)

I.1.1.2 Species Diversity:

This corresponds to the diversity of species itself. Three concepts are distinguished within the concept of species diversity **(Peet, 1974).**

- Species richness: This is the total number of taxa.

- Equitability (distribution of abundance): This is the distribution, in proportion to the total abundance, of all taxa in a given set.

A community is said to be equally distributed when all the taxa that compose it have the same abundance.

- Composition: This is the identification of the taxa that constitute a community.

To quantify taxonomic biodiversity, three levels of estimation are distinguished **(Parizeau, 2001):**

 Alpha diversity: The number of species that coexist in a uniform habitat of a fixed size.

 Beta diversity: Expresses the rate of species replacement across a topographic, climatic, or habitat gradient in a given geographic area.

 Gamma diversity: Expresses the rate of addition of new species when sampling the same habitat in different locations.

To measure species diversity, several indices have been proposed. The best known are:

 Shannon index: derived from information theory **(Barbault, 1995)** is:

$H' = -\Sigma p_i \log_2 p_i$

Of which:

$P_i = n_i/N$ is the relative abundance of species i in the sample.

N, the sum of the numbers of the S species constituting the population.

n_i, the population size of species i

The value of the index varies from 0 (one species) to log S (when all species have the same abundance).

 Simpson index: This is the second most widely used diversity index. Its value varies from 1 (a single species) to S (all species have the same abundance).

$Is = 1/ \Sigma p_i$

Figure 2: examples of specific diversity within a mountain ecosystem(pientrest)

A: the Aleppo pine (*Pinus halepensis Mill*.), B: the Asphodel (*Asphodelus microcarpus Sal & Viv.),* C: the white horehound (*Marrubium vulgare L*)

I.1.1.3 Ecosystem diversity:

"It is the variety that exists in physical environments and biotic communities in a landscape."

Ecosystem diversity refers to the diversity of ecosystems on our planet, the interactions between natural populations and their physical environments. It takes into account both living biotic components (animal and plant species) and non-living abiotic components (soil types, topography, etc.) **(Brahic & Terreaux, 2009).**

It refers to all the different habitats – or places – that exist on the planet, such as tropical or temperate forests, hot or cold deserts, wetlands, rivers, mountains, etc.

Each ecosystem corresponds to a series of complex relationships between biotic (living) elements such as animals, plants and microorganisms, and abiotic (non-living) elements such as sunlight, air, water and nutrients.

The diversity of ecosystems is the result of the interactions that the species they shelter have developed with each other and with their environment. Relationships that ensure each species has the conditions and resources necessary for its survival **(Lévêque, 2008).**

Examples:

− Tropical forest: low light, low day/night temperature difference, high humidity, lush vegetation, high animal density.

− African savanna: high light, low day/night temperature difference, low humidity, medium vegetation level, medium animal density

− African desert: high light, high day/night temperature difference, low humidity, low vegetation level, low animal density

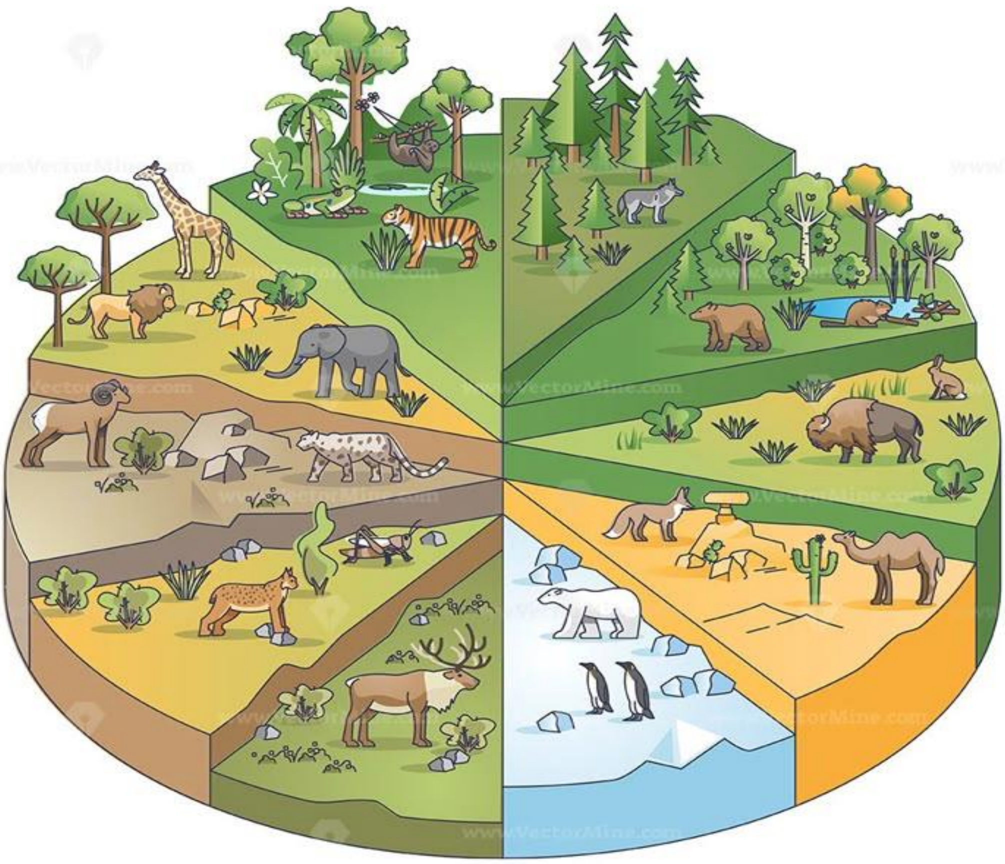

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Figure 3 : represents ecosystem diversity in the world (pientrest)

I.1.2 Global Biodiversity :

In 2008, **Dajoz** reported that approximately 1,800,000 species of living beings are known and

described, but the actual number is between 5 and 10 million, because several groups of insects and fungi are poorly understood.

Biodiversity is distributed unevenly across the globe, with some regions having very high diversity, while others are poor. Regions with very high diversity have been described as critical areas, hot spots, or "hotspots." There are

35 hotspots (Table 1) located mainly in tropical regions, the Mediterranean, California, and South Africa (**Jaisankar et *al*., 2020).** "They form only 1.4% of the land mass but contain 44% of known vascular plants." Regarding the percentages of endemism, birds represent

28.5% of global species, mammals 27.3%, amphibians 53.8%, reptiles 37.5%, and insects in particular are poorly known" **(Dajoz, 2008).**

Table 1different hotspots in tne world (jaisankar et al,2020)

Region	Hotspot
Africa	1. Cape Floristic Region 2. Coastal Forests of Eastern Africa 3. Eastern Afromontane 4. Guinean Forests of West Africa 5. Horn of Africa 6. Madagascar and the Indian OceanIslands 7. Maputaland-Pondoland-Albany 8. Succulent Karoo
Asia-Pacific	9. East Melanesian Islands 10. Himalaya 11. Indo-Burma 12. Japan 13. Mountains of Southwest China 14. New Caledonia 15. New Zealand 16. Philippines 17. Polynesia-Micronesia 18. Southwest Australia

Europe and Central Asia	19. Forests of Eastern Australia (new) 20. Sundaland 21. Wallacea 22. Western Ghats and Sri Lanka
North and Central America	23. Caucasus 24. Irano-Anatolian 25. Mediterranean Basin 26. Mountains of Central Asia
South America	27. California Floristic Province 28. Caribbean Islands 29. Madrean Pine-Oak Woodlands 30. Mesoamerica
	31. Atlantic Forest 32. Cerrado 33. Chilean Winter Rainfall-Valdivian Forests 34. Tumbes-Chocó-Magdalena 35. Tropical Andes

Biological diversity is not only very unevenly distributed across regions(Figure 4) but also across various terrestrial, aquatic, and marine ecosystems (**Dajoz, 2008).**

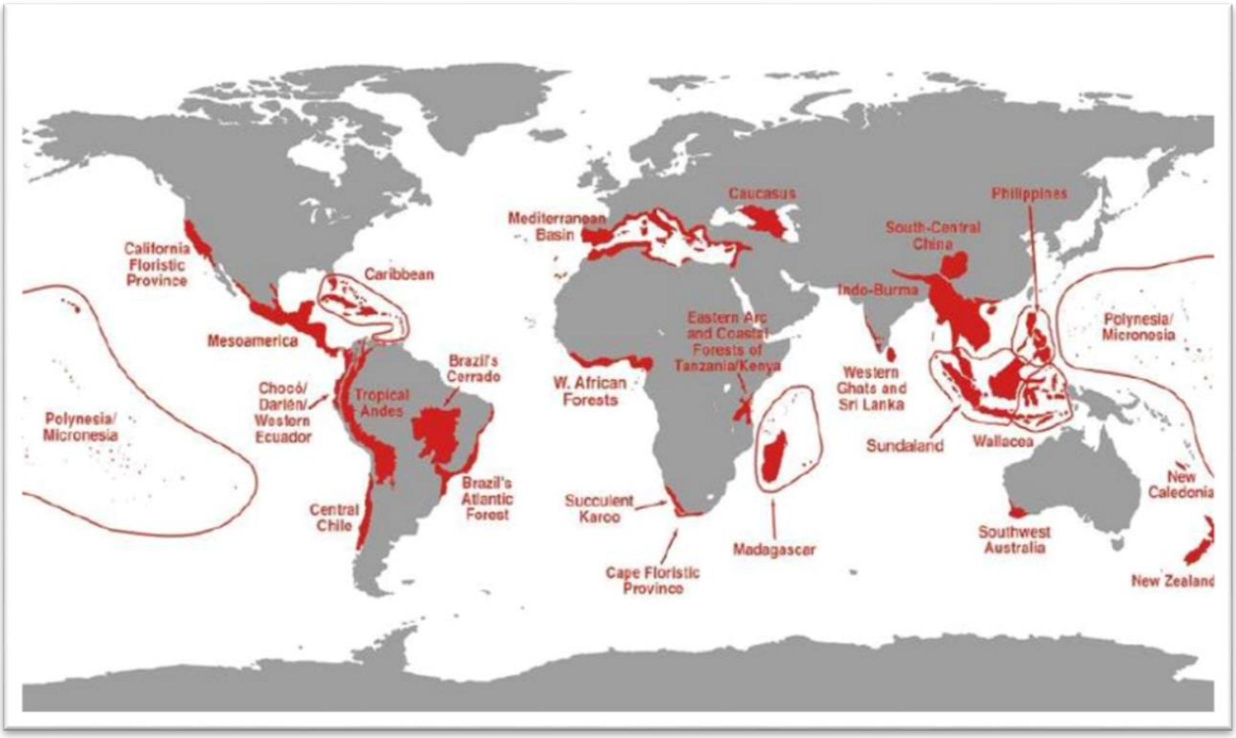


Figure 4 : the distribution of hotspots in the world (jaisankar et al ,2020

I.1.3 Biodiversity in Algeria :

Algeria's geographical location presents a great diversity of biotopes occupied by a significant floristic richness.

This country covers an area of 2,381,741 km², borders the Mediterranean Sea from east to west for 1,622 km and stretches from north to south for nearly 2,000 km (**MATE, 2009**).

The Algerian flora is very diverse in taxa, as it presents the main floristic groups. The following table shows the main floristic groups in Algeria.

Table 2 : the principal florestic groups in algeria (MATE,2009)

	Groupes	Nomber of espècies in the world		Algeria (Nomber of taxons)	
		Décrits	Estimés	Connu	Inconnu Estimé (+/-)
Flora	Champignons Algues	72 000 40 000	1 500 000 400 000	78 468	50 60
	Total Plantes	270 060	320 000 -	- -	- -
	Lichens Mousses	- 17 900	- -	600 2	80 90
	Fougères	10 000	-	44	15
	Spermaphytes	120 529	-	3 159	6
	Espèces introduites	-	-	5128	-

According to table 01, the flora includes approximately 3,139 species spread across nearly 150

families among which 653 species are endemic, an endemism rate of approximately 12.6%.

The richness of taxa in Algeria reflects ecosystem richness (wetlands, mountain ranges, steppe, Saharan, and marine ecosystems), as well as climatic and geographic diversity.

However, this biodiversity is vulnerable to natural and anthropogenic degradation factors. Several species are threatened with extinction: the Tassili cypress, the Numidian fir, the black pine, and the tufa juniper **(IUCN, 2008).**

To protect this natural heritage, a national strategy has been developed. It focuses on the creation of protected areas and the legal protection of certain threatened or vulnerable species. At the national level, the list ofprotected non-cultivated plant species defines 230 plants whose preservation in their natural state is of national interest. This represents 7.3% of Algeria's wild flora and only 14.27% of the total number of species considered rare (**MATE, 2009**). Domestic agricultural biodiversity in Algeria is currently estimated at 1,438 cultivated species (**MATE, 2009)**

I.1.4 Biodiversity in Ain Temouchent

The province of Aïn Témouchent, located in northwestern Algeria, boasts remarkable biodiversity, notably thanks to its wetlands, forests, and Mediterranean coastline.

I.1.4.1 Wetlands and Birdlife :

The region has 18 sites classified as wetlands, including the Rachgoun alê, recognized as being of international importance under the Ramsar Convention. These areas play a crucial role in regulating ecosystems and are home to diverse migratory birds. For example, between August 2016 and January 2017, 18 protected bird species were observed in sites such as Sebkha, Oued Kihal, and Hassi El Ghella, including rare species such as the black-winged stilt, the grey heron, and the slender-billed curlew. **(interieur.gov.dz).**

I.1.4.2 Rachgoun Island: an ecological sanctuary :

In 2023, Rachgoun Island was designated a nature reserve covering an area of 70.15 km². It is home to 593 species of flora and fauna, 71 of which are threatened with extinction. This site combines ecological and archaeological richness, including a historic lighthouse dating back over 150 years.**(interieur.gov.dz).**

Figure 5: beni-saf the island of rachgoun a wetland (pientrest)

I.1.4.3 Forests and ecotourism

Three forests belonging to the province of Ain Temouchent—Madrid (Béni Saf), Ain El-Arba, and Sidi Ali-Cherif (Chentouf)—have been classified as recreational forests.

This aims to develop ecotourism and, at the same time, provide employment opportunities for residents.

In summary, Ain Temouchent is endowed with a rich natural heritage that is the subject of efforts for its conservation and sustainable development. However, some challenges remain, particularly in the areas of green space management and environmental education.

I.2 climate change :

I.2.1 Definition of climate change

Climate is characterized by a statistical representation of the average state of the atmosphere as well as the spatial and temporal variations of climatic parameters such as temperature, precipitation, humidity, wind, and pressure over a period ranging from a few months to millions of years **(Alexandre *et al.* 2009).**

There are a multitude of definitions in the literature, however, the central element remains the description of atmospheric variations in a specific region;this is why the World Meteorological Organization (WMO) characterizes climate as the average conditions observed in a specific location (temperature, precipitation, etc.) calculated from data collected over a minimum period of 30 years

It is therefore characterized by average values, but also by fluctuations and extreme values. According to the Intergovernmental Panel on Climate Change (IPCC), climate change refers to a detectable change in the state of the climate that can be observed (for example, through statistical analyses) by changes in the mean and/or variability of its characteristics, which persist over a long period of time, usually for decades or longer.

The UNFCCC (United Nations Framework Convention on Climate Change) defines climate change as changes, directly or indirectly caused by human activity, that alter the composition of the global atmosphere and are in addition to natural climate variability observed over similar time periods.

I.2.2 Natural climate change

Climate change is already occurring; scientific data show undeniable warming of the climate, and the rate of change is intensifying.

Climate change can be attributed to both natural phenomena and processes as well as human intervention. Major natural factors include variations in the intensity of sunlight reaching the Earth and fluctuations in the density of volcanic dust (capable of reflecting and scattering sunlight) within the stratosphere **(ACHIR „2016)**).

I.2.3 Global warming,

Global warming, observed in the 20th and early 21st centuries, refers to the long-term increase in the Earth's average temperature, particularly since the Industrial Revolution. This phenomenon has become a global concern due to its

environmental, economic, and social impacts.

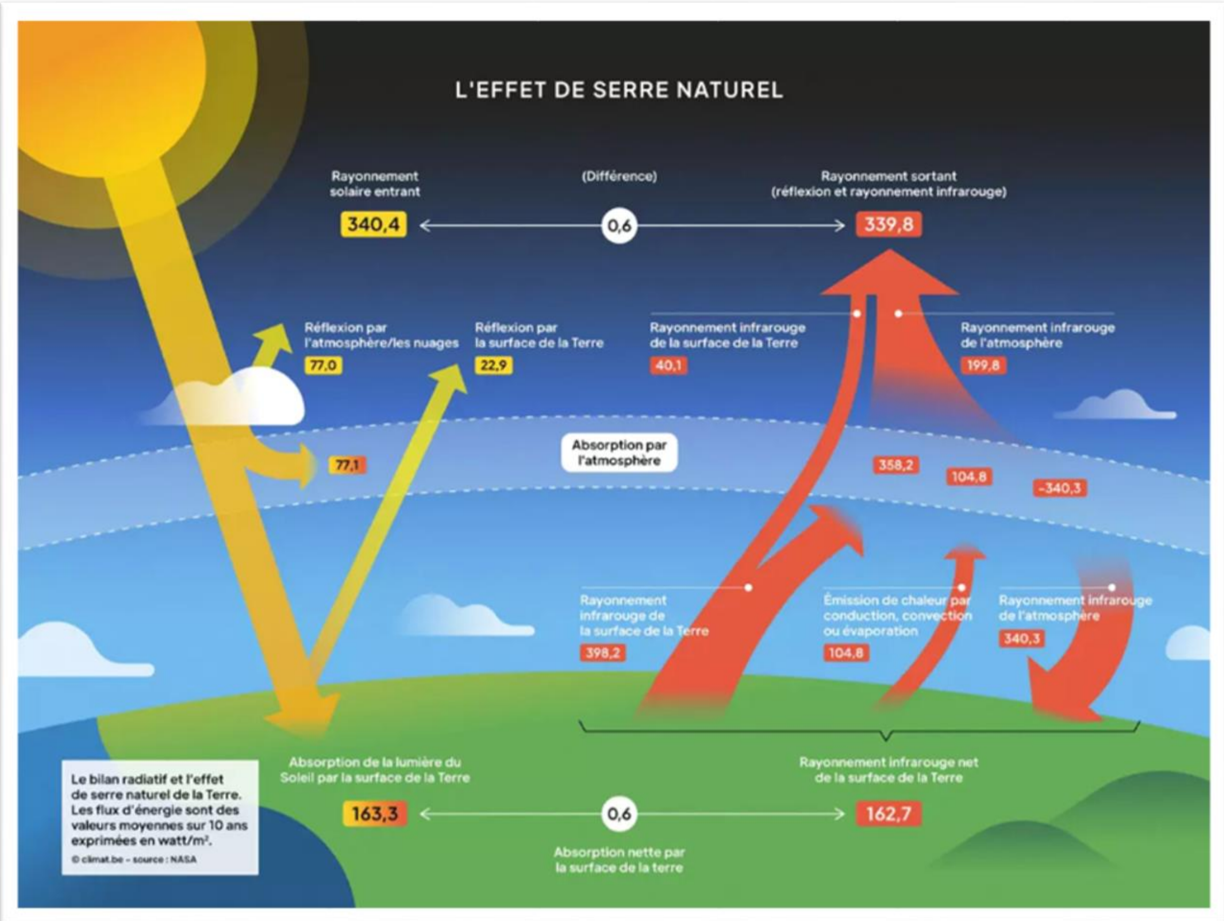


Figure 6: greenhouse effect process(CLIMAT.BE)

The main causes are:

a) Greenhouse gas (GHG) emissions:

Greenhouse gases (CO_2, CH_4, N_2O, H_2O) play a crucial role in global warming. These gases absorb and re-emit infrared heat, thus contributing to the increase in the planet's average temperature. The main anthropogenic sources of these gases are:

- O_2 (carbon dioxide): This gas is generated by the combustion of fossil fuels (coal, oil, gas) used in energy production, industry, and transportation. Deforestation, which reduces the capacity of forests to accumulate carbon, is also a major source of CO_2.
- CH_4 (methane): It is mainly generated by the agricultural sector (especially livestock farming, thanks to the digestion of ruminants), landfills, and energy production (natural gas and oil extraction). Methane, although present in smaller quantities, is significantly more potent than CO_2 in the short term.
- N_2O (nitrous oxide): Resulting from the use of fertilizers in agriculture and industrial processes. This gas is also a powerful greenhouse gas.

b) Land Use Changes and Deforestation

One of the main causes of rising greenhouse gas emissions is deforestation and land degradation. The removal of trees decreases the planet's ability to absorb CO2. Additionally, carbon stored in biomass and soil is released when land is converted for urbanization or agriculture.

c) Industrialization and Economic Growth

The amount of CO_2 in the atmosphere has increased dramatically due to human activity since the Industrial Revolution in the 19th century. The usage of fossil fuels and greenhouse gas emissions have been exacerbated by the expansion of industry, transportation, and urbanization.

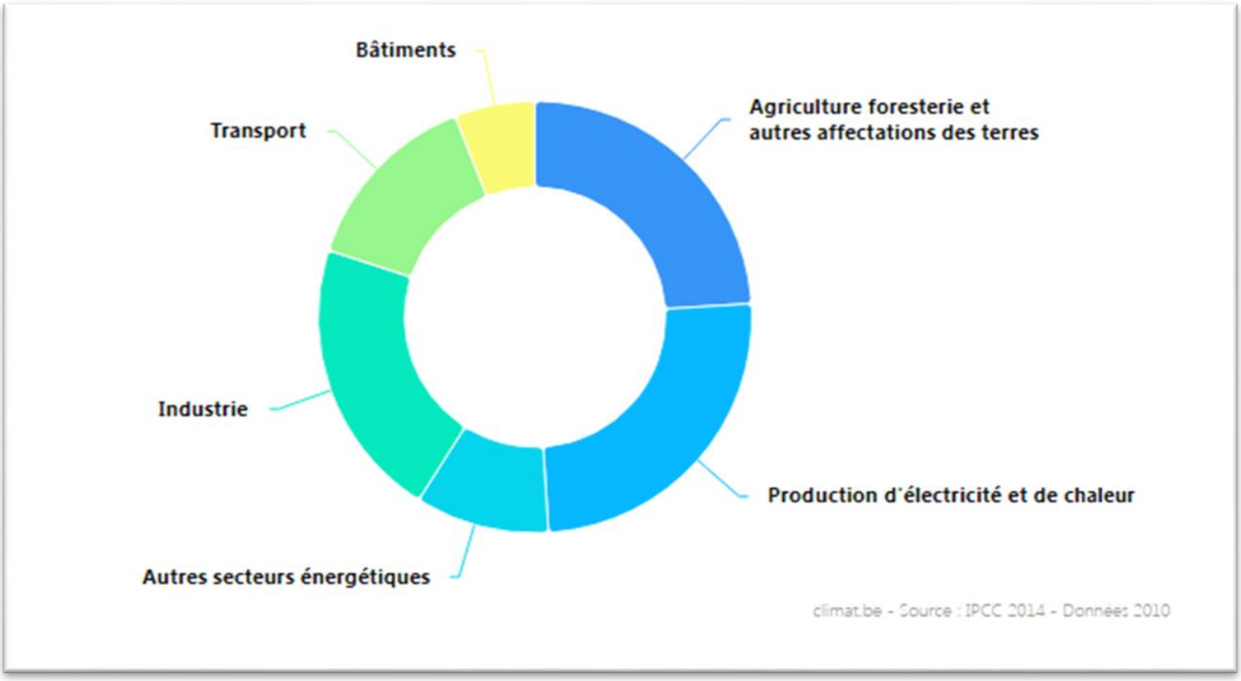


Figure 7: distribution of global greenhouse gas emissions by sectoer

I.2.4 Effects of climate change on vegetation :

Climate change represents one of the greatest environmental challenges of our time. By altering the physical conditions of ecosystems (temperature, precipitation, frequency of extreme events), it exerts unprecedented pressure on plant biodiversity, resulting in impacts. These impacts are divided into two parts**(ACHIR,2016):**

I.2.4.1 Direct impacts on plant biodiversity:

- Changes in Distribution Ranges :

Global warming is forcing some species to migrate to more favorable altitudes or latitudes. This can lead to:

- A contraction in the distribution range of heat-sensitive species.
- An expansion of thermophilic or opportunistic species.
- The local disappearance of endemic species with poor dispersal power.

- Disruption of the Phenological Cycle :

Climate variations alter the natural seasonal rhythms of plants:

- Early or delayed flowering.
- Changes in germination or fruiting periods.

This desynchronizes interactions with pollinators, which can compromise plant reproduction.

- Water and Heat Stress :

Rising temperatures coupled with decreased precipitation cause water stress that affects:

- Plant tissue growth.
- Photosynthetic metabolism.
- The survival of young plants in arid or semi-arid environments.

Regional example: In the Algerian Highlands, vegetation cover declines in the face of repeated droughts, exacerbating soil erosion.

- Spread of fires and pathogens :

The warmer, drier climate promotes:

- The frequency of forest and scrubland fires.
- The development of pests and pathogenic fungi, particularly in agriculture.

I.2.4.2 Indirect impacts on plant biodiversity:

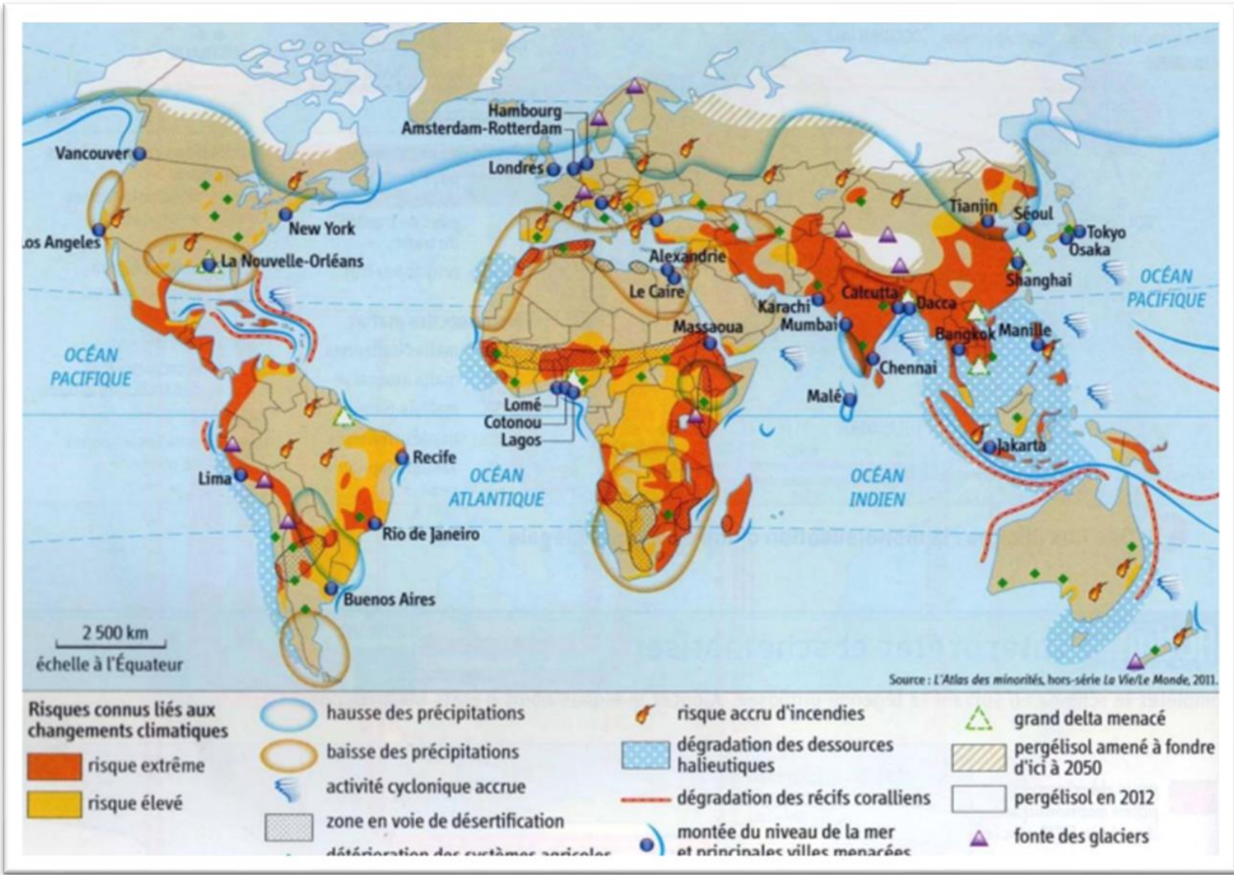
- Degradation of habitat :

Climate change leads to the transformation of natural biotopes:

- Regression of forests and steppe formations.
- Habitat fragmentation, affecting ecological continuity.

- Biological Invasion:

Certain exotic species, more competitive, establish themselves in environments disturbed by



the climate, to the detriment of less adaptable local species.

Figure 8 : Consequences of climate change on a global scale. (The Atlas of miniorities , special issue La Vie / Le monde 2011

I.3 Anthropogenic pressure:

I.3.1 Definition of anthropogenic pressure :

According to **Vitousek*et al.*,** 1997, the definition of anthropogenic pressure is Human activities profoundly modify terrestrial ecosystems, to the point that few, if any, are exempt from anthropogenic influence. This pressure is exerted through processes such as land transformation (agriculture, urbanization), disruption of biogeochemical cycles, addition or loss of species, and alteration of exchanges between ecosystems.

These changes are often of sufficient magnitude to cause irreversible losses of biodiversity.

Also In ecology, anthropogenic pressure refers to all the transformations that humans exert on ecosystems, in which land conversion, modification of natural cycles, introduction or disappearance of species, and impacts on atmospheric, aquatic and biological exchanges. These pressures contribute to the loss of biodiversity and the alteration of ecological functions.

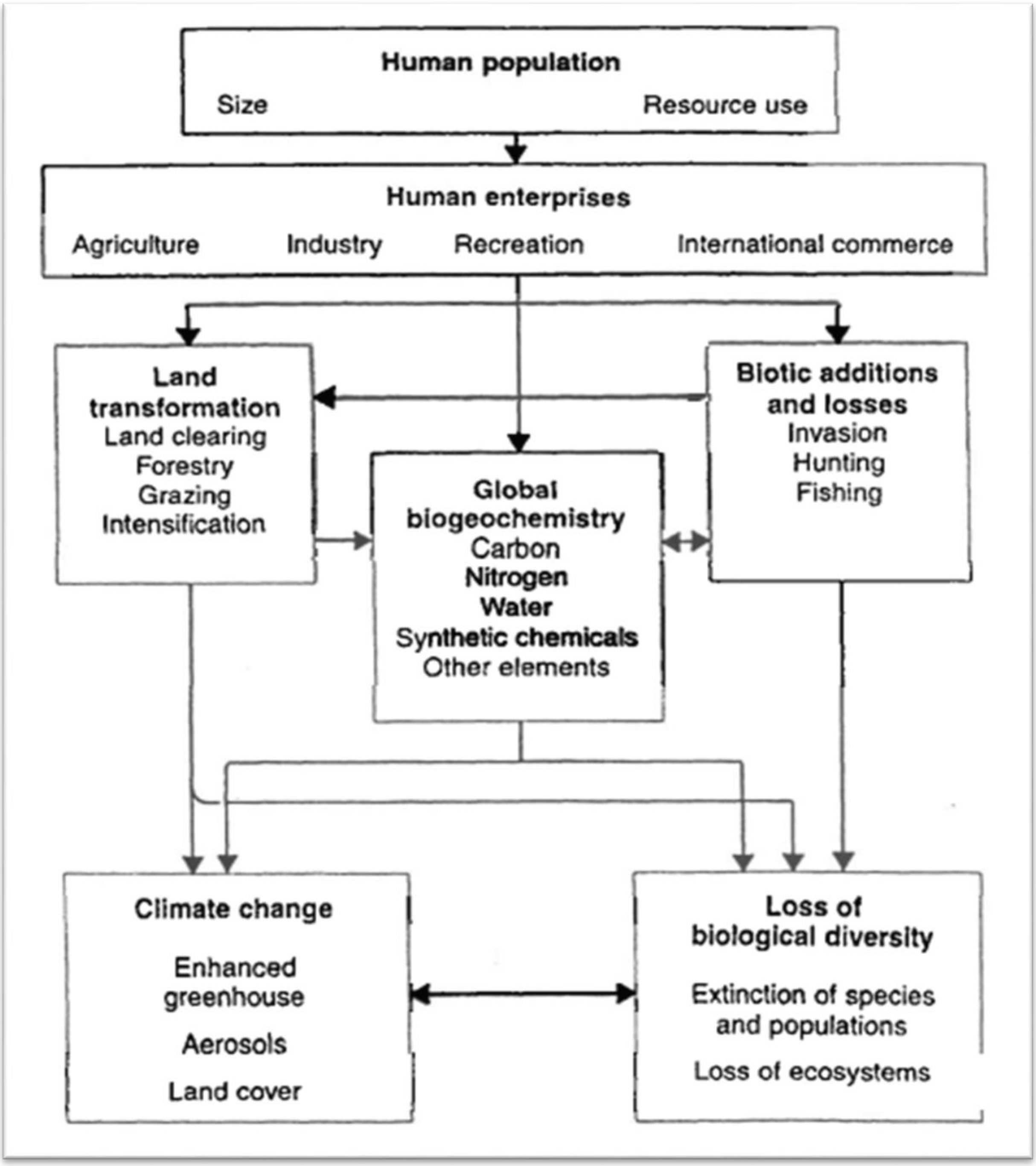


Figure 9 : conceptual diagram illustrating the direct and indirect effects of human activities on ecosystems according to vitousel *et al* ,1997

I.3.2 Anthropogenic Pressure Forms:

Human pressure manifests itself in various forms, which differ depending on geographic, social, economic, and cultural contexts.

The main forms identified in terrestrial ecosystems are:

a) Land Transformation

One of the main pressure factors is the conversion of natural lands into agricultural, urban, or industrial areas. According to **Vitousek***et al*. (**1997)**, between one-third and one-half of the Earth's surface has been transformed by human activities.

b) Intensive Agriculture

Profoundly alters the composition and structure of plant communities through the excessive use of pesticides and chemical fertilizers, massive irrigation, deep plowing, and monoculture, thus reducing plant biodiversity.

c) Urbanization and Infrastructure

The development of roads, housing developments, quarries, and industrial zones leads to land degradation, habitat fragmentation, and the elimination of natural species in favor of ruderal species.

d) Overgrazing

Excessive animal pressure. In steppes or arid zones, it prevents the regeneration of plant species, destabilizes the soil, and promotes erosion. Overgrazing is also often aggravated by a lack of rotational grazing.

e) Deforestation and logging

Excessive tree felling for firewood or construction reduces forest cover, leads to the disappearance of woody species, and alters local microclimates.

f) Pollution

Waste from households, industry, or agriculture (fertilizers, hydrocarbons, heavy metals) contaminates soils and waterways, hindering plant growth and altering their composition.

g) Introduction of exotic species

Some introduced plant or animal species, whether intentionally or accidentally, become invasive, outcompete local species, and disrupt ecological dynamics.

I.3.3 Impacts of Anthropogenic Pressure on Vegetation

Anthropogenic pressures directly and indirectly affect natural and cultivated vegetation, including **(ACHIR.M 2016) :**

a) Reduction in Species Richness

Species sensitive to disturbances disappear, including endemic species or species with low reproductive or dispersal capacity.

b) Fragmentation and Habitat Loss

Ecological discontinuity prevents genetic circulation between plant populations, promotes their isolation, and makes natural recolonization difficult.

c) Genetic Erosion

Ecological discontinuity hinders natural recolonization, isolates plant communities, and stops genetic exchange between them.

d) Changes in Ecological Dynamics

Interactions between plants (pollination, dispersal, mycorrhizal symbioses) are disrupted, threatening the stability of ecosystems.

e) Soil degradation and desertification

The loss of vegetation cover results in water and wind erosion, salinization, or soil compaction, especially in arid and semi-arid areas.

Local example: In El Amria, overgrazing, deforestation for firewood, and the uncontrolled expansion of agricultural land are causing a significant decline in natural plant formations (*Artemisia herba-alba, Stipa tenacissima*) and favoring less ecologically beneficial substitute species.

I.4 Combined Effects of Climate Change and Human Impacts

The synergistic interaction between climate change and anthropometric pressure exacerbates their impacts on plant ecosystems. These combined effects cause profound and often irreversible environmental transformations.

We mention some of them:

1) Amplification of the sécheresse effects:

Natural environments degraded by humans (deforestation, overgrazing, urbanization) are no longer able to withstand extreme events caused by climate change such as drought, heat waves, and fires.

2) Accelerating desertification:

Poorly controlled human activities (tillage, deforestation, and overexploitation of water resources) combined with declining rainfall are intensifying vegetation loss and accelerating soil drying in semi-arid regions such as western Algeria.

3) Decline in ecosystem services:

Ecosystems are losing their ability to perform natural functions (such as water purification, carbon storage, and thermoregulation) due to human pressures, exacerbating the effects of global warming.

4) Increased vulnerability of plant species:

Endominant species have become more sensitive to water and heat stress. Some are unable to adapt or migrate, and are disappearing locally.

5) Disturbed ecological interactions

The imbalance in food chains and plant species reproduction is due to climate-related phenological changes (flowering and fruiting) along with habitat loss.

Chapiter 2

Presentation ofthe area Physical and bioclimatic

II. Chapiter 2 presentation of the area physical and bioclimatic

II.1 Introduction:

The analysis of the effects of climate changes and human activities on the biodiversity of vegetables requires a suitable environment for the physical, climate and socio-economic aspects of the d'étude zone. The community of El Amria, located in the Wilaya of Aïn Témouchent, consists of a permanent observation terrain in the raison of the natural diversity of its milieux, its dominant agricole activity and the croissant of the anthropological impressions of another section.

This chapter is for the purpose of displaying a detailed portrait of the region of El Amria, in a wide range of geographical features, climate, pedology and socio-economics. These elements are essential to comply with local ecological dynamics and susceptible factors that influence the composition and distribution of vegetables. Use these parameters to serve the base to interpréter the previous florist results.

II.2 General Information on the Province of Ain Temouchent:

II.2.1 Geographical context of AIN TEMOUCHENT:

The wilaya of Ain Temouchent is a territorial public authority and administrative district of the Algerian state, whose capital is the city of Aïn Témouchent. It was created by a law of February 4, 1984. The wilaya covers an area of approximately 2,377 km².

It is located in Oranie, bordered to the east by the wilaya of Oran, to the southeast by the wilaya of Sidi-Bel-Abbès, to the southwest by the wilaya of Tlemcen, and to the northwest by the Mediterranean Sea, which borders it for a distance of approximately 80 km.

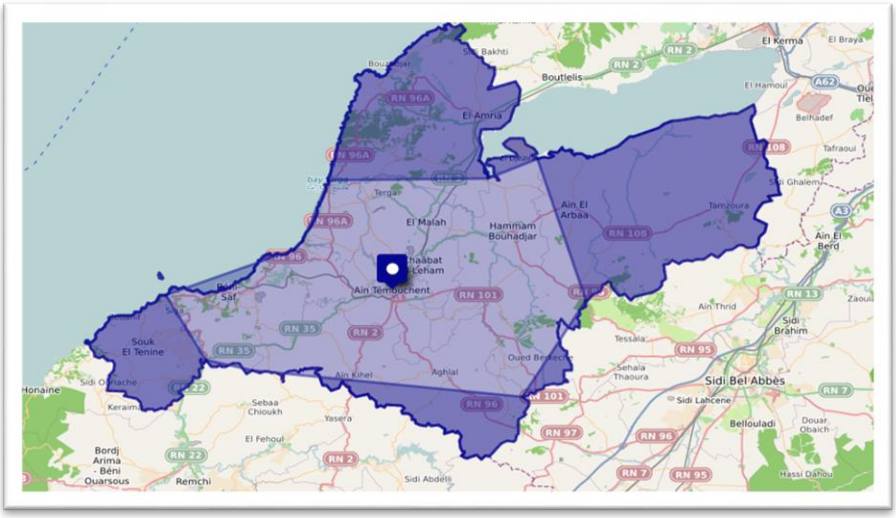


Figure 10 : wilaya of Ain temouchent (google maps)

II.2.2 Administrative division of the wilaya :

The wilaya of Ain Temouchent includes 28 communes spread over 08 Daïras as follows:

Table 3: Administratif devision of the wilaya

T DAÏRA	COMMUNES
AIN TEMOUCHENT	AIN TEMOUCHENT- SIDI BEN ADDA.
EL MALAH	EL MALAH - TERGA - CHAABAT LEHAM -OULED KIHAL.
EL AMRIA	EL AMRIA - BOUZEDJAR - M'SAID - OULED BOUDJEMAA – HASSI EL GHELLA.
HAMMAM BOU HADJAR	HAMMAM BOUHADJAR - OUED BERKECHE- HASSASNA-CHENTOUF
AIN ARBAA	AIN LARBAA - TAMAZOURA - OUED SEBBAH - SIDI BOUMEDIENE.
BENI SAF	BENI SAF - SIDI SAFI - EMIR ABDELKADER
OULHACA GHERABA	OULHACA - SIDI OURIACHE
AIN KIHAL	AIN KIHAL - AGHLAL - AIN TOLBA - AOUBELLIL.

Figure 11 : commune and dairas of the wilaya (Wekipidia)

II.2.3 Typologie des communes de la wilaya:

Table 4 : Typologie of Ain temouchent's comunes

NATURE	COMMONS
PLAIN ZONE	AIN TEMOUCHENT- EL MALAH - CHAABAT LEHAM - HAMMAM BOUHADJAR – CHENTOUF - EL AMRIA – HASSI EL GHELLA.
COASTAL ZONE	TERGA - OULED KIHAL – SIDI BEN ADDA – BOUZEDJAR - OULED BOUDJEMAA – M'SAID – BENI SAF – SIDI SAFI.
MOUNTAINOUS ZONE	OULHACA - SIDI OURIACHE - AIN KIHAL - AGHLAL - AIN TOLBA - AOUBELLIL - TAMAZOURA – OUED SEBBAH – OUED BERKECHE - AIN LARBAA – SIDI BOUMEDIENE - EMIR ABDELKADER –HASSASNA.
URBAN ZONE	AIN TEMOUCHENT - SIDI BEN ADDA - EL MALAH – TERGA - CHAABAT LEHAM - EL AMRIA – HASSI EL GHELLA –HAMMAM BOUHADJAR – AIN LARBAA – BENI SAF - AIN KIHAL - AIN TOLBA
SEMI-URBAN ZONE	SIDI SAFI
RURAL ZONE	OULED KIHAL – BOUZEDJAR - OULED BOUDJEMAA – M'SAID - CHENTOUF - OUED BERKECHE –HASSASNA –TAMAZOURA - OUED SEBBAH - SIDI BOUMEDIENE – EMIR ABDELKADER - OULHACA – SIDI OURIACHE - AGHLAL – AOUBELLIL

II.2.4 Morphological context

The terrain of Aïn Témouchent province is divided into three morphological units defined within the framework of the province's development plan, including:

The interior plains:

include eight (8) municipalities and represent 51% of the total population. These are:

- The Aïn Témouchent-El Amria Plain: consists of plains and hills;
- The Mlita Plain: located between the Oran Sebkha and the northern foothills of Tessala.

The coastal strip:

includes eight municipalities and represents 24% of the total population. It is part of the Tell chain, which is part of the coastal Beni Saf mountain range;

- of the Ouled Boudjemaa plateau;
- of the Bouzidjar Gulf.

The mountainous region:

includes 12 municipalities, representing 25% of the total population. These are:

- The eastern terrain, characterized by steep terrain.
- The high hills of the Berkane, which extend to the Sebaa-Sheikhs Mountains.
- The Tsala Mountains have an average height of 600 meters, with the highest point reaching 923 meters at Jebel Bouhanach.

II.2.5 Contexte Climatic:

Aïn Témouchent province is characterized by a Mediterranean climate, characterized by hot summers and mild winters.

The average rainfall distribution is as follows:

• Along the coast: 300 mm/year.

• Coastal plains: 400 to 500 mm/year.

• Highlands: more than 500 mm/year.

II.3 Local geographical context:

II.3.1 . Geographical framework of the municipality of El Amria:

El Amria (formerly Lourmel) is a commune within the Ain Temouchent plain. It is located east of the wilaya's capital and 35 km away. It is situated in a basin on the national road (RN20) bordering the great sebkha of Oran, with an area of 9,049 hectares. It is bordered:

- To the north by the commune of Bouzedjar.

- To the south by the commune of Hassi Elghalla.

- To the west by the commune of M'said.

- To the east by the wilaya of Oran, including the communes of Boutlelis and Misserghin.

II.3.2 Morphological context

The weak and irregular rainfall directly impacts the environment and physical and economic activity, which relies primarily on agriculture.

The municipality of El Amria is part of the geographic area of the interior plains between the Tell Atlas Mountains and the Mediterranean Sea to the north and the Great Oran Sebkha to the south.

The main relief lines can be summarized in three very distinct physical groups (one of which is generally north-south) (Figure12):

A. A mountainous area located in the north of the municipality, covering an area estimated at approximately 3,630.14 hectares, or 40.11% of the total area

. The elevation ranges between 150 and 300 meters, and the slopes are 25% steep. This area is crossed by a series of bridges and valleys to reach the important Sidi Baroudi Valley

. The mountainous area is mainly covered with shrubs and cereals, indicating that the soil has a poor pedological composition.

B. Mountainous area: In the southwest of the municipality, it occupies an area of 454.93 hectares, or 5.03% of the total. Slopes range from 5 to 9%.
C. A plain area occupies the central and eastern part of the municipality, with an area of 4,963.93 hectares, or 54.86% of the total area, mainly used for vineyards and cereals. It is an organized area in the form of specific plots, with elevations ranging from 80 to 150 meters. Slopes range from 0 to 5%

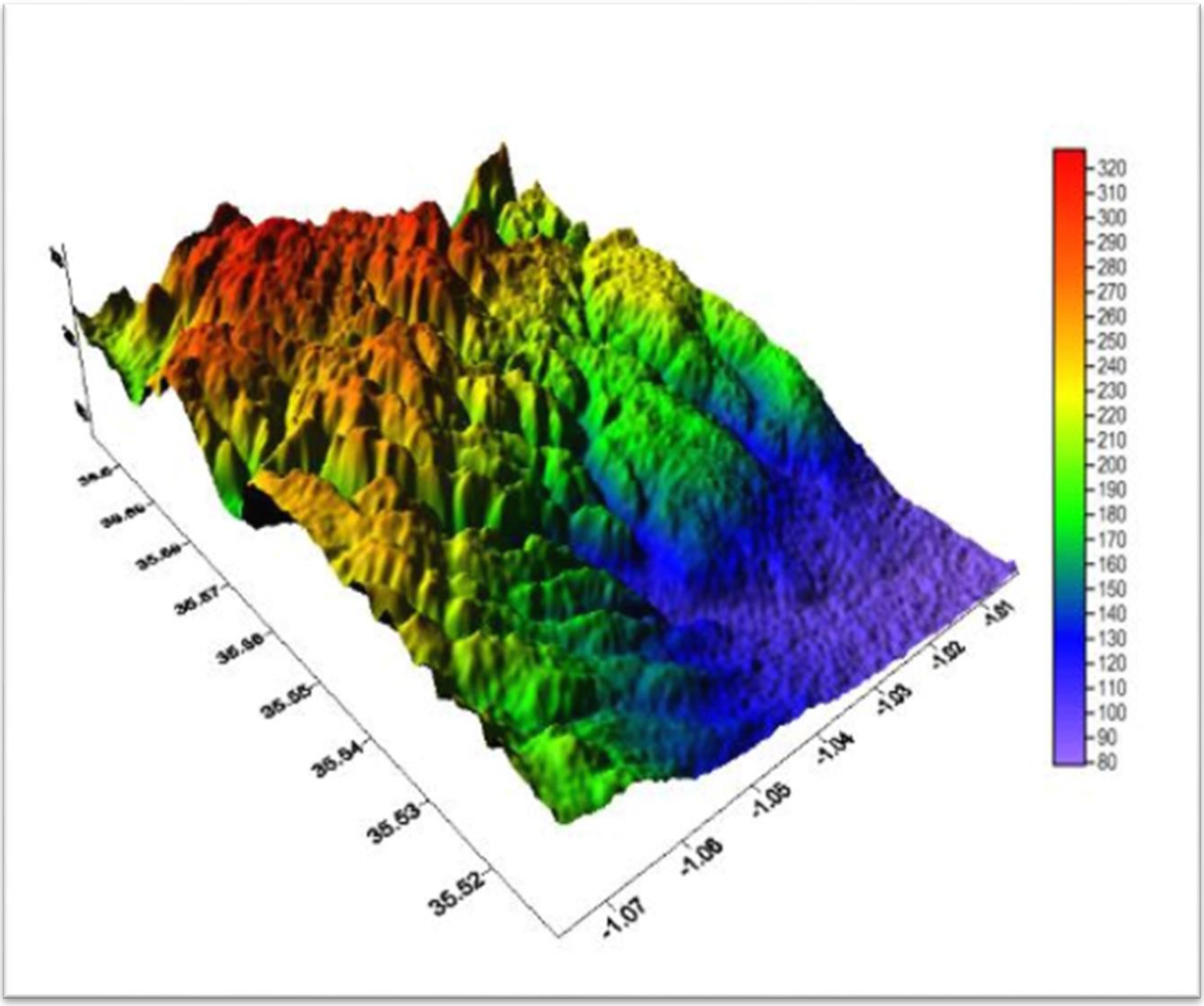


Figure 12: card of altitudes in 3D in El Amria2022 (PDAU El Amria)

II.3.3 Climate Context:

The municipality of El-Amria has a semi-arid Mediterranean climate, characterized by mild winters and hot, dry summers, despite its proximity to the sea. This aridity is the result of drought and low rainfall in recent years.

II.3.3.1 Precipitation *:*

It is one of the most important elements of the climate and the sole source of water supply for the groundwater and dams.

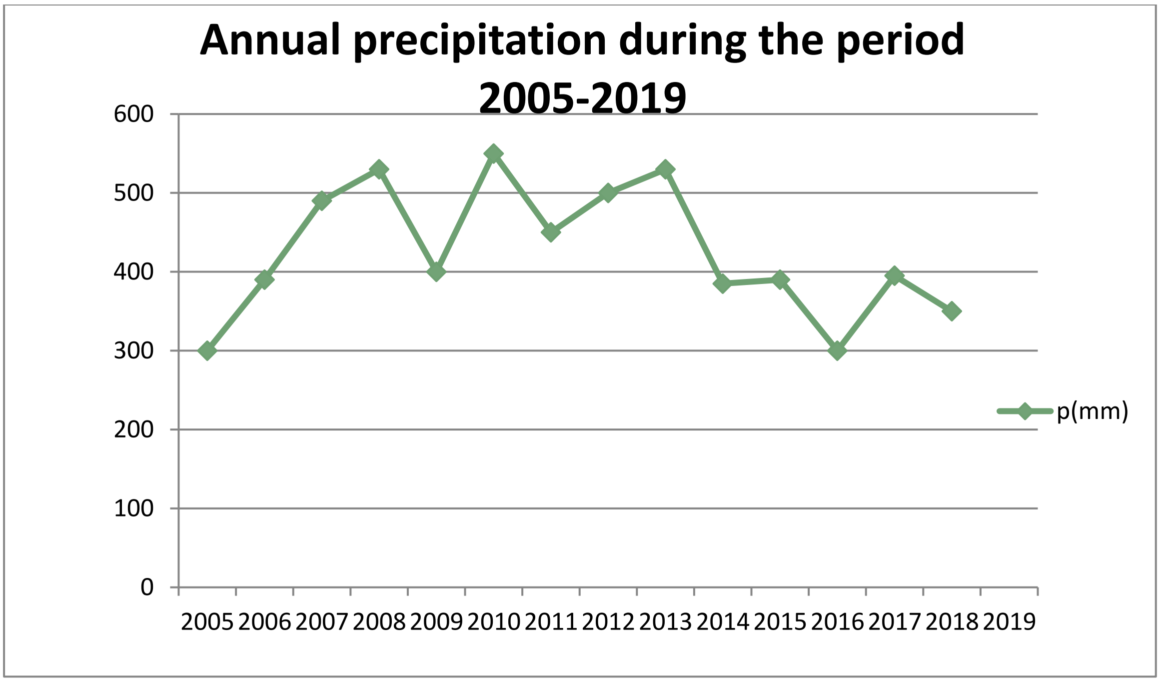


Figure 13: Annual precipitation during the periode 2005-2019 (ONM)

II.3.3.2 Temperature*:*

Temperature plays a very important role in influencing other meteorological parameters such as evaporation and atmospheric humidity, and is a fundamental parameter in climate studies.

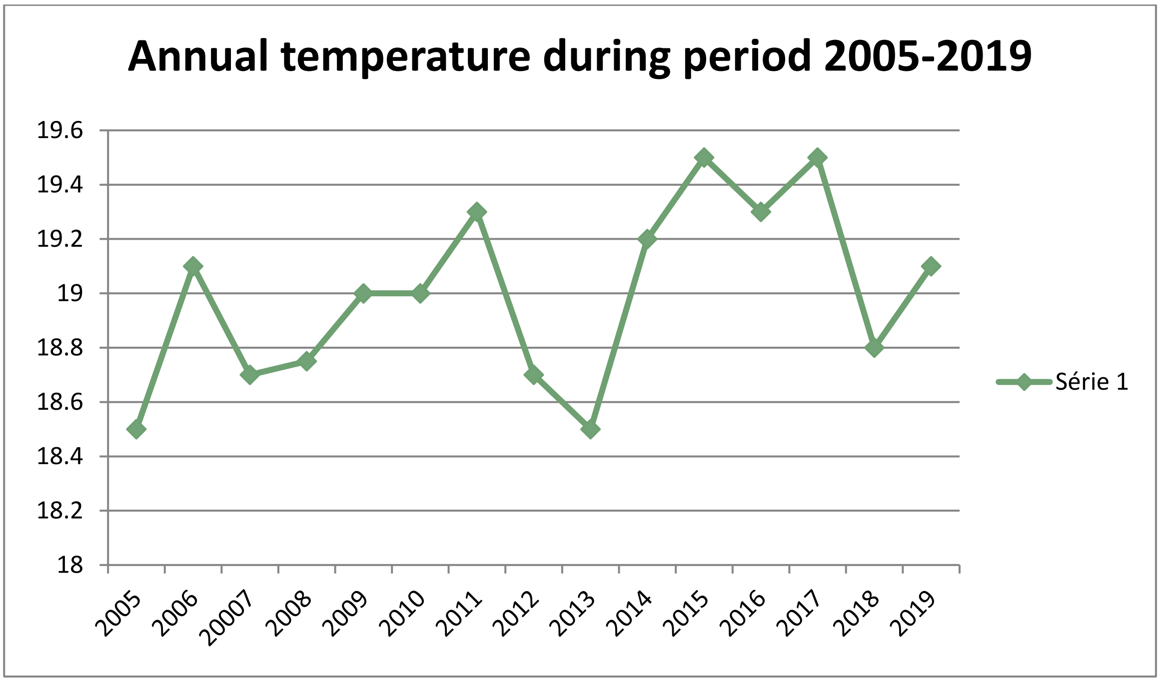


Figure 14 : Annual temperature during period 2005-2019 (ONM)

II.3.3.3 Winds*:*

El Amria's climate is characterized by winds that generally carry little moisture (northwest and southeast winds). These winds lose much of their moisture as they pass over the Moroccan and Spanish mountains.

Furthermore, southern mountains such as Sebaa-Chioukh, Tessala, and the Tlemcen Mountains have a favorable influence by preventing the arrival of dry and hot continental winds from the south (Sirocco).

II.3.4 Hydrographic context:

The municipality of El Amria belongs to the Oued Sidi Baroudi watershed. It is cut by several tributaries, the largest of which is the Sidi Medioni River, which drains all its waters into a single outlet, the great Sebkha of Oran.

Oued Sidi Baroudi, also known as Oued Sidi Medioni, covers an area of 62,875 km². It provides an annual flow of 1,807,657.42 m³ and is fed by two main tributaries:

- Oued Sidi Dfaa, which receives water from Oued Ould Gana, Oued Djorf Labiadh, and Chaabet Ben Mohamed.

- Oued Sidi Mediouni, which serves as a natural border between the municipalities of El Amria and M'said. It is a major tributary of Oued Sidi Baroudi, which receives its waters from Oued Souadjel and Chaabet El Medjalis.**(A.N.A.T,1994)**

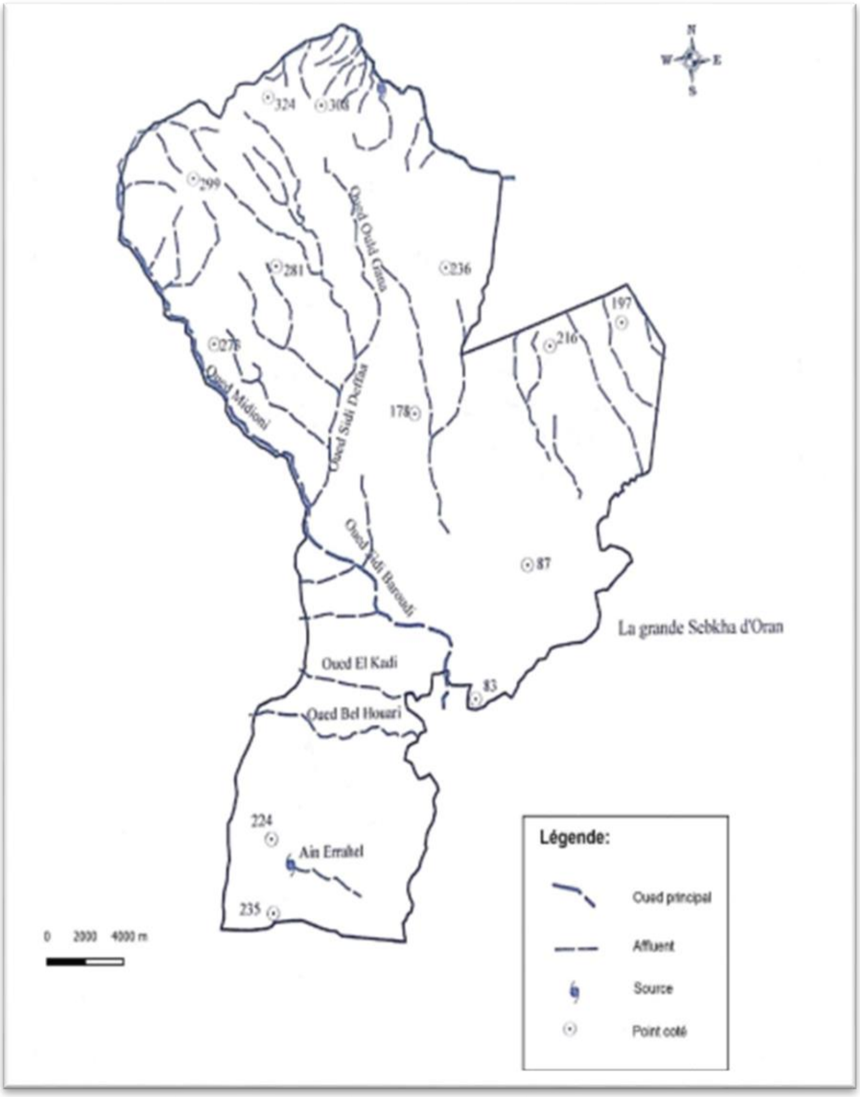


Figure 15: maps of the hydrographic network of tha comune El Amria(A.N.A.T)

II.3.5 Demographic context:

Over time, the municipality of El Amria has undergone considerable transformations, including the population, which has experienced a gradual increase since 1987.

According to ONS statistics, the table below illustrates the population growth during the period 1987-2020:

Table 5 : population and average density of the commune El Amria (ONS)

1987		19998		2008		2020	
Densité moy.HA B/Km²	Pop R.G.P.H	Densité moy.HA B/Km²	Pop R.G.P.H	Densité moy.HA B/Km²	Pop R.G.P.H	Densité moy.HA B/Km²	Pop R.G.P.H
174	15773	217	19604	243	21836	284	25707

According to the previous table, we note that the municipality of El Amria has experienced a constant and gradual increase in its population, rising from 15,773 residents in 1987 to 19,604 in 1998, reaching 21,836.

In 2008, the population was 25,000. In 2020, it increased to 25,707, giving an average density of 284 inhabitants per square kilometer.

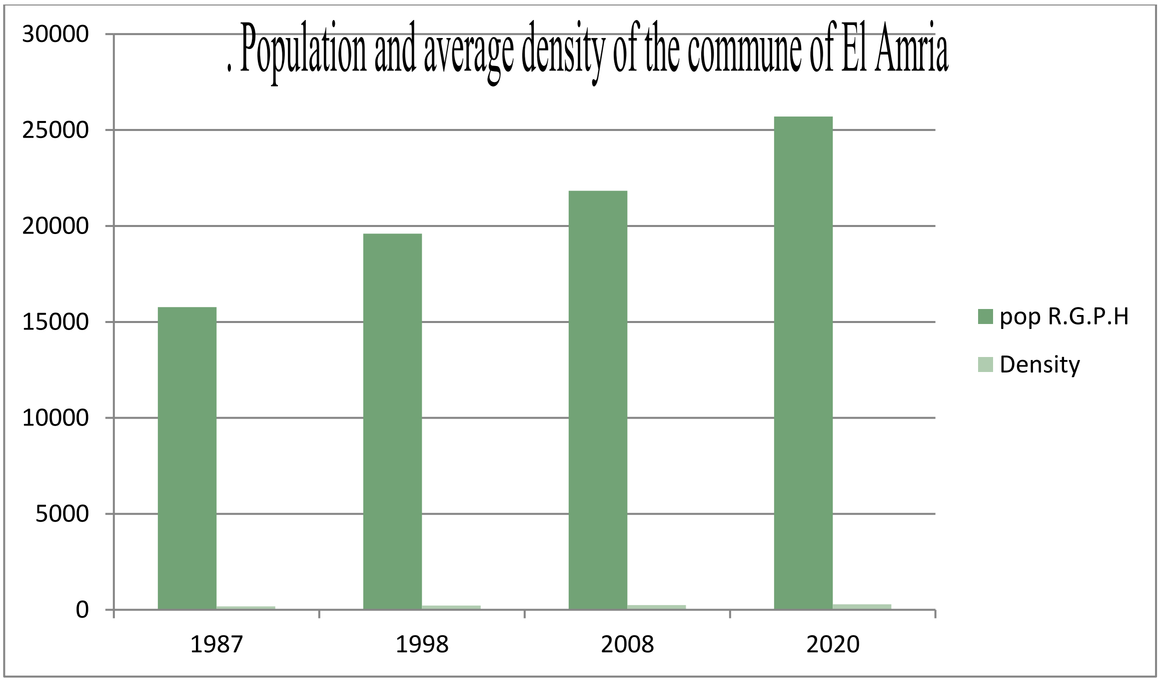


Figure 16: population and density the the commune EL Amria (ONS)

II.4 Conclution

The commune of El Amria, part of the Oran interior plains, is bordered by the Tell Atlas Mountains and the Mediterranean Sea to the north and the great Sebkha of Oran to the south. It covers 9,249 hectares.

El Amria has a semi-arid Mediterranean climate, according to climatic studies. There are notable differences in average temperatures and annual precipitation. Northwesterly winds, which shed a lot of precipitation, are the most common in this commune.

Surface waters are represented by small and temporary wadis (dry in summer), the largest of which is the Sidi Baroudi wadi.

Demographically, the commune's population has experienced a steady and gradual growth, reaching 25,707 inhabitants in 2020.

CHAPITER 3

Material and Methods

III. Material and methods :

III.1 Presentation of Study Sites :

As part of this study,11 sites located in the commune of El Amria (wilaya of Aïn Témouchent) were selected for the collection of floristic data.

These sites were chosen based on their ecological representativeness, their accessibility, and the degree of anthropogenic pressure.

Table 6 : presentation of the sites

Site	Soil type	Scientific name	Family	biological type	Frequency	Coverage (%)/	Remarks.
01	Fallow land	*Stipa tenacissima*	Poaceae	Hémicryptophyte	Fréquente	40	Dominant steppe formation
		Thymus algeriensis	Lamiaceae	Chamaephyte	Moyenne	15	Strong odor, isolated plants
2	Agricultural zone	*Sinapis arvensis*	Brassicaceae	Thérophyte	Abondante	30	Weed in cultivated fields
		Convolvulus arvensis	Convolvulaceae	Géophyte	Moyenne	20	Tangled between crops
3	ConstrucЕton area	*Atriplex halimus*	Amaranthaceae	Chamaephyte	Faible	5	Resistant, persists in hard soil
		Anacyclus clavatus	Asteraceae	Thérophyte	Très ffaible	2	Pioneer species

4	Agricultural zone	*Chenopodium album*	Amaranthaceae	Thérophyte	Moyenne	10	Indicator of disturbed soils
5	Fallow land	*Artemisia herba-alba*	Asteraceae	Chamaephyte	Fréquente	25	Well adapted to drought
6	Agricultural zone	*Medicago sativa*	Fabaceae	Hémicryptophyte	Abondante	35	Forage crop, well established
		Lolium perenne	Poaceae	Hémicryptophyte	Moyenne	20	Species introduced for grazing
		Malva sylvestris	Malvaceae	Hémicryptophyte	Faible	5	Common ruderal species
7	Constructon area	*Salsola vermiculata*	Amaranthaceae	Chamaephyte	Moyenne	15	Xerophytic species, tolerant of disturbance
		Erodium cicutarium	Geraniaceae	Thérophyte	Faible	5	Small pioneer herb
		Cynodon dactylon	Poaceae	Hémicryptophyte	Abondante	25	Cover species, indicator of compacted soils
8	Agricultural zone	*Plantago albicans*	Plantaginaceae	Hémicryptophyte	faible	5	Low plant, common in fallow land
		Olea europaea	Oleaceae	phanerop	moyen	15	Olive tree,

				hyte			often cultivated
		Cenchrus ciliaris	Poaceae	therophyte	Abondante	30	Resistant forage grass
9	Construction area	*Asphodelus microcarpus*	Asphodelaceae	Géophyte	abondante	30	Herbaceous plant, indicator of fallow land
		tus salviifolius	Cistaceae	Chamaephyte	Aondant	35	Prefers dry, well-drained soils
		Capsella bursa-pastoris	Brassicaceae	Thérophyte	Moyenne	10	Frequent weed at field edges
10	Agricultural zone	*Triticum aestivum*	Poaceae	Thérophyte	Abondante	35	dominante Culture
		Lolium rigidum	poaceae	Thérophyte	Abondante	35	Abundant in cereal crops
		Sinapis arvensis	Brassicaceae	Thérophyte	Fréquente	20	Common weed in wheat
		Papaver rhoeas	Papaveraceae	Thérophyte	Moyenne	15	Present mainly at crop edges
11	Agricultural zone	*Cicer arietinum*	Fabaceae	Therophyte	Abondant	35	Main crop observed on the site
		Bromus spp	Poaceae	Therophyte	frequent	20	Common weed in cereal fields
		Convolvulus arvensis	Convolvulaceae	Géophyte	Moyen	20	Climber in chickpea crops

The sites studied have different environmental characteristics, with some being located in agricultural areas, while others are close to built-up areas or areas undergoing urban expansion.

III.2 Floristic sampling methodology Quadrat Method:

III.2.1 Sampling Period and Frequency:

The floristic surveys were carried out during the peak flowering period between April/2025 and May/2025, to ensure optimal species identification.

III.2.2 Sampling Technique:

To conduct the floristic inventory, the **quadrat sampling method** was employed, which is widely recognized in plant ecology for its reliability and practical application in field studies. **Quadrats measuring 10 m × 10 m** were established at various study sites. This dimension provides an effective balance between capturing species richness and ensuring manageable fieldwork.

Quadrats were **placed either randomly or systematically**, depending on the topographical and ecological characteristics of each site. In heterogeneous environments (e.g., areas with varied microhabitats), random placement was favored to reflect the true plant diversity. In contrast, in more homogeneous environments (such as agricultural plots or fallow land), a systematic layout was adopted, with quadrats spaced at regular intervals.

The **number of quadrats per site**ranged from **3 to 5**, based on the area's size and ecological complexity. Across all sites, the **total sampled area** amounted to approximately **700 m²,** providing adequate coverage for statistically meaningful results.

Within each quadrat, **all visible vascular plant species** were recorded. Species were identified **in situ** whenever possible. When immediate identification could not be achieved, **specimens were collected** for subsequent identification using regional botanical references such as the *Flora of Algeria* by **Quézel & Santa**, and the *Flora of Tunisia* by **Pottier-Alapetite**, among others.

III.2.3 Equipment Used:

The following materials and tools were used to carry out the quadrat sampling:

- Measuring tapes **(**50 m): for accurate delimitation of quadrat boundaries.
- Wooden or PVC stakes**:** used to mark the corners of each quadrat.
- String or twine: to connect stakes and define quadrat edges.
- GPS device or smartphone with GPS app**:** to record the coordinates of each quadrat.
- Notebook and data sheets: for recording species lists, abundance estimates, and site observations.
- Field guides and floras (Quézel & Santa, Pottier-Alapetite): for on-site or post-survey plant identification.
- smartphone: for photographic documentation of habitats and species.
- Protective gear(gloves, hat, sunscreen, etc.): to ensure safety during fieldwork.

III.3 Mapping and Spatial Analysis:

III.3.1 Material :

In order to analyze the spatio-temporal evolution of land use and land cover (LULC) in the commune of El Amria, four sets of Landsat satellite images acquired at the end of spring were used (see Table7).

These images offer the advantage of covering the entire study area with sufficient spatial resolution, allowing for accurate mapping of landscape dynamics, particularly forested areas.

Table 7 : sets of Landsat satellite images

Date d'acquisition	Satellite	Capteur	Résolution Spatialele
18-05-2015	Landsat 5	TM	30 m
06-04-2025	Landsat9	TM	30 m

III.3.2 Image preprocessing :

Image preprocessing is a critical step that allows for the combined use of satellite images acquired at different times and by various sensors (**Andrieu, 2008; Ducrot, 2005).** Its main objective is to facilitate segmentation by enhancing the similarity between pixels within the same spatial region, while increasing the dissimilarity between those belonging to different regions (**Bolon *et al*., 1995).**

Radiometric calibration corrects anomalies caused by sensor distortions. When raw satellite images are used without calibration, they may propagate significant errors throughout subsequent image processing operations. Calibration transforms the recorded signal into a physical value, such as radiance, to ensure accurate representation of the Earth's surface **(Derrar, 2014).**

Study area extraction was performed using a geometric clipping method based on the administrative boundary vector of the El Amria municipality.

For **image classification**, an object-oriented approach was applied using the eCognition software. This method offers a more structured overview of the LULC classes. Several authors (**Corbane et *al.*, 2004; Delahaye, 2016**) have compared object-based and pixel-based classification techniques, highlighting the advantages of the former. The object-based method is not only faster but also more accurate, thanks to the advanced capabilities of Definiens eCognition®, which allows sample adjustment and correction throughout the classification process. In contrast, pixel-based classification using ENVI 5.3 or Erdas Imagine 9.1 is less effective for interpreting complex land cover categories.

III.3.3 Tools Used in The Study :

The tools employed in this study are as follows:

- ENVI 5.3software, used for geometric correction of satellite images and for generating color composites. It provides accurate spatial data processing capabilities.
- eCognition software, which operates differently from most traditional classification tools.

Instead of working at the pixel level—treating pixels as the basic units for classification—eCognition adopts an object-based approach. It first generates its own spatial entities, referred to as **"image objects"**, through a customizable **segmentation process**. These objects are then classified using one of the available methods provided by the software.

The eCognition processing workflow consists of three main steps:

1. Creating a project based on image data.
2. Producing appropriate segmentations for the specific application. This can include multiple **scale levels**, where each level results from segmentation applied to the previous one. Objects generated at one level serve as the basis for segmentation at higher levels.
3. Finally, the image objects derived from the various segmentation levels are classified according to user-defined criteria.

The procedure followed by the software is illustrated in Figure.

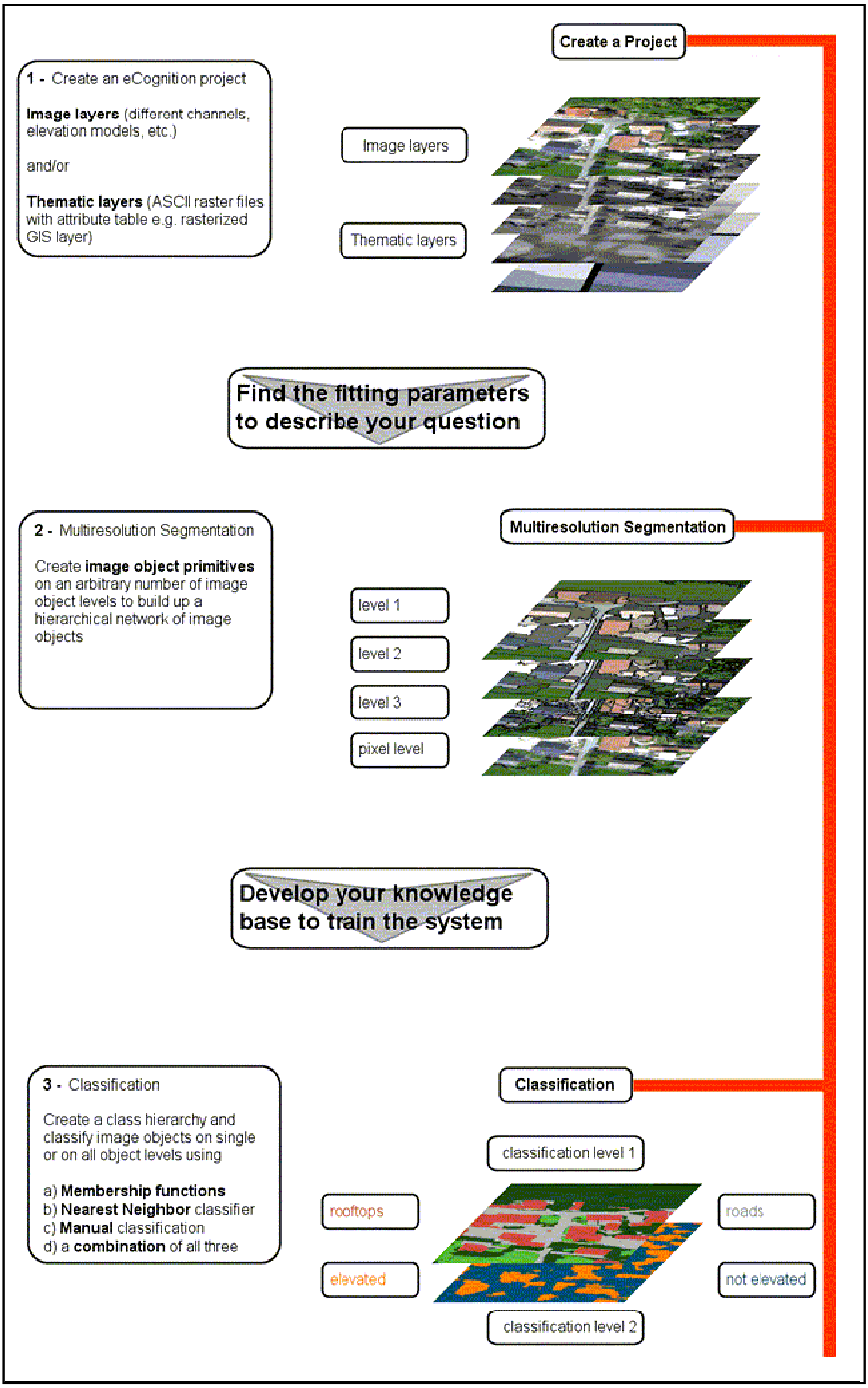


Figure 17: eCognition Software Operating procedures (ABDELKADER BARDADI)

III.3.4 Fieldwork and Validation of the Classifications Obtained:

In addition to verifying and validating the thematic classes defined prior to the image classification stage, the fieldwork consisted of recording GPS points for each of these classes. These points were used to validate the mapping results for the most recent year.

III.3.5 Mapping LULC Changes

To assess changes in LULC, several statistical indicators were calculated: rates of change and the transition matrix.

- Calculation of rates of change (overall rate of change and annual rate of change)

according to the equation proposed by **Bernier** (**1992**), frequently used to measure growth between two given periods **(Mama *et al.*, 2003; Soro *et al.*, 2014)**. The rates of change in the area of LULC classes between 1987 and 2017 were calculated as follows:

- $Tg = (S2 - S1) \times 100/S1$ (1)
- $Tc = (\ln S2 - \ln S1) \times 100/(t2 - t1) \times \ln e$ (2)

Where:

S1 is the area of a unit area class at date t1; S2 is the area of the same unit area class at date t2.

In the natural logarithm; e is the base of the natural logarithms (e = 2.71828).

Positive values represent an increase in the area of the class over the study period, while negative values represent a loss of area between the two dates. Values close to zero express the relative stability of the class.

This cartographic work constitutes a fundamental tool for visualizing the spatio-temporal dynamics of the study region and supporting comparative analyses on plant biodiversity, particularly in the context of assessing the impacts of climate change and human activities.

Chapiter 4

Anthropogenic pressure and dynamics of land use

IV. Chapiter 4 anthropogenic pressure and dynamics of land use :

IV.1 Introduction :

In the Al-Amria Municipality, plant biodiversity is severely impacted by human activities, particularly urban expansion and agricultural intensification. These pressures have intensified over the past two decades, causing significant changes in the composition and structure of local plant communities.

This chapter aims to analyze the direct impacts of urban expansion, agriculture, and other forms of human disturbance on the vegetation of the study area.Land Use Typology and Dynamics

IV.2 Land Use Typology and Dynamics :

Land use in El Amria reflects a landscape structure in transition, strongly influenced by socioeconomic dynamics and land use practices. Through mapping data and field observations, it was possible to identify several main land use classes, each with specific ecological and functional characteristics. These classes include:

Agricultural zones: These represent one of the dominant land uses in the municipality. They mainly cultivate cereals (durum wheat, barley), legumes (chickpeas), and fodder plants such as alfalfa. Agriculture is often extensive but is tending to become more mechanized, with significant use of chemical inputs (fertilizers, pesticides). These areas are subject to annual or biennial crop rotation, which results in regular soil disturbance.

Fallow land: These are former agricultural lands that have been temporarily left uncultivated or permanently abandoned. They form intermediate environments where spontaneous vegetation can develop freely. These areas play a fundamental role in maintaining biodiversity, providing refuge for xerophytic and native plant species, and enabling soil regeneration.

Urbanized or under-construction areas: Their rapid expansion is linked to population growth and infrastructure development. These areas are characterized by high soil sealing, erosion of the natural substrate, and a near-absence of stable plant cover. They are often colonized by pioneer ruderal species capable of withstanding extreme conditions.

Natural rangelands: These are pastoral areas used for extensive grazing by sheep and goats. Although often overlooked, these areas represent important ecological reservoirs for

Mediterranean flora adapted to low rainfall. Their reduction, observed on maps between 2015 and 2025, poses a direct threat to several local species.

Forests and woody vegetation: located mainly on the periphery, these formations are sparsely populated and consist of maquis, scrubland, and Mediterranean shrubs. They provide soil stabilization and act as an ecological buffer against climate disturbances.

Wetlands and bodies of water: although marginal in area, they harbor specific biodiversity and are essential for hydrological regulation. Their gradual decline (-20% between 2015 and 2025) is a cause for concern in a context of increasing water stress.

A diachronic analysis of land use shows a marked shift in land area from rangelands and fallow land to agricultural and urban areas. This shift reflects increasing pressure on natural resources, altering local ecological balances and accelerating the trivialization of flora. Three main types of land use were identified:

- Agricultural areas: characterized by high levels of human activity (wheat, chickpea, and alfalfa cultivation) and a significant presence of ruderal or introduced species.
- Fallow areas: areas left undisturbed or abandoned, where wild, often xerophytic, species thrive.
- Construction areas: marked by soil destruction and almost complete replacement of plant cover by pioneer or disturbance-tolerant species.

Map changes between 2000 and 2025 show a gradual decline in fallow land and forest land in favor of agricultural and urbanized areas.

IV.3 Cartographic Analysis and Spatial Interpretation

IV.3.1 Spatial Analysis Methodology

The analysis of spatiotemporal changes was performed using Landsat satellite data acquired in 2015 and 2025. The images were processed using object-oriented classification, allowing for detailed and precise mapping of land cover units (LULC).

Data Sources:

Landsat 5 (TM) image from May 18, 2015

Landsat 9 (TM) image from April 6, 2025

Preprocessing: radiometric calibration, geometric correction, municipal boundary extraction

Segmentation and Classification: using eCognition software, supplemented with GPS points for field validation

Software Used: ENVI 5.3, eCognition, ArcGIS 10.5

Area change rates were calculated using the Bernier method (1992)

IV.4 . Classification Results and Interpretation

The land use maps developed for 2015 and 2025 provide a clear visualization of the changes occurring in El Amria. These include:

- A significant increase in cultivated areas (+30.07%), reflecting the intensification of agriculture.
- An expansion of built-up areas (+31.03%), confirming the rapid urbanization of the municipality.
- A significant reduction in natural rangelands (-40.28%), an often overlooked area but crucial for local biodiversity.
- A slight decline in forest and wetland areas, which increases the region's ecological vulnerability.

These transformations highlight the growing pressure exerted by human activities on natural environments. This

Table 8: visually confirms the trends observed in the maps

classe	Superficie				Taux d'évolution annuel	Taux d'évolution global
	2015		2025		2015-2025	2015-2025
	ha	%	ha	%	Tc	Tg
WATER	6,63	0,000748	5,25	0,0591981	-2,3266461	-20,81447964
Forest	74,22	0,008369	58,73	0,6622293	-2,333687134	-20,87038534
Culture	4661,5	52,56238	6063,24	68,368038	2,621026619	30,07029911
Batis	344,25	3,881703	451,07	5,0861868	2,694297556	31,02977487
Sol nu	98,37	2,670529	90,51	1,020575	-0,830214336	-7,990240927
Parcours	3683,5	41,53496	2199,67	24,803096	-5,139937144	-40,28380308
Total	**8868,53**	**100%**	**8868,53**	**100%**		

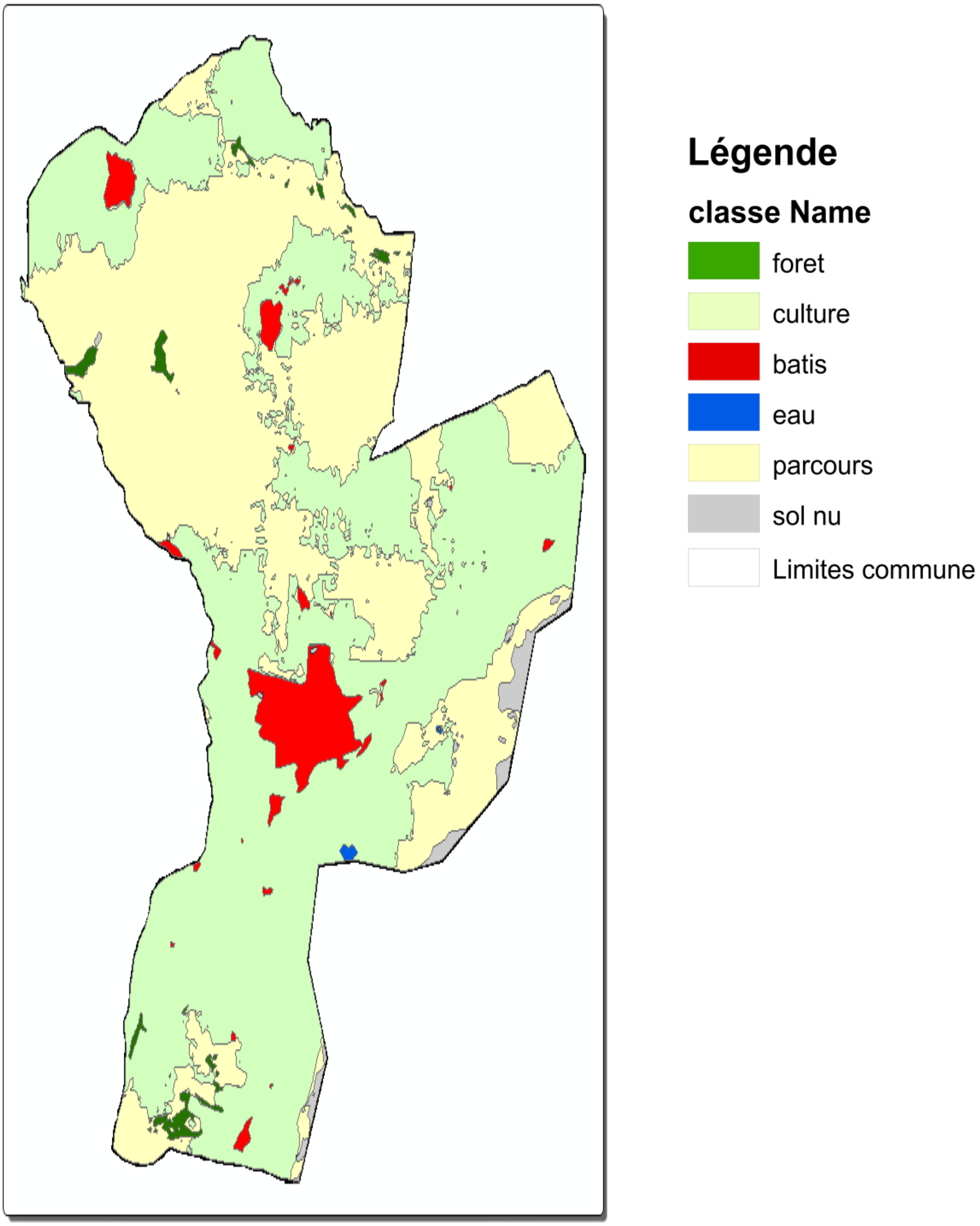


Figure 18 land use and occupation map of the el amria region in 2015

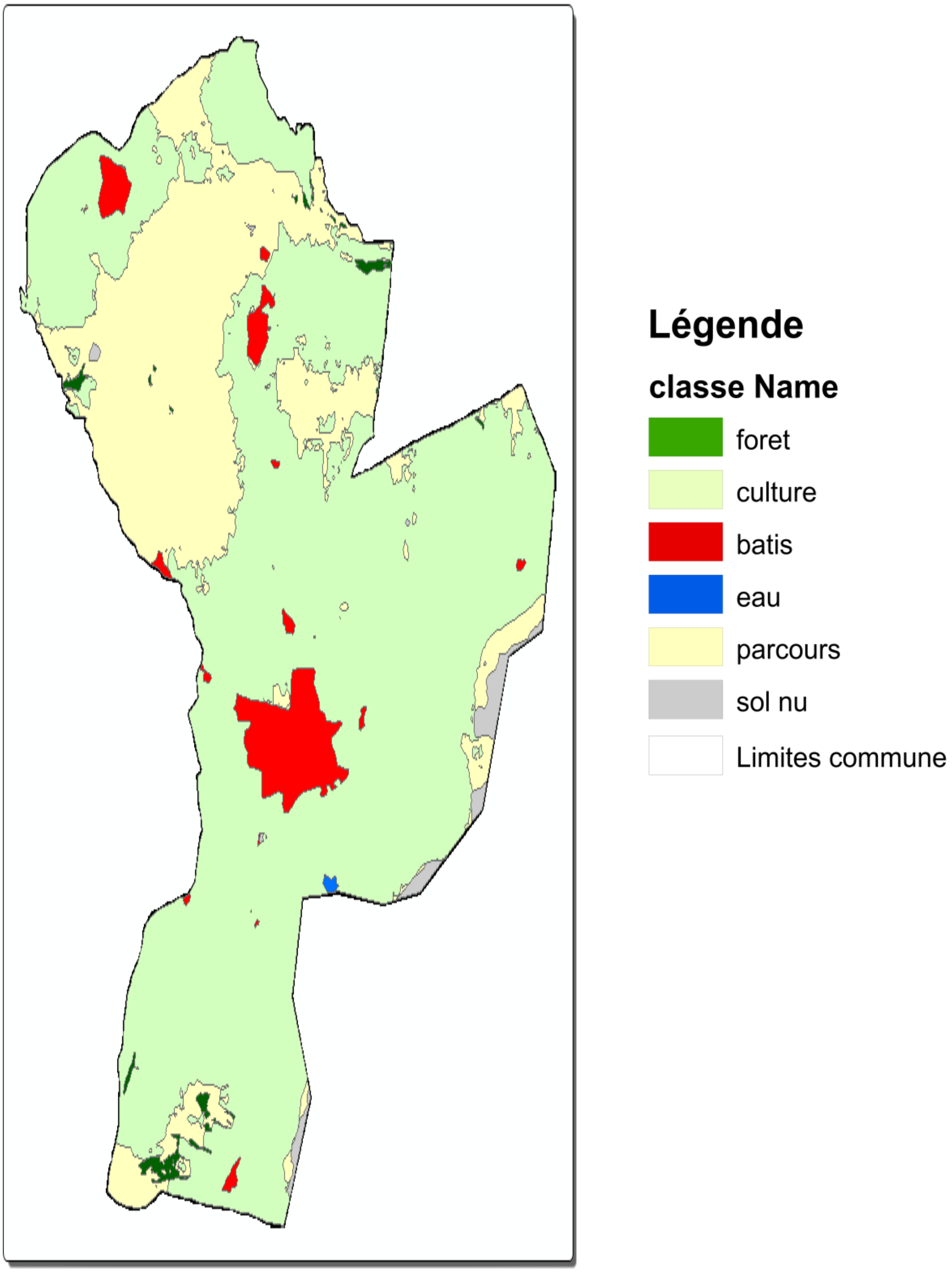


Figure 19: Land use and occupation map of the El Amria region in 2025

IV.5 Floristic Composition by Site Type

Floristic analysis conducted at 11 sites identified 26 species, with a strong predominance of therophytes (approximately 50%), followed by chamaephytes (approximately 23%) and hemicryptophytes. This distribution reflects a landscape subject to climatic and human disturbances.

- Agricultural areas:

Dominant species: *Sinapis arvensis, Cicer arietinum, Malva sylvestris*

Frequency: Medium to high

Coverage: Between 20% and 35%

- Fallow land:

Dominant species*: Stipa tenacissima, Thymus algeriensis, Artemisia herba-alba*

Adaptive and ecologically resilient species

Coverage: Up to 40%

- Areas under construction:

Pioneer species: *Atriplex halimus, Salsola vermiculata, Capsella bursa-pastoris*

Low cover, reduced diversity

Figure 20 site fallow land in El Amria (by IKRELEF Amina Ferial)

IV.6 Ecological Interpretation and Discussion

The data collected show that land use intensity directly influences vegetation structure:

The more human-affected the land use (cultivated or built-up), the more floristic diversity decreases.

Fallow land, despite its abandoned appearance, plays a crucial role in biodiversity conservation. It hosts a typically Mediterranean flora, resistant to drought and poor soils.

This trend is consistent with several studies conducted in similar environments (Tunisia, Morocco, southern Spain), which conclude that anthropogenic pressure causes floristic homogenization and promotes the disappearance of specialized species.

Therophytes thrive in disturbed environments because their short life cycle allows them to complete their reproduction before the onset of adverse conditions. Conversely, chamaephytes and hemicryptophytes, which are more sensitive to mechanical disturbances, are becoming scarce in agricultural or urban areas.

The progressive loss of plant diversity can lead to a decline in ecological stability, a reduction in protective soil cover and an increase in the risk of erosion.

IV.7 Conclusion

The study of vegetation in relation to land use in El Amria shows a strong correlation between anthropogenic pressure and floristic alteration. Maintaining biodiversity necessarily requires balanced management of rural and urban areas, as well as the enhancement of semi-natural environments such as fallow land.

Chapter 5

Impacts of climate variability on biodiversity

V. Chapiter 5 impact of climate variability on phytobiodiversity

V.1 Introduction :

In semi-arid areas such as the municipality of El Amria, climate change is an increasingly determining factor in the evolution of natural ecosystems. It profoundly affects the distribution, dynamics, and composition of plant species. This chapter aims to study recent regional climate trends and analyze their potential impacts on floral biodiversity, particularly through the study of thermal and rainfall data and dominant biological types.

V.2 Climate Change Analysis in El Amria:

Analysis of average climate data recorded in El Amria over the period 1991–2021 highlights marked seasonal variability, typical of the Mediterranean climate type Csa according to the Köppen-Geiger classification (temperate climate with hot and dry summers).

Mean monthly temperatures range from 11.2°C in January to 26.5°C in August, with an annual difference of 15.4°C between the coldest and warmest months. Average minimum temperatures reach their maximum in August (21.9°C) and their minimum in January (7.4°C), while maximum temperatures peak at 31.9°C in August.

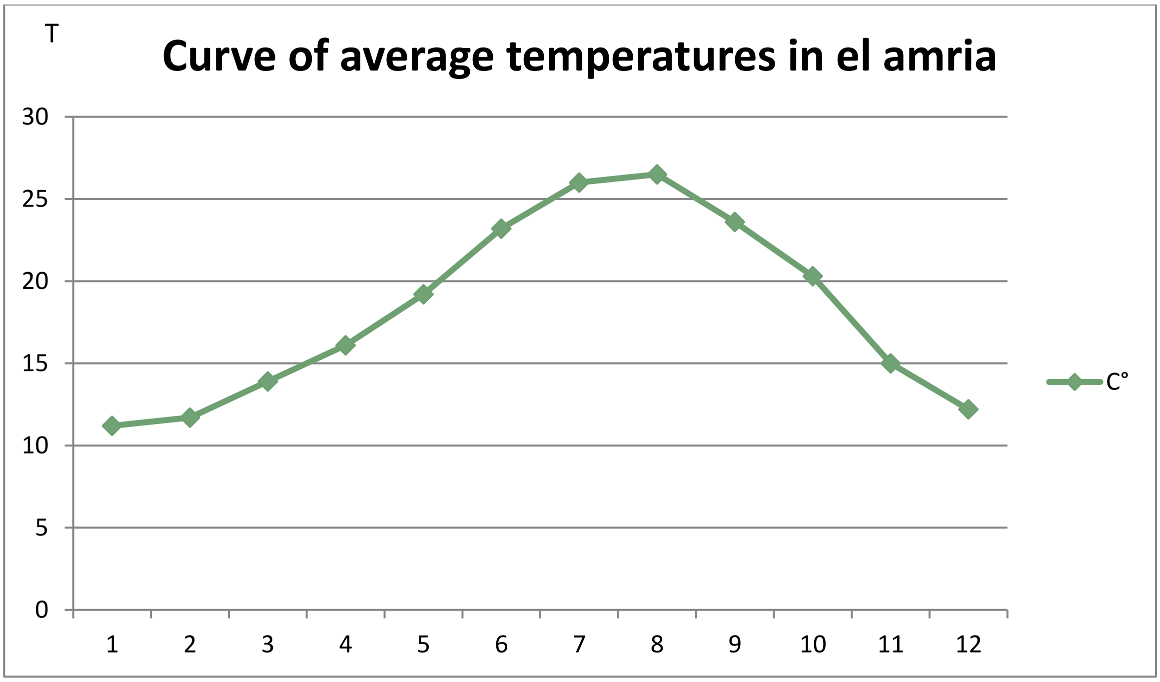


Figure 21: Annual curve of average temperature in el amria 1991-2021(ONM)

Rainfall is highly concentrated during the winter period, with a maximum of 68 mm in November and a minimum of 1 mm in July, for an annual variation of 67 mm. This uneven distribution indicates a very pronounced dry season in summer, accentuating water stress for vegetation.

Relative humidity follows an inverse curve: it is high in winter (76% in January) and gradually decreases, reaching its minimum in July (58%). The number of rainy days is also highly variable: it is 7 days in winter compared to 0 to 1 day in summer, confirming the summer drought. Sunshine, meanwhile, reaches its maximum in July (11.9 hours/day), reinforcing the arid conditions.

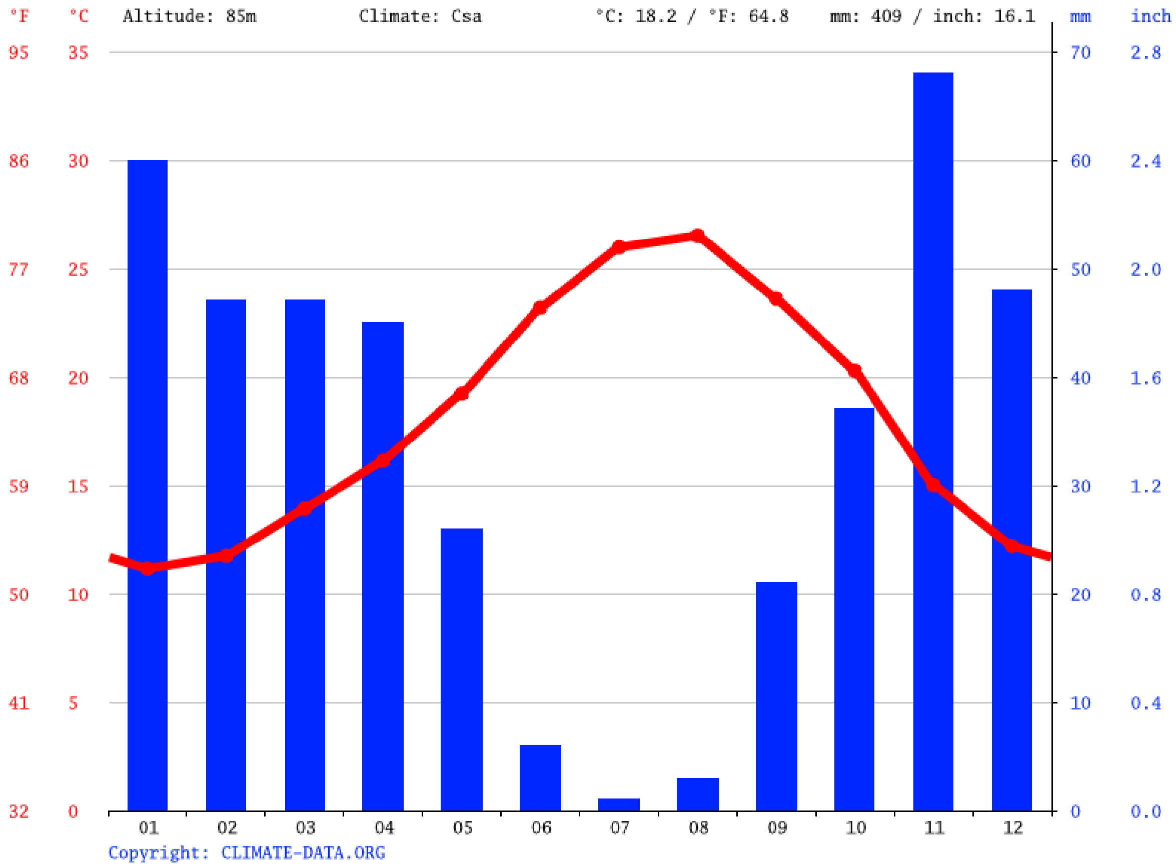


Figure 22: el amria ombothermic diagram ONM

These climate data, both numerical and graphical, confirm that the El Amria region is subject to severe seasonal climate variability, with prolonged droughts, high temperature peaks, and poor rainfall distribution. These factors pose a major challenge to the ecological resilience of the local flora.

Table 9: EL Amria climate table (CLIMAT CHANGE ORG)

Month	January	February	March	April	May	June	July	August	September	October	November	December
Average Temperature (°C)	11.2	11.7	13.9	16.1	19.2	23.2	28.0	28.6	23.6	20.8	15.0	12.2
Average Minimum Temperature (°C)	7.4	7.2	9.7	11.8	14.7	18.4	21.1	21.9	19.2	16.8	11.3	8.5
Maximum Temperature (°C)	15.5	16.1	18.5	20.9	24.0	28.4	31.4	31.9	28.5	25.2	19.2	16.5
Precipitation (mm)	80	47	47	45	28	6	1	3	21	37	68	43
Humidity (%)	76%	75%	73%	68%	65%	60%	58%	61%	67%	71%	74%	76%
Rainy Days (avg.)	7	6	5	5	4	1	0	1	2	4	7	6
Sunshine Hours (h)	7.1	7.8	8.7	9.8	10.8	11.8	11.9	11.0	9.8	8.8	7.4	7.0

Data: 1991 - 2021 Average minimum temperature (°C), Maximum temperature (°C), Precipitation (mm), Humidity, Rainy days. Data: 1999 - 2019: Sunshine hours

V.3 Ecological consequences of climate change :

The climate changes observed in the El Amria region, including rising summer temperatures, decreasing rainfall, and prolonged drought periods, are having profound ecological effects on both natural and cultivated vegetation. Among the most pronounced consequences is a reduction in plant diversity in sensitive areas. The most vulnerable species, particularly those that require a minimum level of moisture during the growing season, are tending to disappear or become rare. Conversely, xerophilous or drought-tolerant species are becoming more dominant, particularly in fallow or highly disturbed areas.

Changing climatic seasons also cause imbalances in plant biological cycles:

• Early or shortened flowering.

• Decreased seed production.

• Increased water pressure during the optimal growth phase.

• Increased mortality rate of young plants.

In agricultural areas, climate change contributes to the decline in productivity of traditional crops such as wheat (*Triticum aestivum*) and chickpea (*Cicer arietinum*), due to the shortening of the favorable growth period and the irregularity of rainfall.

Moreover, the rise in temperature encourages the establishment of certain fast-growing ruderal species, which are able to take advantage of stressful conditions to colonize new environments (e.g., *Sinapis arvensis*, *Papaver rhoeas*, *Convolvulusarvensis*).

These ecological disruptions reflect a weakening of local ecosystem balances and indicate that the flora of El Amria is currently undergoing a significant transition under the combined influence of climate and anthropogenic disturbances..

V.4 Floristic responses observed in the sites studied :

The floristic analysis conducted at the eleven study sites spread across the El Amria region reveals a plant diversity influenced by both local climatic conditions and the nature of the soils and human uses. In the table 6

A total of 28 plant species were identified, belonging to 11 botanical families dominated by Poaceae, Brassicaceae, Fabaceae, and Amaranthaceae. The most represented biological types are therophytes (short-lived annual species), followed by hemicryptophytes and chamaephytes. This dominance of therophytes reflects an adaptation to arid climatic conditions and human disturbances, particularly in agricultural areas.

- In agricultural areas, species such as Sinapis *arvensis, Papaver rhoeas, Lolium rigidum, Cicer arietinum,* and *Triticum aestivum* are commonly found. These species are characteristic of agricultural environments, and some of them are weeds associated with cereal crops. Their presence reflects intense agricultural pressure.
- Fallow land hosts more spontaneous species such as *Stipa tenacissima, Artemisia herba-alba,* and *Thymus algeriensis*, which are a sign of drought-resistant steppe vegetation.
- Construction areas expose generally xerophilous and pioneer species such as *Atriplex halimus, Salsola vermiculata, Cistus salviifolius, and Asphodelus microcarpus,* which are adept at colonizing degraded and compacted environments.

The high proportion of therophytes indicates an adaptive strategy to summer drought. These species complete their life cycle quickly, before the onset of the dry season. Other species, such as *Artemisia herba-alba and Salsola vermiculata*, demonstrate morphological and physiological adaptations to aridity (small leaves, hairiness, deep rooting).

Some species, such as *Convolvulus arvensis* and *Capsella bursa-pastoris*, are common in disturbed environments, demonstrating ecological resilience under conditions of multiple stresses (drought + human pressure).

The results obtained highlight a flora strongly influenced by climatic conditions and human activities. The predominance of annual and xerophytic species demonstrates the ability of certain plants to adapt to current ecological constraints.

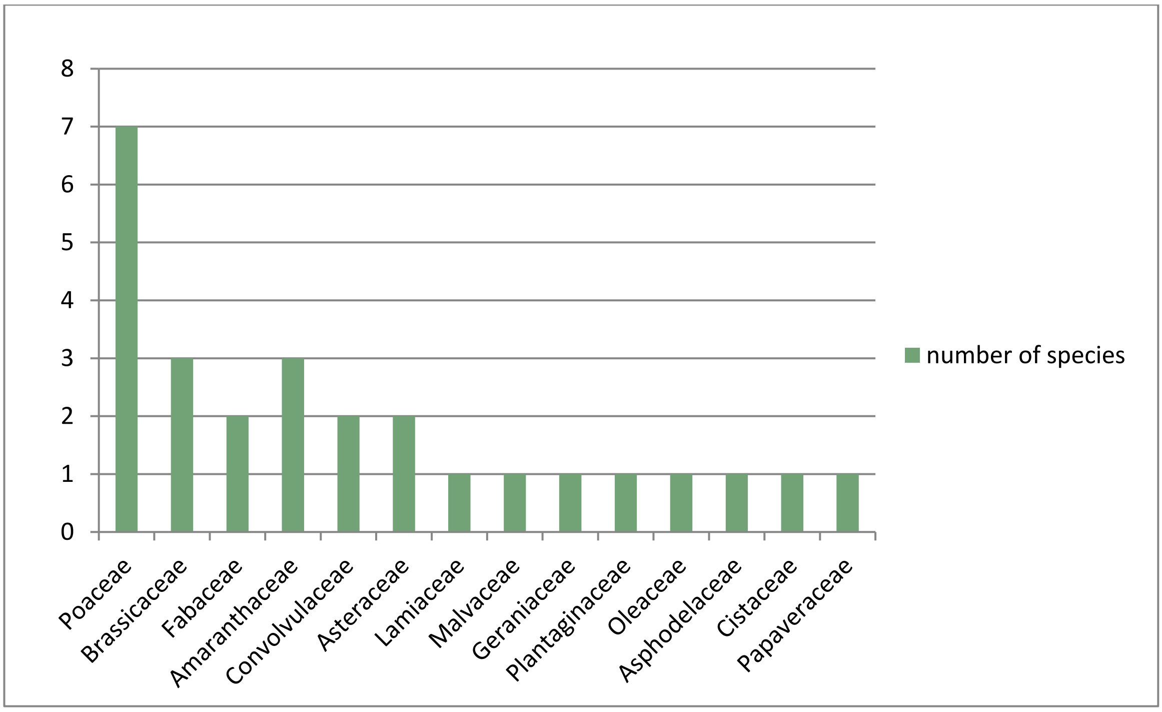


Figure 23: distribution of species by botanical family

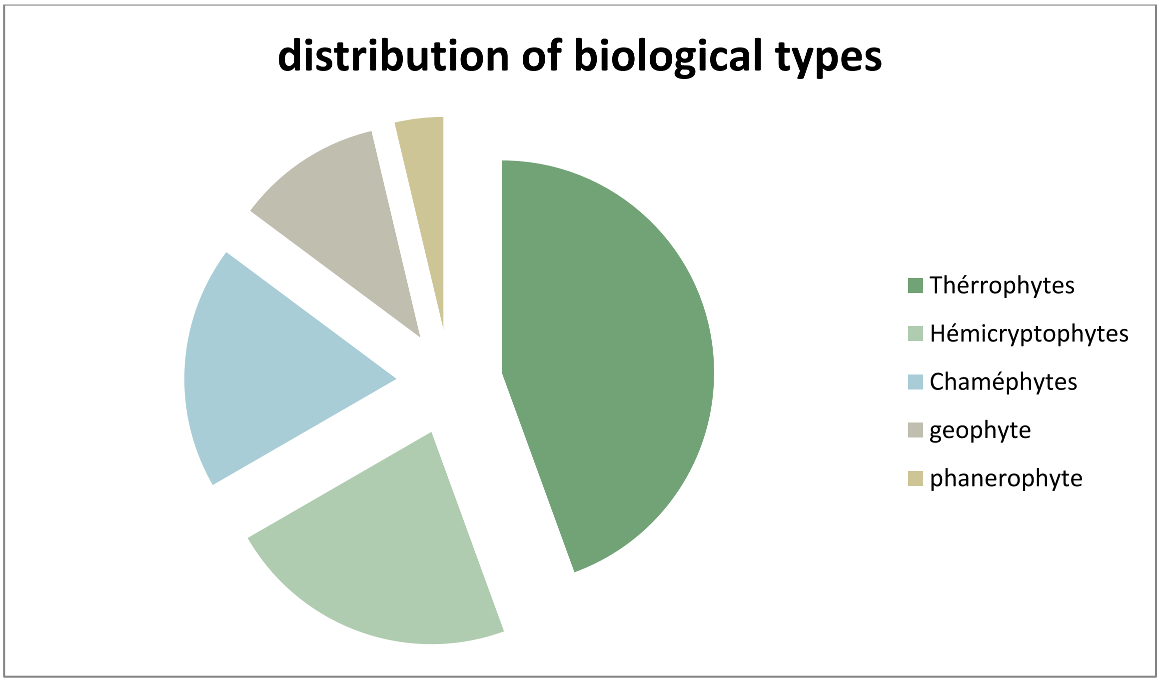


Figure 24: distribution of biological types

V.5 Interactions between climate variability and anthropogenic pressure:

The findings of the study show that it is impossible to evaluate the effects of climate change without taking into account the pressures imposed by human activity. Climate variability in El Amria, which is typified by hot temperatures and protracted summer drought, works in tandem with human activities to hasten the deterioration of the environment.

The resilience of soils and plant species is restricted in agricultural areas by crop intensification, overuse of chemical inputs, and shorter fallow times. Because they can adapt effectively to disturbed settings, xerophilous and ruderal species like *Sinapis arvensis* and *Convolvulus arvensis* are more likely to establish.

In construction areas, soil compaction, artificialization, and the disappearance of natural vegetation cover create unfavorable conditions for regeneration. Only certain pioneer species, such as *Atriplex halimus* and *Cistus salviifolius*, manage to establish themselves.

Thus, the combination of climate-related water stress and human disturbances leads to a reduction in plant diversity, a simplification of plant structures, and a weakening of ecosystems in the face of future climate hazards.

This observation calls for integrated land management, taking into account both changing environmental conditions and increasing human uses.

V.6 Discussion

The cross-analysis of floristic and climatic data highlights a synergy between anthropogenic pressure (Chapter 4) and climatic constraints. The decline of specialist species and the rise of generalist species indicate a process of floristic homogenization.

Similar studies in other Mediterranean regions confirm these trends: slow desertification, depletion of native flora, and proliferation of tolerant or invasive species. These dynamics could intensify under future climate scenarios.

V.7 Conclution

The El Amria region, facing an increasingly dry and erratic climate, is undergoing a change in its floristic structure. Plant biodiversity is shifting toward communities dominated by xerophytic species with rapid adaptive strategies. The vulnerability of ecosystems is increasing in the absence of sustainable management measures.

It is imperative to implement:

• Climate and floristic monitoring programs

• The development of natural fallow land as reservoirs of diversity

• The reduction of anthropogenic pressures through sustainable agriculture and controlled urbanization

General conclusion

Plant biodiversity represents a fundamental pillar of ecosystem functioning. It plays a crucial role in regulating natural cycles, stabilizing soils, increasing agricultural productivity, and ensuring environmental resilience in the face of disturbances. However, this rich flora is increasingly weakened by two major pressures: global climate change, on the one hand, and increasing human activity, on the other. These two factors often interact cumulatively, accelerating the degradation of natural habitats and disrupting local ecological balances.

In this context, this research focused on assessing the combined impact of these two pressures on plant biodiversity in the municipality of El Amria, located in the wilaya of Aïn Témouchent. Through a multidisciplinary approach, utilizing field floristic surveys, climate data, and a cartographic analysis of land use changes between 2015 and 2025, this study provided an overview of plant dynamics at the local level.

The results revealed a significant decline in certain sensitive species, alongside the proliferation of ruderal or xerophilous species, which are more tolerant of water-stressed conditions. This change in floristic composition reflects a gradual adaptation of ecosystems to increasingly severe environmental constraints, while revealing a loss of specific diversity in certain areas. Furthermore, the intensification of human practices—particularly extensive agriculture, overgrazing, and uncontrolled urbanization—significantly contributes to the fragmentation and degradation of natural habitats.

Given these findings, it is essential to implement concrete and sustainable actions. Establishing a local ecological monitoring system to detect changes in plant cover is a priority. Restoring degraded environments through the reintroduction of adapted local plant species is also a necessary measure. On the agricultural front, more environmentally friendly practices should be promoted, such as agroecology, crop rotation, and limiting the excessive use of chemical inputs.

Furthermore, raising awareness among local stakeholders (farmers, livestock breeders, communities) of the importance of plant biodiversity and the risks associated with climate change appears to be an essential lever to ensure adherence to these strategies. Finally, integrating climate issues into local land-use policies is an essential condition for the sustainable and resilient management of plant resources.

In short, this study highlights the urgent need to adopt an integrated management approach, based on science, local consultation, and ecological prevention, in order to preserve the floral heritage of the El Amria region. Such an approach is fully in line with the perspective of sustainable rural development, reconciling environmental protection and ecological security for future generations.

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