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**Flood Risk Study of the Land Use Plan  
N°=07A**

Case study of the Land Use Plan N°=07A: Bordj Bou Arreridj city

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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

.....In The Name Of Allah, The Most Gracious, The Most Merciful.....

# Dedication:

*To my dear family, who have been the greatest support throughout my academic journey especially my dear sister "Assia".*

*To everyone who believed in me and encouraged me to keep going despite the challenges.*

*To my colleagues and my second sister "Manar", respected professors who contributed to the foundation of this academic path.*

*I dedicate this humble work to you with deep gratitude and appreciation.*



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**حالة مخطط شغل 07A بمدينة برج بوعريريج**

أصرح بشرفي أنني ألتزم بمراعاة المعايير العلمية والمنهجية ومعايير الأخلاقيات المهنية والتزامه الأكاديمية المطلوبة في انجاز البحث المذكور أعلاه.

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# GENERAL INTRODUCTION

## I. General introduction:

Floods are one of the most frequent and impactful natural occurrences in the urban, economic, and social tissues of communities that have become a real threat to urban areas, especially those that are rapidly and thoughtlessly expanding. The increase in the intensity of flooding has been ascribed to several interrelated factors, including climatic changes, spontaneous urbanization, and the reduction of natural environmental ability to absorb rainwater, due to the lack of appropriate green areas and stream diversion without a thorough study. The municipality of Bordj Bou Arréridj offers a relevant case study in this regard. On September 24, 1994, the city experienced severe flooding caused by the overflow of four wadis that cross the urban area, leading to the death of 16 people and material damage affecting more than 800 homes. While the floods were triggered by natural conditions, the scale of the damage was largely exacerbated by urban planning deficiencies and the failure to account for flood risk in land use decisions. Studying the floods in urban layouts is not a secondary matter, but a fundamental element in the approach of contemporary urban design and planning of the Land Use Plan N°=07A which represents the study's framework, is situated in a very fast-growing urban area with an increasing demand for housing and expansion of land use. However, this expansion is mostly made at the expense of the necessary conditions, which are both environmental and hydrological, thus putting the residents and the structures directly in the face of the flood hazard. Against this background, this memo aims to carry out a comprehensive analysis of the phenomenon of floods in an urban area within the land use plan of parcel 7 through a field study and the cartographic treatment of hazard sources, vulnerability and exposure areas. The latter, with a focus on the morphological and hydrological characteristics of the environment. Furthermore, the study will attempt to propose preventive measures and design approaches that protect the urban area from the flood hazard, and among them are mattering the adoption of effective water drainage systems, respecting the non-buildable areas and land-use allocation following the adaptation principle to natural hazards. Setting up urban protective schemes that consider the dynamics of nature and the human intervention restraint as the best option to ensure safe and sustainable urban development. Such integration of environmental and spatial dimensions into urban policies and the embedding of a risk-averse culture at all stages of urban project preparation and management are the only way to achieve this ideal. This report consists of a general introduction, two chapters, and a concluding section that sets out the main results of our work. In the introduction we present the research problem, the hypotheses and the

objectives of our work. The first chapter, dedicated to the theoretical background, is divided in two parts. The first one presents the principles of urban planning, while the second one discusses the main types of hazards, with a particular emphasis on floods and fluvial flooding. The second chapter is dedicated to the risk study of the city. We start with a brief description of the area under study, which we defined on the basis of the land use plan of the city. Then, we expose our methodology, which consists in determining the major sources of risk on one hand, and in analysing the exposition and the vulnerability of the population and goods to this risk on the other hand. Our work is completed with the presentation of our results, which we summarized in a map of the flooding sensitivity. This document is intended to be a precious tool in the hands of decision makers, if they want to manage the risk actively, by creating an anti-flood plan for the study area



## II- Statement of the problem :

In recent years, Algerian cities have been increasingly confronted with natural hazards, particularly floods, which are among the most devastating disasters in terms of their impact on urban development and population safety. This threat is especially acute in cities experiencing rapid and unregulated urban expansion, where natural factors intersect with spatial planning deficiencies. The city of Bordj Bou Arréridj exemplifies this situation, as it has undergone significant urban sprawl that encroaches on natural environments, and is traversed by several wadis—including Oued ELmerdja, Oued Boumrged, and Oued Bordj Bou Arréridj—which act as flood channels during heavy rainfall, posing serious risks to lives and property.

The absence of preventive infrastructure and effective urban planning near these watercourses, coupled with a general lack of public awareness, contributes to increased vulnerability among the local population. Therefore, addressing the issue of floods requires more than just technical analysis; it calls for an integrated approach that combines spatial assessment with community behavior and awareness. A thorough diagnosis of urban vulnerability is needed, focusing on neighborhood exposure based on their geographic distribution, land use patterns, and proximity to flood-prone wadis.

Accordingly, this study seeks to answer the following research questions:

### The main question:

- To what extent can spatial analysis of flood risks in Bordj Bou Arréridj and especially in Land Use Plan N°=07A particularly in areas near wadis support awareness-raising efforts and the implementation of effective preventive measures?

### Sub-questions:

- How can an integrated flood risk assessment approach, based on environmental and urban data, provide a foundation for a proactive awareness and prevention strategy to protect residents and infrastructure in The Land Use Plan N°=07A?

## III Study Objectives :

The objectives of this study are

- Identify the adequacy of land use plan 07A in Bordj Bou Arréridj with the flood risk situation, and to what extent does it actually consider natural hazards in the land use allocation.
- Identify classified installations and inhabited areas and identify their exposures to flood risk by their geographic characteristics (altitude, distance to watercourse, type of urban construction, etc).
- Identify the errors of location in Land Use Plan N°=07A in regards to the distribution of land that were responsible for the increased vulnerability to flooding and therefore of the risk of disaster.

- Propose modifications or alterations to sections or all of the plan to satisfy the requirements of flood risk prevention and mitigation, while remaining congruent with the urban structure that has already been established.
- Propose technical recommendations to allow a more practical use of urban planning instruments at the local level to facilitate the inclusion of the identified topographical and hydrological characteristics in the spatial decision-making process.

#### **IVI.Importance of the Study:**

##### Significance of the Study:

- The significance of the study stems from an examination of the field of city planning and the area of environmental risk management, particularly flooding risk. By examining the Land Use Plan N°=07A for the municipality of Bordj Bou Arréridj, this study will provide greater understanding of how spatial planning can mitigate or increase natural hazards. The significance of the study includes:
  - Connecting the topics of planning and disaster risk reduction and using this dialogue to assist in developing urban areas with limited infrastructure.
  - Offering a local scale diagnosis of flood risk vulnerability associated with specific land use configurations, which can help inform better planning processes and policy changes.
  - Providing applicable insights for urban planners and other decision-makers, especially municipalities, such as Bordj Bou Arréridj that suffer from similar constraints of environmental hazards and structural concerns.

#### **V.Justifications for Choosing the Topic:**

Several academic and contextual reasons interrelate to allow the selection of this research topic:

- It relates to pressing urban issues facing local municipalities in Algeria related to current improper land use planning as synonymous environmental vulnerability.
- There is limited research at the local level that focuses on the direct relationship between Land Use Plans (POS) and flood risks exposure, especially in medium-sized cities such as Bordj Bou Arréridj.
- The research relies on design arrangements made before a national priority for planning was made public, such as spaces that position rapid assessments of risk linked to development tools, as called for by the Algerian urban policy and the Environmental Plan.
- The 1994 flood event is a case study in real and measurable results attributed to the futility of spatial planning and a points to conceptual forms to allow research to be made.

## **VI.Reasons for Choosing the Topic:**

The selection of this topic was motivated by both academic interest and practical necessity:

- Personal academic interest in urban risk management and environmental planning.
- The need for spatial risk analysis in regions like Bordj Bou Arréridj that are subject to recurring floods yet lack sufficient preventive planning tools.
- The opportunity to analyze a real, documented case Land Use Plan N°=07A that allows for detailed spatial and institutional analysis.
- The desire to contribute to the development of resilient cities, by offering evidence-based recommendations to improve existing urban planning instruments.

## **VII.Study Methodology:**

The study relies on modern approaches in spatial studies, particularly the descriptive method and automated spatial analysis using Geographic Information Systems (GIS). It also involves cartographic representation of the results of spatial analysis, in addition to incorporating traditional methodologies.

# MEMORY STRUCTURE

1  
General Introduction :  
General introduction, Problematic (or Research problem), Study objectives, Importance of the study, Justifications for choosing the topic, Reasons for choosing the topic, Study Methodology

2  
General concepts  
Urban Concepts  
Risk Concepts "Floods"  
GIS Concepts

3  
Analytical Study of bordj bou arreridj City

4  
•Workflow Steps Using ArcGIS:  
•Analytical Study of Land Use Plan 07A  
Sensitivity study of urban area components  
Summary  
Conclusion

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# THE THEORETICAL PART

**Introduction:**

Natural hazards and those caused by human activity have increased and become part of daily life. These risks turn into disasters when they threaten people's lives and livelihoods. Despite the enactment of laws in the urban planning sector that address this issue, challenges remain. This chapter is divided into four sections: the first section, entitled "Urban Concepts", Definition of the city, urban planning, planning and development tools, Definition of the Master Plan for Development and Urban Planning (PDAU), Land Use Plan (POS), the second section, entitled "Major Hazards", includes several definitions related to them; Hazard, Hazard cause and Types of major hazards, "Flood-Specific Concepts" Definition of flood, Causes of flooding, Types of floods and Factors influencing flood magnitude while The final section included an overview of Geographic Information Systems (GIS), covering their components, applications, advantages, specialized software, as well as their key functions.

## 1. Urban concepts:

### Urbanism:

The study or appreciation of the processes of change in towns and cities; making towns and cities work; town (UK) or city (US) planning. Charles Landry (2000) describes urbanism as 'the discipline which helps understand the dynamics, resources and potential of the city in a richer way'.

2 The process of becoming urban (as a result of development on formerly rural land, for example). 3 The product of town planning or development. ANDRES DUANY (2000) describes urbanism as 'the created habitat of humanity'. As a NEW URBANIST, Duany refuses to accept suburban places as being anything but 'a lesser or permanently incomplete version of urbanism'. Duany and Elizabeth Plater-Zyberk (2001) argue that in contemporary America 'there are two types of urbanism available: the NEIGHBORHOOD, which was the model in North America from the first settlements to the second world war, and SUBURBAN SPRAWL, which has been the model since then.' PATRICK ABERCROMBIE wrote: 'Let urbanism prevail and preponderate in the town and let the country remain rural. Keep the distinction clear' (Hall, 1994).

(Cowan, 2005, p. 431)

### City :

A large Town : a place with a cathedral; a place with a city charter. A New Urbanist Lexicon (McLaughlin, 2000) defines a city as 'the aggregate of two or more towns, specialized districts and connective transportation and open space corridors.'

'The city,' says John Norquist (2002), mayor of Milwaukee, 'is the only natural form of government. Empires decline, cities endure.' DAVID ENGWICHT (2003) describes cities as 'an invention to maximise exchange opportunities and minimise travel'. BILL HILLIER has called a city 'a mechanism for generating contact'.

RICHARD SENNETT (1978) describes a city as 'a human settlement in which strangers are likely to meet'. The architect LEON KRIER has described the invention of the city as 'a spiritual and technical achievement the historical significance of which surpassed by far the discovery of fire or the invention of the wheel'. (Cowan, 2005, p. 61)

### Definition of Urban Planning and Development Tools :

Urban planning and development rules and tools are legal mechanisms used by the state to regulate urban areas. These rules serve as substitutes for planning tools in the absence of formal plans. While urban planning and development tools or schemes define the general framework for land allocation, urban planning rules—whether general or specific—precisely determine the lands, their usage, and the standards that must be adhered to in this regard.

### **The Master Plan for Urban Development and Planning :**

is a tool for spatial planning and urban management. It defines the main directions for urban development within a single municipality or across multiple municipalities that share common factors, such as shared infrastructure and basic facilities. This plan sets the reference framework for urban development, including technical reports, maps, diagrams, and statistics. It also delineates land divisions in terms of their potential for urbanization.

### **The Land Use Plan :**

is a tool for urban planning and development, through which the basic guidelines for construction are determined at the level of a municipality or part of it. It specifically outlines the rules and rights for land use and construction in terms of the urban form of buildings, including the minimum and maximum permissible construction volumes, expressed in square meters or cubic meters. It also addresses the external appearance of buildings, public and green spaces street heights, monuments, and the locations of agricultural lands that must be protected, all in accordance with the regulations set forth in the Master Plan for Urban Development and Planning. (Belfadel, 2010. p. 8+10)

### **SNAT:**

The National Land Use Planning Scheme (SNAT), established under Law No. 01-20 of 2001, is a 20-year strategic framework evaluated every five years. Initiated by the central government, it guides the spatial distribution of population and activities across Algeria. Its goal is to ensure balanced resource allocation, especially toward southern and border regions,

### **SRAT:**

The Regional Land Use Planning Schemes (SRATs), defined by Article 03 of Law 01-20, are 20-year plans updated every five years, covering groups of wilayas with shared characteristics. Initiated by the state, they guide spatial planning and sustainable development at the regional level. Their formulation involves stakeholder participation through workshops and conferences. SRATs coordinate population and activity distribution, infrastructure development, and regional urban planning.

### **PAW:**

The Wilaya Land Use Plan (PAW) is a key planning tool at the provincial level, initiated by the Provincial People's Assembly (APW). It includes three phases: territorial diagnosis, a sustainable development vision, and zoning-based planning. Positioned between national, regional, and local plans, it guides strategic decisions and ensures coherence across scales. It aligns with higher-level directives while shaping local development policies.

## 2. a.Risk concepts: Risk

### Risk :

According to Algerian legislation, the concept of hazard is defined in Article (02 of Law 20-04, dated December 25, 2004, related to the prevention of major hazards and the management of large-scale disasters within the framework of sustainable development). The law defines a "major Risk" as any potential threat to humans and their environment, which may arise either from exceptional natural risks or from human activities.

### Risk components:

components of major hazards:

$$\text{Risk} = \text{Hazard} \times \text{Vulnerability}$$

### Hazard :

It is the sum of the physical phenomena that constitute the starting point of the hazard, such as hydrological, morphometric, geological, vegetation cover, and climatic characteristics, which may contribute to the emergence of the hazard.(Auer & Böhm, 1994, pp. 103–117)

### Vulnerability:

It is the second factor in the risk equation and can be applied to flood hazards. This concept is complex and difficult to measure. Vulnerability consists of assets, people, and the environment. Economic vulnerability involves damage to built systems (such as damage to equipment, housing, roads, and transport networks, as well as disruption of activities).

As for demographic vulnerability, it concerns assessing harm to individuals on both physical and mental levels (e.g., injured or missing persons). Vulnerability can also include social considerations that are not easily measurable (such as emotional or psychological factors).

Another definition of vulnerability involves integrating the social, economic, and geographical dimensions in a comprehensive manner to establish a multidimensional analysis and assessment framework.(Cutter, 2001, p. 50)

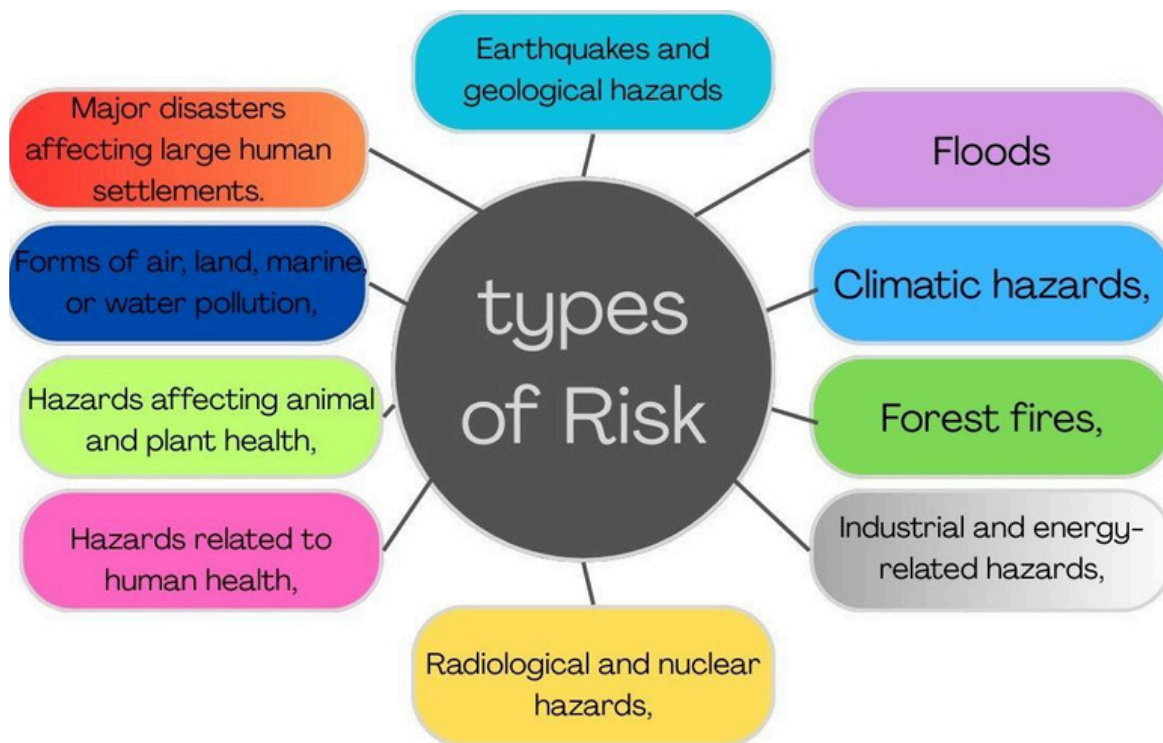
Fig No01:Risk Components



## Types of risk:

According to Law No. 20-04 (2020), disaster risk prevention must be integrated within the framework of sustainable development. types of Risk are:

Fig No02:Types of Risk



## Natural Hazard :

There is a general definition of natural hazards as being a sudden and rapid impact of the natural environment on economic and social systems. However, Mauffrey sees them as spatially and temporally concentrated events that destroy a community or a specific area, with undesired consequences emerging due to the collapse of the sense of security or precaution long internalized by the population.

Another definition considers a natural disaster to be a unique event in a given area that results in material damage estimated at around one million dollars, or causes the death or injury of more than one hundred people.

In fact, Burton's definition of natural hazards by being so specific—opens the door to disagreement and varying opinions. This is because losses, whether material or human, are essentially relative. Their impact varies from one society to another depending on the level of economic and technological development. For instance, a disaster may be extremely costly and disruptive in a developed society due to its complex infrastructure, while the same type of disaster may have limited economic consequences in a poorer or more primitive society, lacking advanced engineering systems. In such cases, the outcomes are typically limited to the destruction of basic buildings, damage to agricultural lands, or loss of grazing areas mostly affecting indirect human land use.

## 2. a. Risk concepts: Floods

### **Floods:**

Flooding is an overflowing of water onto land that is normally dry. Floods can happen during heavy rains, when ocean waves come on shore, when snow melts quickly, or when dams or levees break. Damaging flooding may happen with only a few inches of water, or it may cover a house to the rooftop. Floods can occur within minutes or over a long period, and may last days, weeks, or longer. Floods are the most common and widespread of all weather-related natural disasters. (NOAA National Severe Storms Laboratory, 2020)

### **Types of floods:**

A river flood occurs when water levels rise over the top of river banks due to excessive rain from tropical systems making landfall, persistent thunderstorms over the same area for extended periods of time, combined rainfall and snowmelt, or an ice jam.

A coastal flood, or the inundation of land areas along the coast, is caused by higher than average high tide and worsened by heavy rainfall and onshore winds (i.e., wind blowing landward from the ocean). Places like Charleston, South Carolina, and Savannah, Georgia, experience impacts from shallow coastal flooding several times a year because of coastal development and lower elevation.

Storm surge is an abnormal rise in water level in coastal areas, over and above the regular astronomical tide, caused by forces generated from a severe storm's wind, waves, and low atmospheric pressure. Storm surge is extremely dangerous, because it is capable of flooding large coastal areas. Extreme flooding can occur in coastal areas particularly when storm surge coincides with normal high tide, resulting in storm tides reaching up to 20 feet or more in some cases.

Along the coast, storm surge is often the greatest threat to life and property from a hurricane. In the past, large death tolls have resulted from the rise of the ocean associated with many of the major hurricanes that have made landfall. Hurricane Katrina (2005) is a prime example of the damage and devastation that can be caused by surge. At least 1500 persons lost their lives during Katrina and many of those deaths occurred directly, or indirectly, as a result of storm surge.

Inland flooding occurs when moderate precipitation accumulates over several days, intense precipitation falls over a short period, or a river overflows because of an ice or debris jam or dam or levee failure. Hurricane Floyd (1999), aided by Tropical Storm Dennis (1999), caused widespread severe flooding that caused the majority of the \$3 to 6 billion in damage reported after those storms.

A flash flood is caused by heavy or excessive rainfall in a short period of time, generally less than six hours. Flash floods are usually characterized by raging torrents after heavy rains that

rip through river beds, urban streets, or mountain canyons. They can occur within minutes or a few hours of excessive rainfall. They can also occur even if no rain has fallen, for instance after a levee or dam has failed, or after a sudden release of water by a debris or ice jam.

Areas damaged by wildfires are particularly susceptible to flash floods and debris flows during rainstorms. Rainfall that is normally absorbed by soil and vegetation can run off almost instantly, causing creeks and drainage areas to flood much earlier and with higher magnitude than normal. Heavy rainfall on recently burned areas can also mobilize sediments and cause a much more destructive debris flow. (NOAA National Severe Storms Laboratory, 2020)

## Factors contributing to flooding :

### 1• Torrential Seasonal Rainfall:

It refers to heavy rainfall that occurs in a short period of time, usually during specific seasons of the year. When a large amount of rain falls suddenly:

- The soil cannot absorb all the water quickly.
- Water starts to flow on the surface. This water gathers and rushes into valleys and rivers. If the volume of water exceeds the capacity of the valley a flood occurs.

### 2• Construction within Riverbeds (Wadi Courses):

The riverbed is the natural path where water flows during rain or floods. When people build homes or structures inside these riverbeds:

They block the natural flow of water.

Water is forced to find another path, often flooding the built-up areas.

This increases the risk of flooding and causes significant material and human losses.

### 3. Presence of Solid Obstacles in the Valleys:

This includes things like:

- Large rocks
- Cut-down trees
- Construction debris
- Or poorly designed bridges

These elements obstruct the flow of water inside the valley.

Fig No03: Factors contributing to flooding :



**Floods causes:**

Flooding is one of the most devastating natural phenomena and can occur due to a variety of reasons, classified into natural and location-based (site-specific) causes:

**1. Natural Causes:**

Rise in sea level

Changes in water pressure under the ocean

Heavy and prolonged rainfall

Melting of accumulated snow on mountains during spring

Storm surges and tsunami waves sweeping the coasts

Collapse or failure of dams

**2. Location-Based Causes:**

The city's location in valleys, at mountain slopes, or where river tributaries converge

Topography of the city and variation in land levels and types

The proximity of the city to flood outlets, or its location along riverbanks

Poor choice of construction sites, such as building in flood-prone areas (Jamal, 2002, p. 30)

**Elements of studying Floods Hazard****1. Topography:**

Topography is one of the most fundamental natural factors influencing flood risk. It refers to the elevation, slope, and shape of the land surface. These features determine how water moves across an area.

Regions with steep slopes tend to experience rapid surface runoff, which increases the likelihood of flash floods, while low-lying areas such as valleys and floodplains are more susceptible to water accumulation and prolonged inundation.

Understanding topographic conditions is essential for identifying natural drainage paths, determining flood-prone zones, and planning flood mitigation infrastructure like levees and retention basins. (Ouma & Tateishi, 2014)

**2. Precipitation**

Precipitation is the most direct and influential trigger of flooding events. It includes not just the total amount of rainfall, but also its intensity, duration, and temporal distribution.

High-intensity rainfall over a short period can saturate the soil quickly, leading to rapid surface runoff and potential flash flooding. Recurrent or seasonal rainfall can also reduce soil infiltration capacity, increasing flood vulnerability.

Rainfall analysis is therefore essential in flood hazard modeling and in estimating return periods and flood recurrence intervals

### 3. Soil type

significantly affects how rainfall infiltrates the ground or remains on the surface. Soils vary in texture, porosity, and hydraulic conductivity, which in turn influence flood dynamics.

Sandy soils have high infiltration rates and generally reduce surface runoff.

Clay-rich soils tend to retain water on the surface, increasing flood potential.

Loamy soils have moderate infiltration capacities and are more balanced.

Furthermore, anthropogenic impacts such as soil compaction and land degradation can reduce infiltration and exacerbate flood risks (Rawat & Sharma, 2015)

### 4. Vegetation Cover

Vegetation acts as a natural barrier against flooding. Plants intercept rainfall, reduce the velocity of surface water, and enhance soil stability through root systems. In areas with rich vegetation cover, more water is absorbed into the ground, and erosion is minimized.

In contrast, deforestation or urban sprawl reduces vegetation density, thereby increasing surface runoff and the severity of flooding. Monitoring vegetation cover through remote sensing and GIS helps assess changes in flood vulnerability. (Bradshaw et al., 2007)

### 5. Flood History

Flood history includes records of past flood events such as their frequency, duration, intensity, and geographic extent. These historical data are critical for identifying high-risk zones and modeling future flood scenarios.

Historical analysis helps to:

- Calibrate flood prediction models,
- Identify patterns of recurrence,
- Support land use planning and zoning regulations.

Data sources may include hydrological records, satellite imagery, historical maps, and local knowledge (Kundzewicz et al., 2014)

Fig No04:Elements of studying Floods Hazard

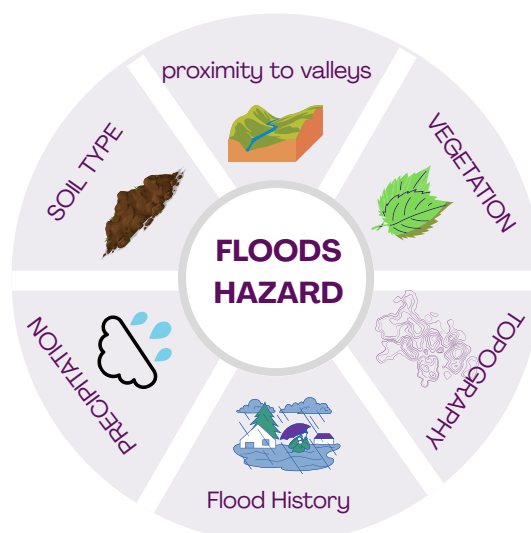
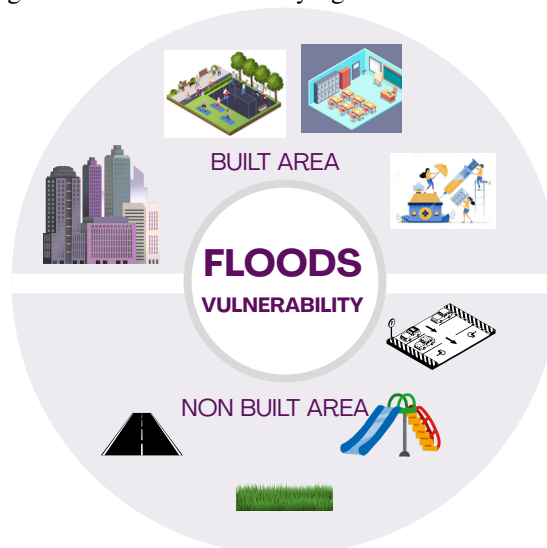


Fig No05: Elements of studying Floods Vulnerability



### 3.GIS concepts

#### Geographic Information Systems (GIS)

##### Definition of Geographic Information:

Geographic information refers to data that possesses spatial dimensions and geographic referencing. This term emerged around 1960 in response to significant technological developments.

Geographic information is typically divided into two main categories:

**Geometric Information:** Represented using primary geometric components (point, line, polygon), which are displayed in GIS as maps.

**Descriptive Information:** Represents detailed attributes of the geometric data, and is displayed in GIS in the form of attribute tables.

Main Geometric Components: Polygon (Area)-Lines (Linear Features)

##### Characteristics of Geometric Information:

These characteristics are primarily numerical and analytical, describing phenomena spatially and geometrically, explaining relationships among them, and analyzing their components under specific conditions and factors. Key characteristics include:

A. Location -Area-Shape-Pattern

B. Characteristics of Descriptive Information:

Descriptive information is usually linguistic (e.g., name of a district, street name) or statistical (e.g., population count, type of infrastructure). (Bouchrit, 2010)

##### Definition of a Database:

A database is a logically organized collection of related information, stored and managed as a single unit, and processed within the same digital system. Often, the terms data and database are used interchangeably. A geographic database specifically refers to a logically structured

collection of information related to the physical world—namely, to spatial locations on the Earth's surface.(National Center for Geographic Information and Analysis, 2010, p. 220)

### **Spatial Analysis:**

Spatial analysis refers to the set of techniques used to extract meaningful information from geographically referenced data. It encompasses the integration of different spatial data layers and the classification, analysis, and interpretation of geographic phenomena.

In the context of GIS, spatial analysis includes methods such as:

- Overlay analysis
- Proximity analysis
- Spatial process modeling
- Migration path analysis (National Center for Geographic Information and Analysis, n.d.)

### **Definition of Geographic Information Systems (GIS):**

- GIS represents an applied model of computer technologies, encompassing both core components: hardware and software. These technologies enable the collection, storage, processing, and output of various types of information and data in multiple forms, such as maps, models, tables, and texts. This signifies that GIS is an analytical tool that utilizes information describing specific locations on the Earth's surface, allowing the identification and definition of spatial relationships between the components of a map.
- According to Ozemoy, Smith, and Cicherman, a Geographic Information System is a set of functions that offers advanced automated capabilities in the domains of storing, analyzing, displaying, and retrieving data associated with specific geographic locations.
- Mulier (SIG 1999) views GIS as operations concerned with large-scale maps and substantial hydrological sources, derived from administrative divisions and municipalities. The primary objective of such systems is to support policymakers and administrators in making balanced decisions regarding resources
- GIS is essentially the analysis of relationships that link spatial databases with interpretation and outputs, often presented in the form of detailed maps. These are managed via computer programs capable of storing,
- retrieving, verifying, integrating, analyzing, and displaying data about the Earth and its location on the map. These systems facilitate the collection, input, processing, analysis, display, and dissemination of both spatial and descriptive geographic information for specific purposes. They assist in planning and decision-making related to risks, vulnerabilities, and the implementation of disaster risk management measures.
- Burrough (1986) defines GIS as a collection of software packages capable of inputting, storing, retrieving, processing, and displaying spatial data corresponding to a portion of the Earth's surface.(El-Khouzami Azir, 1998)

## History of Geographic Information Systems:

The emergence of GIS dates back to the 1960s, when several governmental agencies in the United States, Europe, and Canada began employing such systems to implement spatial tasks and projects. Within the academic realm, Harvard University in the United States pioneered the development of programs for automated map drawing and spatial analysis in its computer and cartographic laboratories. Likewise, the University of Washington in Seattle developed specialized software dedicated to transportation and urban planning tasks.

Canada's GIS (CGIS), developed in 1964, is considered the first operational geographic information system. Its emergence followed the inaugural meeting of the Planning Information Program, which subsequently led to the establishment of the Urban and Regional Information Systems Association (URISA) in the United States. Further developments followed, such as the Land Use and Natural Resources Management System in the State of New York in 1967 and the Minnesota Land Management Information System in 1969. These projects were, at the time, highly expensive and accessible only to major administrative entities in countries such as the United States, Canada, Australia, and the United Kingdom. By the mid-1970s, the term "Geographic Information Systems (GIS)" was formally adopted due to the diversity of names and software used across the advanced nations engaging with this technology.

Fig No06: GIS Developments Efforts



## Factors Behind the Development of GIS:

The evolution of GIS can be attributed to several key factors:

**The Information Explosion:** Particularly in relation to environmental data accumulated over the centuries across various domains. This vast body of information required systematic collection and analysis to support development, planning, and decision-making at national, regional, and local levels.

**Advancements in Geographic Scientific Research:** Modern progress in cartographic production methods, remote sensing technologies, and Global Positioning Systems (GPS), alongside real-time communication technologies, significantly contributed to the development of GIS.

**The Multidimensional Nature of Geographic Data:** Spatial data inherently possess three dimensions—length, width, and elevation. GIS enables the integration and interaction of these dimensions through composite mapping, which merges quantitative and descriptive data within a single layer. This facilitates a better understanding, description, assessment, and prediction of complex phenomena.

**The Efficiency and Power of GIS:** Numerous governmental institutions, research bodies, and private enterprises have recognized the critical importance of GIS across multiple sectors. GIS has thus emerged as a powerful technology, enabling geographers to complement traditional data and models with new methods and tools that enhance the scope and effectiveness of spatial analysis. (Al-Dulaimi, 2011, p. 2322)

## Applications of Geographic Information Systems (GIS) in Various Fields:

The remarkable capabilities of Geographic Information Systems (GIS) in querying databases, conducting various types of analyses, and presenting results in a simplified form for decision-makers have proven highly beneficial across numerous domains, including:

### 1. Crisis Management

GIS allows for the analysis of transportation networks and infrastructure to identify the shortest paths between two points and the most efficient routes among multiple locations. It also aids in facilitating the maintenance of newly established networks, saving both time and effort. Crises are typically spatial events—such as floods, earthquakes, fires, hurricanes, epidemics, civil disturbances, and famines. Thus, possessing up-to-date maps and geospatial information is essential for effective disaster management.

### 2. Emergency Medical Services

GIS is a highly effective tool for emergency medical response. It provides data on the types of incidents and the demographic characteristics of the affected populations, which can be quickly and easily visualized. GIS contributes to faster emergency responses by identifying the closest ambulance unit to the reported incident location and determining the shortest or most appropriate routes, including alternatives. Additionally, GIS enables the analysis of stored

data to predict the speed and extent of the spread of diseases or epidemics, facilitating proactive planning.

### **3. Urban Planning**

GIS is instrumental in evaluating the performance of various public services (educational, healthcare, security, etc.) within urban areas to identify underserved regions and facilitate the redistribution of services accordingly. It also enables the comparison between planned and actual land use in specific areas, helps identify land ownership and legal responsibilities, and supports the creation of mathematical models to study informal settlements by analyzing patterns of urban growth. This, in turn, helps limit unplanned expansion and supports the development of existing urban areas.

### **4. Environmental Protection:**

GIS enables the classification and study of various environments from multiple perspectives—particularly their physical, biological, chemical, and climatic characteristics. It facilitates the monitoring of environmental changes in specific areas and the assessment of various impacts by comparing images and maps from different time periods, including the impacts on neighboring regions.

### **5. Land Use and Natural Resource Mapping:**

Modern GIS technologies can be used to produce maps that identify natural resource concentrations (such as water, petroleum, or mineral ores) within specific areas. These maps illustrate current land use and can also be used to generate forecasts of future land use .

## **Types of GIS Users:**

### **A. Managers:**

These individuals are responsible for overseeing systems and databases and ensuring access to them. They also define the objectives that GIS is expected to achieve and determine the necessary steps and strategies for reaching those goals.

### **B. Users:**

These are the professionals who directly handle the data, from inputting it into the system and converting it into digital form, to analyzing it and producing outputs such as maps, graphs, and reports.

### **C. Viewers:**

These individuals use GIS to query information and answer specific questions without engaging in data entry, processing, or analysis. A viewer might, for instance, request a map showing the locations and types of available equipment, and GIS would generate and display the relevant visual output accordingly. (Iraqi Information Life, 2011, pp. 332–333)

**D. The Viewers:** These are individuals who occasionally consult the contents of a Geographic Information System (GIS), similar to browsing a book or an encyclopedia. This access is

typically made possible through computer screens connected to the institution's internal GIS network or via the internet. (Proceedings of the First Regional Conference on Geographic Information Systems, 2002, p. 39)

### **GIS Advantages:**

Geographic Information Systems (GIS) offer numerous advantages related to the nature of data entered and the variety of applications. Some of the key benefits include:

- Assists in planning new and expansion projects.
- Enhances the speed and efficiency in accessing large volumes of data.
- Supports timely and appropriate decision-making.
- Facilitates the dissemination of information to a broader range of beneficiaries.
- Integrates spatial and descriptive data into a unified database.
- Provides verified and standardized data documentation.
- Promotes coordination among relevant stakeholders prior to decision-making.
- Offers high spatial analytical capability.
- Enables spatial and attribute-based queries.
- Provides powerful visual representation of spatial information.
- Simulates proposed planning projects and forecasts their outcomes before implementation on the ground.

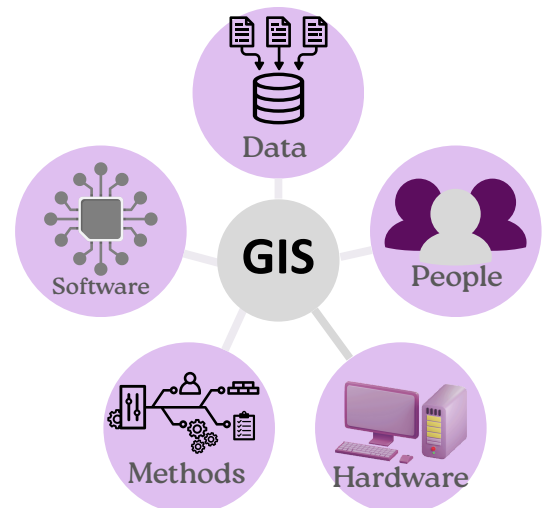
### **Core Components of a GIS**

A Geographic Information System (GIS) is comprised of five essential components, which work together to manage and analyze spatial data effectively:

- Hardware
- Software
- Data
- Methods (or Procedures)
- People (Users)

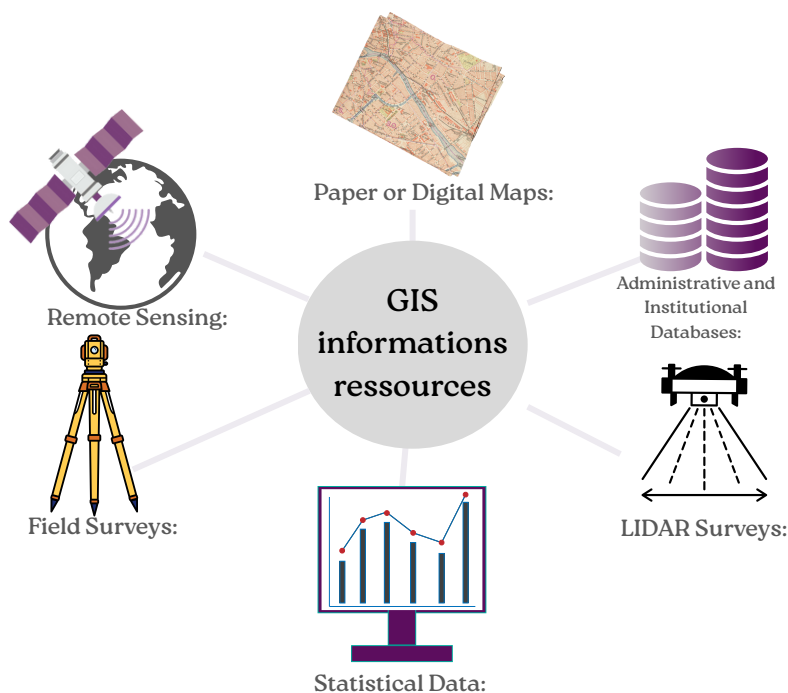
These elements collectively ensure the success of a GIS, from data acquisition and processing to analysis, visualization, and decision support

Fig No07: Core Components of a GIS



## GIS informations ressources

Fig No08:SIG informations ressources



### The role of Geographic Information Systems (GIS) in flood risk prevention:

Geographic Information Systems (GIS) play a crucial role in flood risk prevention by providing tools and methods for data collection, analysis, visualization, and decision-making. Here's a breakdown of the key roles GIS plays in this context:

#### 1. Flood Hazard Mapping

- GIS allows the integration of spatial data such as:
  - Topography (elevation and slope),
  - Hydrology (rivers, drainage patterns),
  - Soil types,
  - Land use and land cover.
- These data help identify flood-prone areas and produce flood hazard maps, which are essential for planning and zoning regulations.

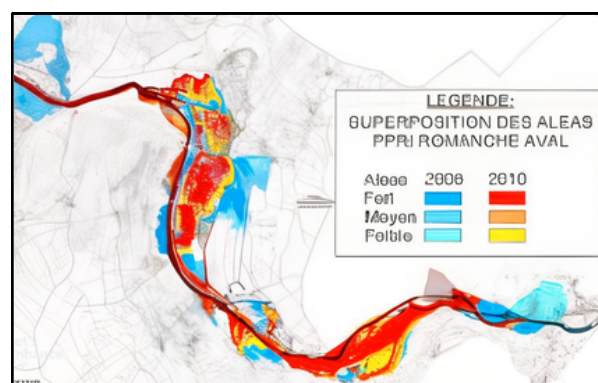
#### 2. Risk Assessment and Analysis:

- Geographic Information Systems (GIS) are used to integrate and analyze various datasets to determine the extent to which different areas are exposed to flood risks. One of the key tools in this analysis is:
  - Flood Sensitivity Map:
  - A Flood Sensitivity Map shows how susceptible a given area is to flood hazards, based on several environmental and physical factors. It helps in making informed preventative

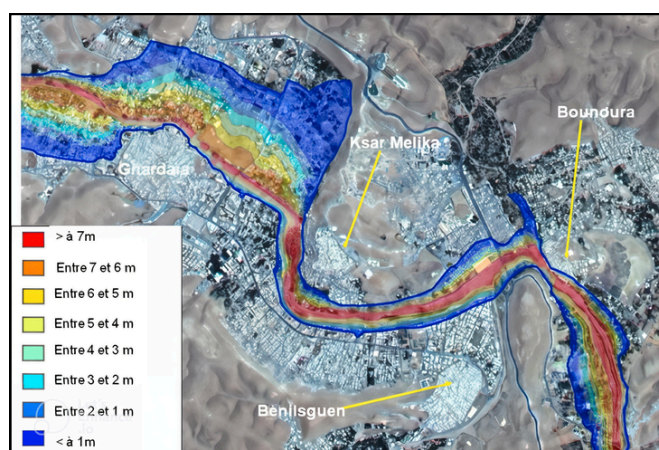
decisions by classifying areas according to their sensitivity levels:

- Low Sensitivity
- Moderate Sensitivity
- High Sensitivity
- **Factors Used in Creating a Sensitivity Map:**
  - Elevation and slope: Low-lying or flat areas are more prone to water accumulation.
  - Proximity to water bodies: Areas closer to rivers, streams, and drainage paths have higher sensitivity.
  - Soil type: Impermeable soils contribute to more surface runoff.
  - Land use: Urban areas (buildings, roads) increase flood vulnerability.
  - Rainfall quantity and intensity: The higher the precipitation, the greater the flood risk.
- **Importance of the Sensitivity Map:**
  - Supports sustainable urban and regional planning.
  - Guides investments in flood-prevention infrastructure.
  - Helps prioritize areas for emergency response and planning.

FigN09: Sensitivity map in romanche France



FigN10: Sensitivity map in Ghardaia Algeria



**Conclusion:**

This chapter presents the fundamental conceptual framework for understanding the relationship between urban planning and risks. The first section clarifies the notions of urbanism and spatial planning, while the second section provides various definitions related to major hazards. The third section focuses specifically on flood-related concepts. This theoretical foundation is essential for analyzing the extent to which risk considerations—particularly flood risk—are integrated into urban planning and development tools, thereby setting the stage for the practical case studies and assessments discussed in the following chapters.

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# ANALYTICAL STUDY

**Introduction:**

This chapter presents the fundamental conceptual framework for understanding the relationship between urban planning and risks. The first section clarifies the notions of urbanism and spatial planning, while the second section provides various definitions related to major hazards. The third section focuses specifically on flood-related concepts. This theoretical foundation is essential for analyzing the extent to which risk considerations—particularly flood risk—are integrated into urban planning and development tools, thereby setting the stage for the practical case studies and assessments discussed in the following chapters.

# Analytical Study of the City of Bordj Bou Arréridj

## 1.1 Introduction to the City of Bordj Bou Arréridj:

### Geographical Location:

The city of Bordj Bou Arréridj is located in the western part of the eastern high plateaus of Algeria and serves as an important administrative and economic center in the heart of Bordj Bou Arréridj Province.

It is bordered by:

**North:** the municipalities of Medjana and Hassenaoua

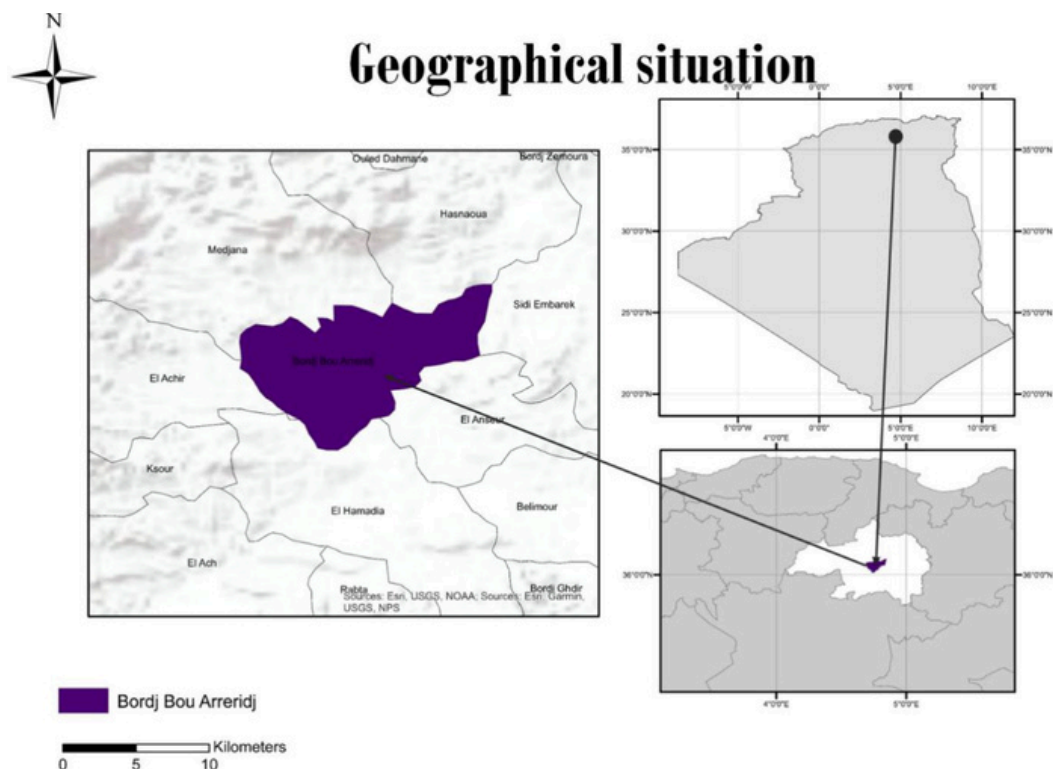
**South:** the municipality of El Hamadia

**East:** the municipalities of Sidi M'barek and El Aneur

**West:** the municipality of El Yachir

The city covers an area of approximately 81.1 km<sup>2</sup>, making it a medium-sized municipality in terms of geographical extension within the province.

Fig11: Geographical location of the city of Bordj Bou Arréridj



Prepared by the student-2025

### **Astronomical Location:**

Using Google Earth software, the following geographical coordinates can be determined:

- Latitude: 36.073° North
- Longitude: 4.763° East

### **Natural Study:**

The location of the city of Bordj Bou Arréridj within the High Plateaus region endows it with distinct natural characteristics that set it apart from other cities. To better understand these features, a natural study of the area was conducted to identify the city's physical characteristics and their impact on the urban fabric.

#### **Topography:**

According to the Master Plan for Development and Urban Planning (PDAU), the province of Bordj Bou Arréridj is naturally divided into three main regions:

The High Plateaus:The Northern Mountainous Zone, which includes the Bibans and the Setif Highlands

The Southern Mountainous Zone: which includes the Hodna Mountains

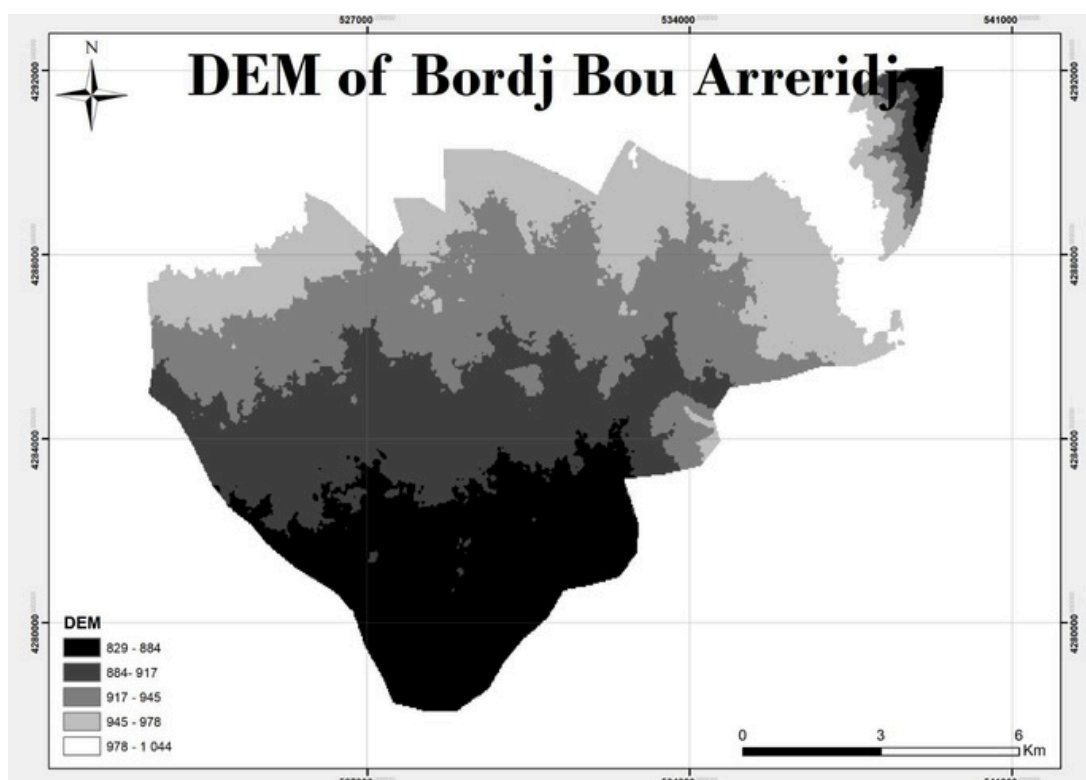
The municipality of Bordj Bou Arréridj falls within the High Plateaus zone. Mountainous terrain borders the northwestern part of the municipality, notably Mount Ben Rouane, with an altitude reaching 1042 meters. In the eastern part, the municipality is bordered by Mount Djahifa, which rises to 1019 meters.

The remaining area of the municipality is mostly composed of plateau landscapes, dominated by elevations ranging between 850 meters and 960 meters, with some areas reaching up to 1044 meters.

#### **Elevation:**

Bordj Bou Arréridj is primarily a flatland city, nestled between the by Mount Ben Rouane (elevation: 1042 m) and in the east by Mount Djahifa (elevation: 1019 m). The city's terrain is characterized by elevations ranging from a minimum of 829 meters to a maximum of 1044 meters.

Fig 12: Digital Elevation Model (DEM) of Bordj Bou Arréridj



Prepared by the student-2025

### Slopes:

Given the importance of this factor in assessing the natural characteristics of the area and determining its suitability for construction, the Slope Map of Bordj Bou Arréridj reveals that the impact of slope variation is relatively minor, as the terrain is generally gentle. Three main slope categories can be identified within the city:

- **First: Moderate Slope Category:**

Slope gradients range from 8% to 12%, appearing in two main zones: one in the northwestern part of the city, and the other in the eastern sector.

- **Second: Low Slope Category:**

Slopes range from 4% to 8%. These are scattered across various points of the city, including two notable areas currently overlaid by urban structures—one in the east and the other in the west of the city.

- **Third: Very Low Slope Category:**

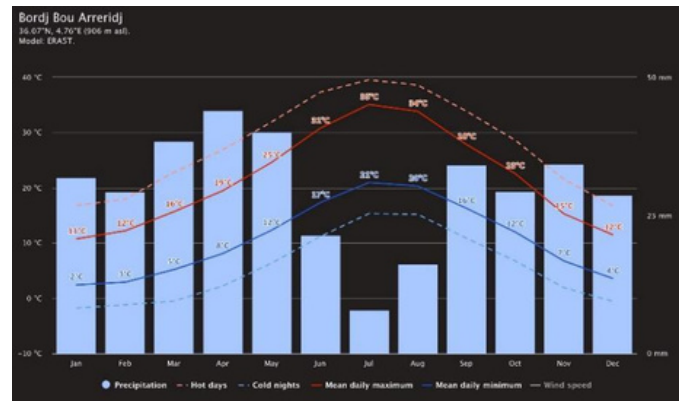
With gradients ranging from 0% to 4%, this category represents the most predominant slope level across the city, particularly within the urban fabric, making it highly suitable for construction and urban development

**Climate:**

Climate is one of the key factors influencing urban expansion and population distribution.

In general, the region is characterized by a semi-arid continental climate, with cold and rainy winters, and hot, dry

Fig No13:Climate

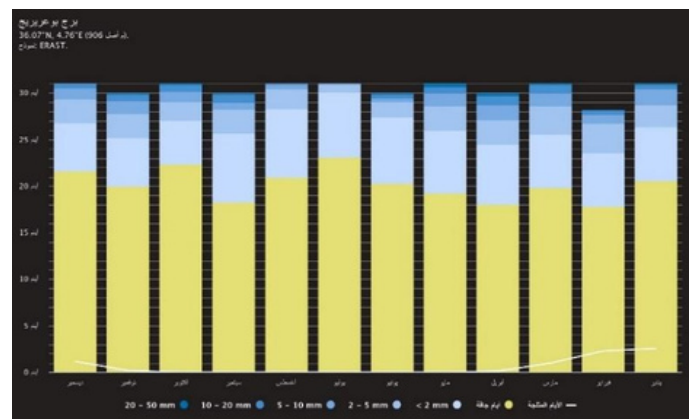


Meteo Blue

**Precipitation:**

The amount of precipitation in the city of Bordj Bou Arreridj varies throughout the year, typically ranging between 300 mm and 400 mm annually.

Fig No14:Precipitation



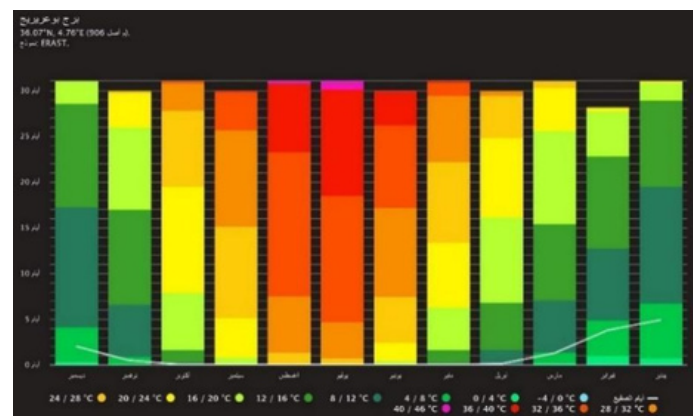
Meteo Blue

**Temperature:**

Throughout the seasons, the city of Bordj Bou Arreridj experiences varying temperatures, with an average annual temperature of approximately 17.25°C.

January is typically the coldest month, with an average temperature of 8°C, while July is the hottest month, reaching an average of 36°C.

Fig No15:Temperature



Meteo Blue

## Hydrology of the Region:

The large hydrographic network plays a crucial role in the flow of water within the region, particularly in how rainwater is drained, and is thus responsible for flooding, especially when combined with contributing factors such as steep slopes, rocky formations, and human interventions. The Solit watershed contains a dense hydrographic network that cuts through the urban fabric. The main rivers in this network are :

**Oued Areridj:** Originating from the northern region (Hassenaoua area and part of Ain Sultan), it crosses the city starting from the Laqraf neighborhood and extends over 8.5 km.

**Oued Slaib:** Coming from the western side of the city, it stretches from the Medjana village in the north, passing through the southern exit of the city, and flows through the Belbabbouche neighborhood over a length of 11 km.

**Oued Merj El-Wost:** Originating from the northern region, starting from the Hassenaoua area and Ain Ben Imran, it passes through the center of Houza Sidiqi, the November 1st neighborhood, and the October 17th neighborhood, covering 6.2 km.

**Oued Boumraged:** Flowing from the eastern side, it starts from the Hassenaoua area and Bir Semb to the eastern exit of the city, passing through the October 17th neighborhood, with a length of 10 km.

The total catchment area for these four rivers is estimated at 13,943 hectares, with a flow rate of approximately 142 m<sup>3</sup>/s.

Fig16 : Hydrographic network of the city of Bordj Bou Arréridj

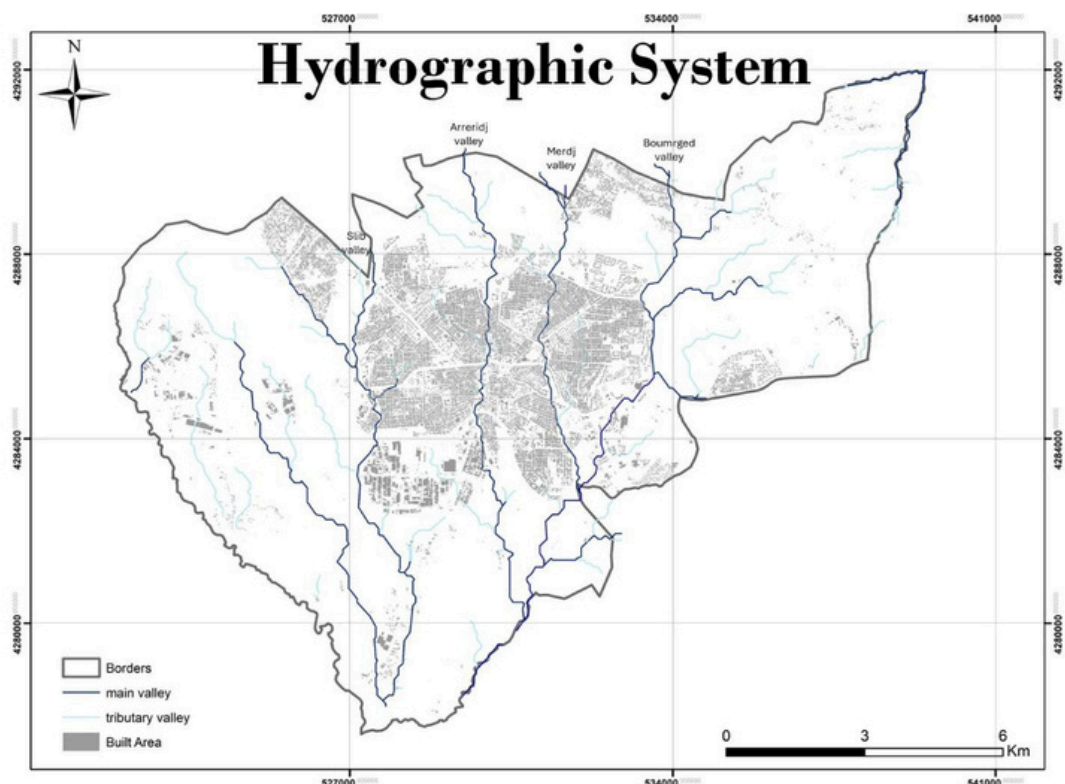
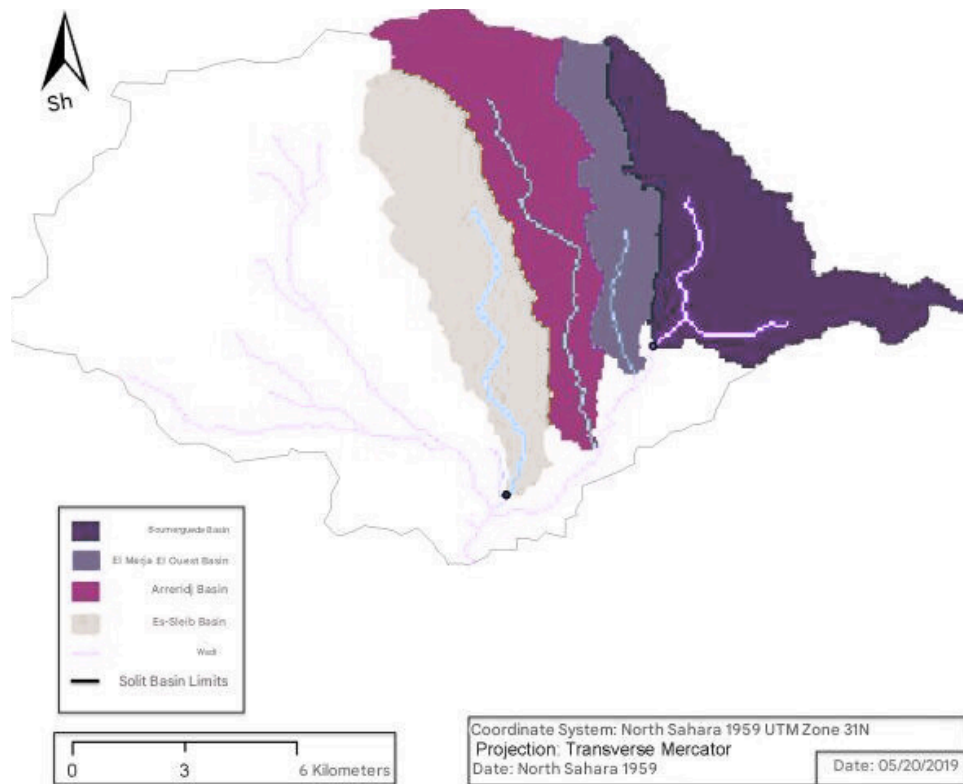


Fig17: collectif bassins of the city of Bordj Bou Arréridj



التوسع العمراني وخطر الفيضانات دراسة حالة مدينة برج بوعريريج Memory Thesis

### Geology of the Region:

Based on the geological map of Northern Algeria at a scale of 1:500,000 and previous studies, it was found that the study area consists of the following landforms:

#### Quaternary Period:

Coarse-grained formations: These include both modern and ancient formations, covering areas such as plains and valleys (gravel, sand, soil, etc.).

#### Triassic Period:

Triassic Formation: This is an evaporitic formation resulting from the phenomenon of diapirism, found sporadically in the region, with the presence of a series of faults and Cretaceous formations.

#### Jurassic Period:

Jurassic Formation: This is a relatively rare formation, characterized by calcareous deposits, conglomerates, and sandstones.

#### Cretaceous Period:

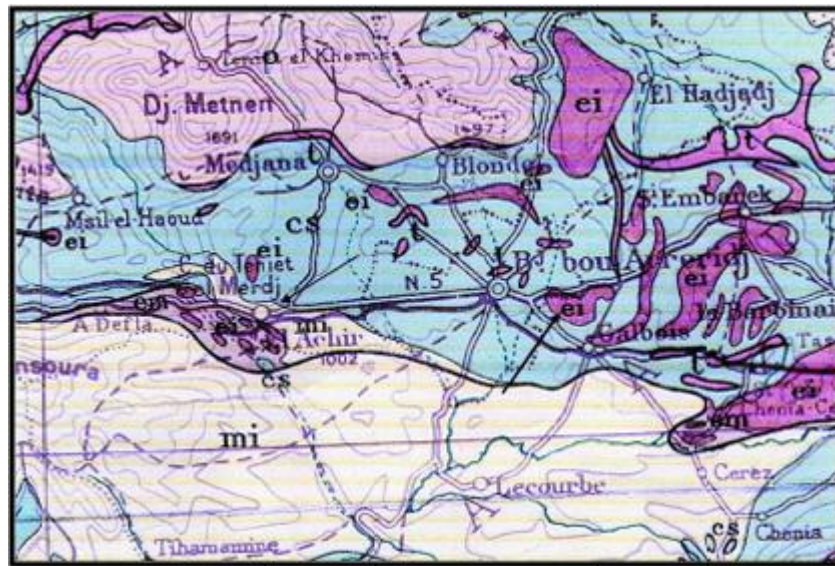
Cretaceous Formation: Represented by both Middle Cretaceous and Lower Cretaceous formations, this constitutes the majority of the study area.

#### Tertiary Period:

Marl, sandstone, conglomerates, and dolomite formations. Eocene: This formation is

composed of marly, clayey layers, along with quartz sandstone.

Fig18: Geology of the city of Bordj Bou Arréridj



PDAU BBA

### Population Study:

Studying the population size allows us to estimate their various needs and ensures that planning is organized and programmed in line with ongoing developments.

### Population Growth of the City:

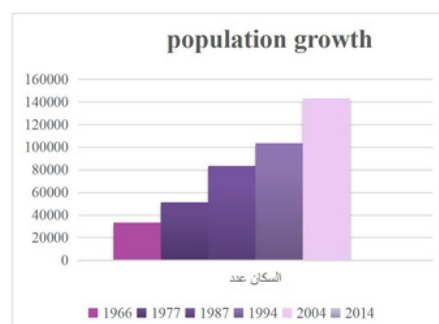
The city of Bordj Bou Arréridj witnessed significant population growth after independence, with its population increasing more than five times from 1966 to 2014, as shown in the following table:

Table 01: Population Growth of the City of Bordj Bou Arréridj

Years	1977	1994	1987	2004	2014
Number of population	51505	103717	83607	143464	167921
Population Growth Rate	3.90	4.94	4.94	3.2	2.01

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Fig19: collectif bassins of the city of Bordj Bou Arréridj



PDAU BBA

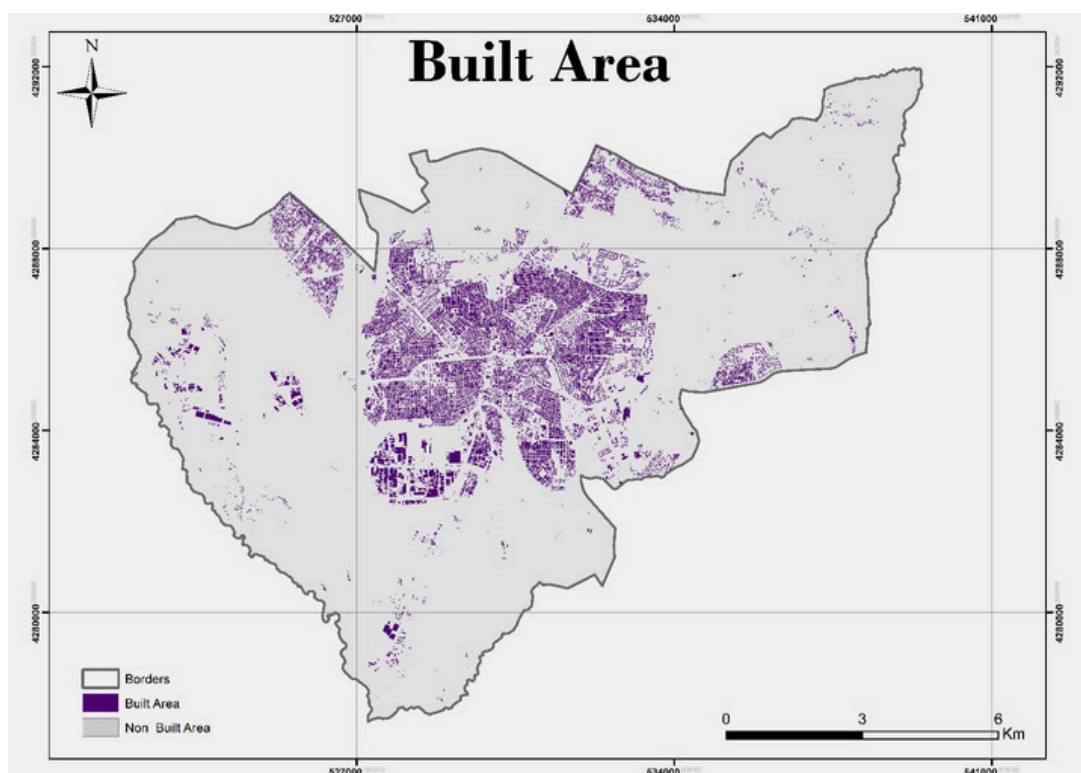
## Urban study:

### The built-up framework:

The residential area is one of the main features of the city, as housing is considered one of the most important indicators reflecting the capabilities of urban and material communities, especially economic ones. It also serves as a translated reflection of their past and present, depending on housing patterns, building heights, and the construction materials used.

It occupies a significant area, represented by the main cluster in Bordj Bou Arréridj and secondary areas such as Aouine Zariga, Bir Snab, and Boumerghed. These are distributed in a scattered manner within the urban area.

Fig20: built Area Of Bordj Bou Arreridj city



Prepared by the student-2025

Table N2: number of habitants in Bordj Bou Arreridj

Number of habitant	Number of habitats	T.O.L
184188	30698	6

PDAU BBA

## Housing Types in the City of Bordj Bou Arréridj:

Housing in the city can be divided into three main types:

### A - Individual Housing:

In 2014, the number of individual houses was estimated at 28,449 units, representing approximately 62.93% of the total housing stock in the city. These vary in condition from good to average and poor. They also differ in the number of floors and building heights, and include old and modern houses—even some dating back to the colonial era, particularly found in the old neighborhoods located in the city center. This percentage has increased in 2024 and becomes about 83% with 152877 habitats

### B - Collective Housing:

In 2014, the number of collective housing units was estimated at 10,029, accounting for about 36.2% of the total housing stock in the city. . Most of them are located in the new urban neighborhoods on the outskirts of the city.

In 2024 collective housing is about 40.6% of the total housing

### C - Semi-Collective Housing:

In 2014, this type of housing amounted to 250 units, making up about 0.87% of the city's housing. These are two- or three-story buildings, each containing two apartments with separate entrances. This type of housing is concentrated in the northwestern part of the city.

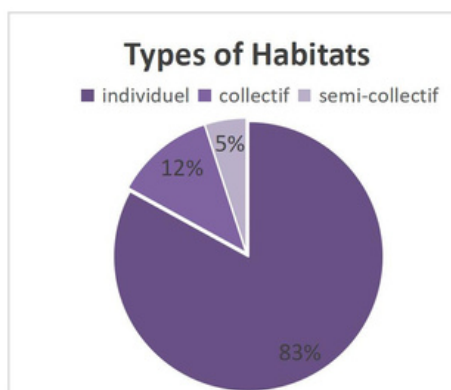
In 2024 Semi-collectif represent 5% of the total city housing

Table N3.: Housing Types in the City of Bordj Bou Arréridj

type of habitats	collectif	semi-collectif	individuel
number of habitats	22103	9210	152877

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Fig21: Types of Habitats Of Bordj Bou Arreridj city



## Equipments:

Urban facilities in the city of Bordj Bou Arréridj are primarily concentrated along the main transportation axes, particularly along Houari Boumediene Avenue (which follows the route of National Road No. 5). This area experiences significant levels of both vehicular and pedestrian traffic, due to the concentration of key facilities and services that receive the highest proportion of daily flows, such as the municipal headquarters, the daily market, and the administrative district.

Table N4: Distribution of Urban Facilities in the City of Bordj Bou Arréridj

### Educational Equipment

Vocational Training Center 3	High school 11	middle school 28	school 29
---------------------------------	-------------------	---------------------	--------------

### Sanitary Equipment

Hospital 2	Multi-Service Clinic 6	Treatment Room 8
---------------	---------------------------	---------------------

### Sports Equipment

Swimming Pool 1	Gymnasium 2	Swimming Pool 3	Neighborhood Playground 45	OMS Stadium 1	Municipal Stadium 1	Youth Center 2
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### Religious Equipment

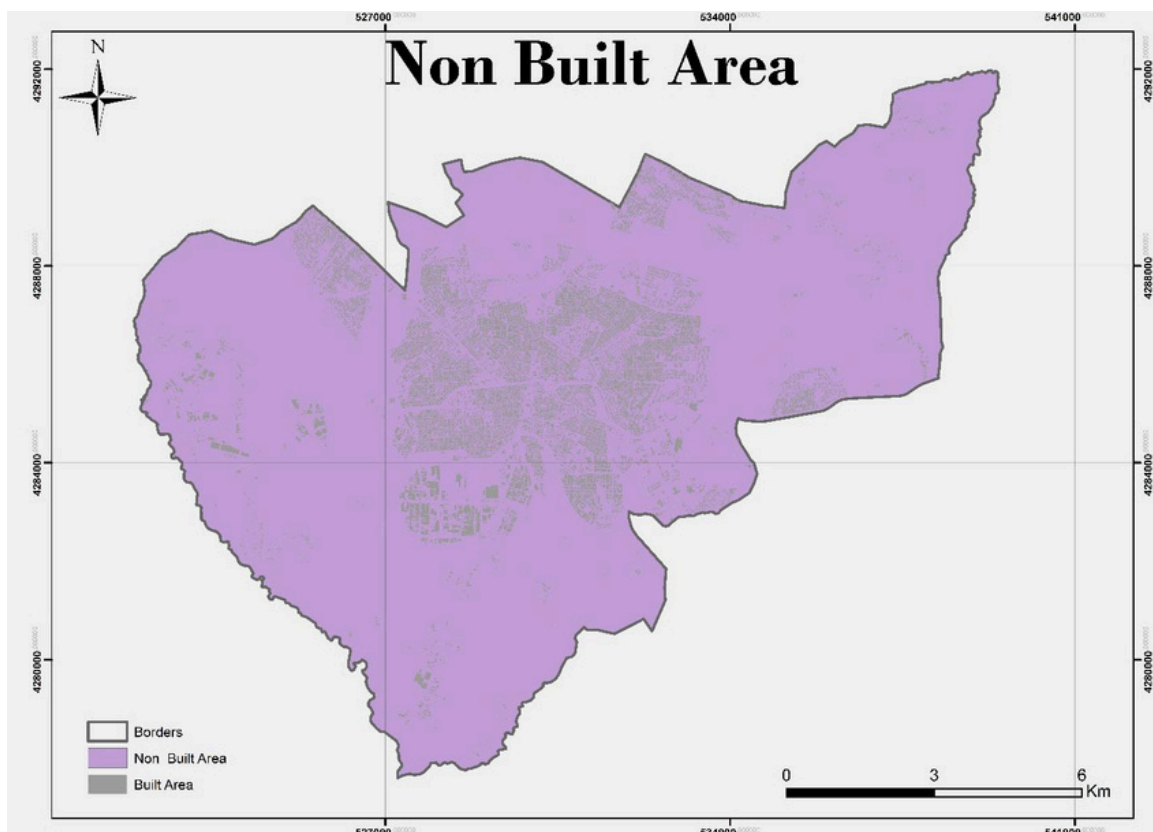
mosque 44	Quranic Corner 2	Quranic school 1
--------------	---------------------	---------------------

### Cultural Equipment

Hotel 6	Cultural Complex 1	Cultural Center 1	Exhibition Hall 1	Municipal Library 1	Municipal Stadium 1	Youth Center 1
------------	-----------------------	----------------------	----------------------	------------------------	------------------------	-------------------

## Non built Area:

FigN22: The Unbuilt Framework of the Study Area"



Prepared by the student-2025

### Road Network:

Roads play a crucial role in connecting various urban centers and contribute significantly to reducing isolation in remote rural areas. The city of Bordj Bou Arréridj benefits from a well-structured and diverse road infrastructure, which includes:

#### The East–West Highway:

This major highway traverses the municipality of Bordj Bou Arréridj from the northern side.

#### National Roads:

National Road No. 5: Connects Constantine to Algiers, passing through the municipality from east to west.

National Road No. 76: Links the municipality to the northern part of the province.

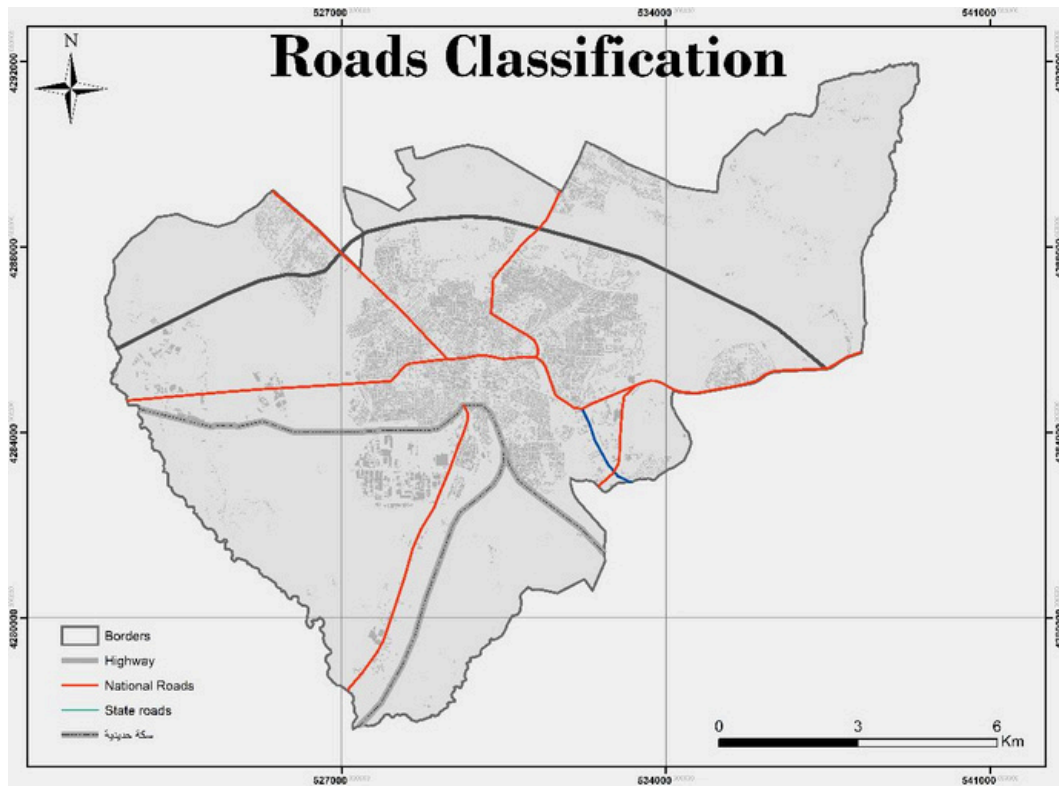
National Road No. 45: Connects the municipality of Bordj Bou Arréridj to the province of M'Sila.

#### Provincial Roads:

Provincial Road No. 42: Crosses the city from the northwest towards the southeast, linking the municipality of Bordj Bou Arréridj to the province of M'Sila via the municipality of Bordj Ghedir.

#### Municipal Roads:

Fig N23: Classification of the road network of the city of Bordj Bou Arréridj.



Prepared by the student-2025

**Conclusion:**

Through the analytical study of the city of Bordj Bou Arréridj, after addressing all the elements such as the natural, historical, and urban study, we reached the following conclusions:

- The city of Bordj Bou Arréridj has a strategic location ,serving as a link between the East and the Center.
- The city has undergone several transformations and developments due to various factors, including the increase in investments in the region.
- The city faces several obstacles that limitits expansion in certain areas,the most important of which are natural barriers, such as valleys.
- Natural factors such as the region's topography and climate contribute to the occurrence of floods.



# Analytical Study of the Land Use Plan N°=07A

## Introduction:

As part of the study of Land Use Plan N°=07A, Geographic Information Systems (GIS) specifically the ArcGIS software will be used to analyze the spatial structure of the plan, with a particular focus on distinguishing between the built-up and non-built-up areas. The aim of this analysis is to understand the distribution of urban development and land use, and to assess patterns of urban expansion in relation to the principles of sustainable spatial planning. The technical and methodological steps followed in ArcGIS have been outlined and explained, including data collection, preparation of geographic layers, digitization, and spatial analysis.

## 1.Workflow Steps Using ArcGIS:

collection, and careful verification to ensure scientific accuracy when applying the data to maps. The principle of data input into the computer memory relies on converting all collected information from paper format into digital form.

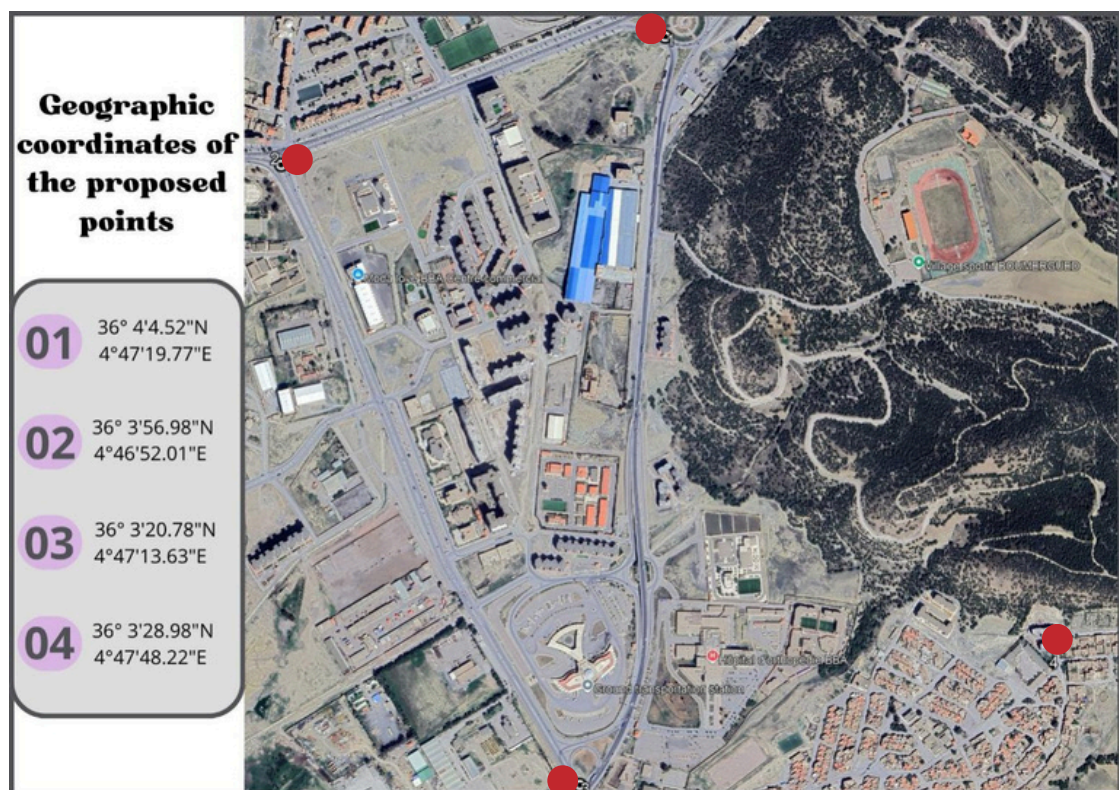
We imported a satellite image of the Land Use Plan N°=07A (from the year 2025) using Google Earth software, which allows capturing high-resolution aerial images of any area on Earth's surface. These images were then stored within the ARC GIS software to perform georeferencing of the image extracted for the Land Use Plan. This process involves three main steps:

Choosing the Projection System:

The UTM Zone 31N (Northern Hemisphere) was selected, where the studied Land Use Plan is located.

Selecting Four Proposed and Distinct Control Points:

Fig N24: Geographic coordinates of the proposed points



Prepared by the student-2025

Different points from the city were chosen, and their geographic coordinates were entered to complete the georeferencing process.

Inputting Spatial and Attribute Data:

Spatial data refer to information related to the location, such as geographic features on maps (e.g., the river network, land use distribution according to rainfall rate, components of the Land Use Plan).

Attribute data describe the spatial data and their various characteristics, such as data type, number of floors, population number, etc.

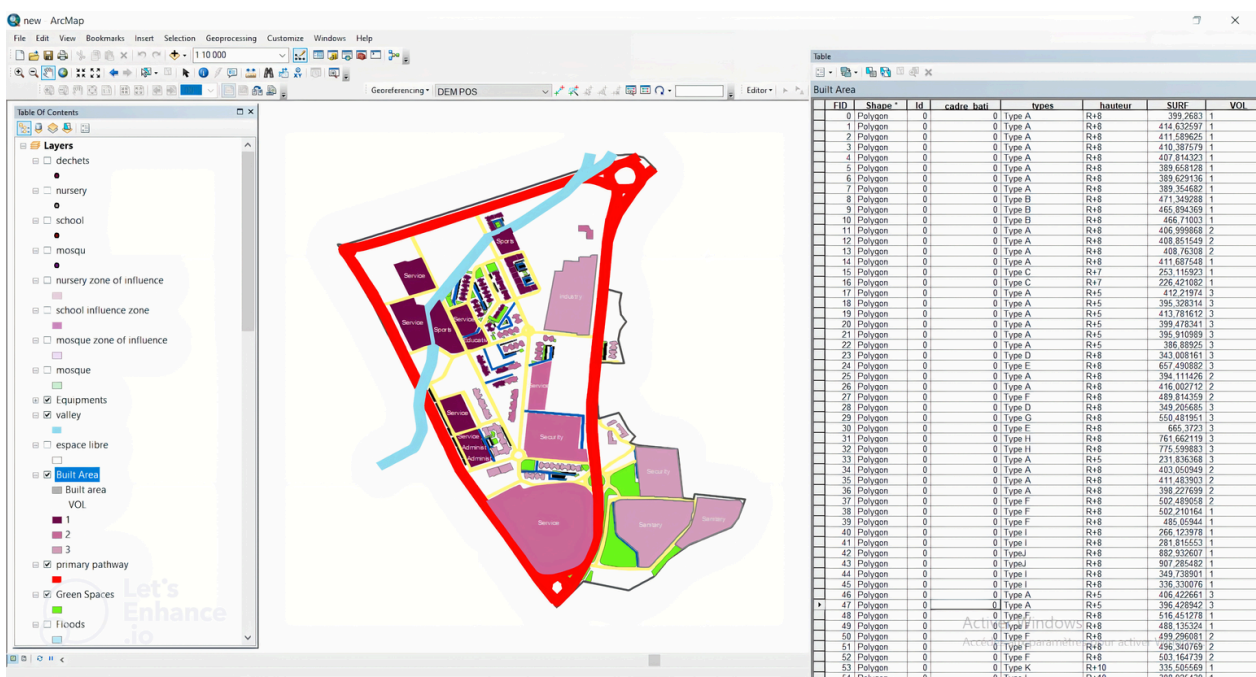
### Second Phase: Data Storage and Retrieval:

This stage involves storing geographic data from different sources such as maps, digital, and descriptive data in various formats (points, lines, and polygons), linking them together to allow easy retrieval as layers or multiple layers.

### Third Phase: Data Processing and Analysis:

This stage focuses on modifying data formats and levels, correcting input errors, and updating data. It also includes performing mathematical operations such as calculating areas and perimeters.

Fig N25: Workspace in the program in the programm of Arc Gis 10.3



### Arc Gis 10.3

The software provides powerful data analysis and cartographic representation tools, such as bar charts, proportional circles, density points, and more.

It also includes map decoration, design, and preparation for output.

### Fourth Phase: Data Presentation and Display:

After completing the data processing and analysis, the final phase is dedicated to presenting and displaying the results for reading and interpretation.

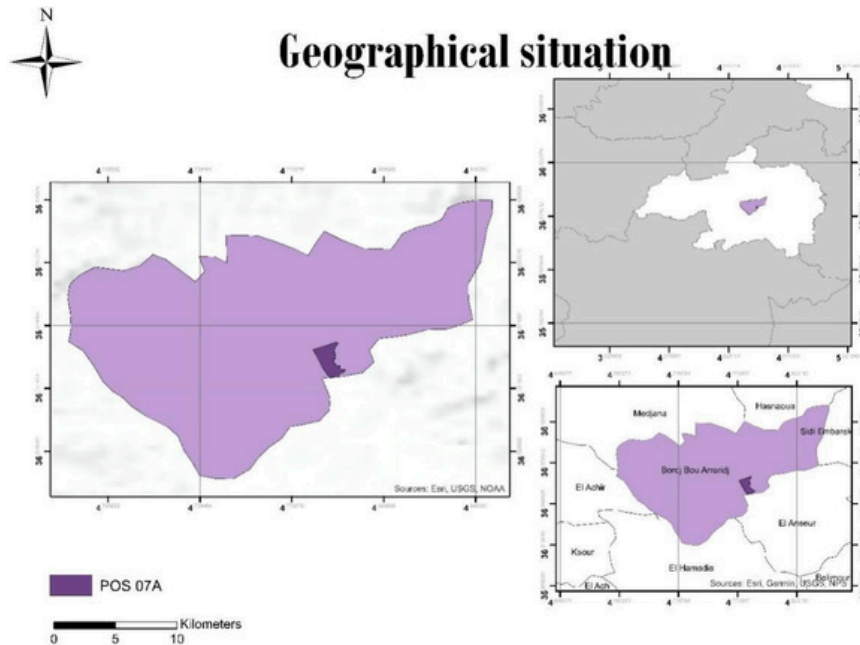
Outputs are produced in various forms, such as maps, charts, or images, and can be displayed on the screen, printed on paper maps, saved as image files, or published on web platforms.

## Analytical study of the Land Use Plan 07A

### Geographical and Administrative Location

The Land Use Plan N°=07A is located at the eastern entrance of Bordj Bou Arreridj city.

Fig N26: Geographical and Administrative Location of the Land Use Plan N°=07A



Prepared by the student-2025

### Geographical Coordinates:

The Land Use Plan is located within the following coordinates

X=687.80a688.6Km Y=308.5a 309.5Km Z=900m

Fig N27: Aerial Image of the Land Use Plan N°=07A



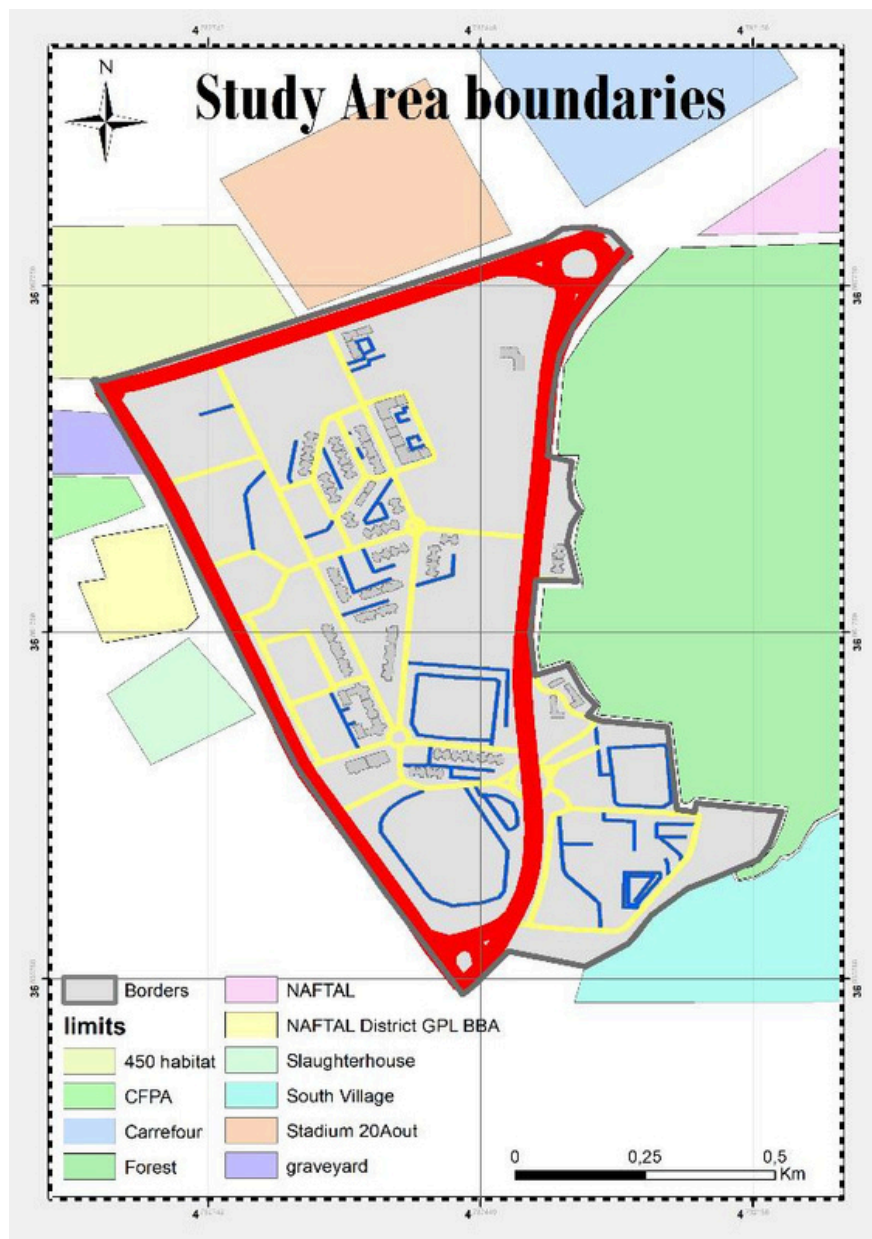
Google Earth Pro

## Study Area Boundaries:

The study area has a functional diversity regarding its surrounding boundaries, as we find:

- **Natural Boundary:** Represented by the Bumergad Forest
- **Residential Boundary:** 450 housing units and the southern village
- **Cultural Boundary:** Youth Center
- **Service Boundary:** Carrefour Commercial Center, Naftal
- **Sports Boundary:** August 20th Stadium

Fig N28: Boundaries of the Study Area



Prepared by the student-2025

## Urban Development of the Land Use Plan 07A:

The land use plan was approved on 2001 and the actual construction began in 27/05/2013 .

The land use plan went through several stages as follows:

First Stage: the emergency orthopedic hospital and the Samsung factory was established.

Second Stage: The creation of civil protection services and various service entities.

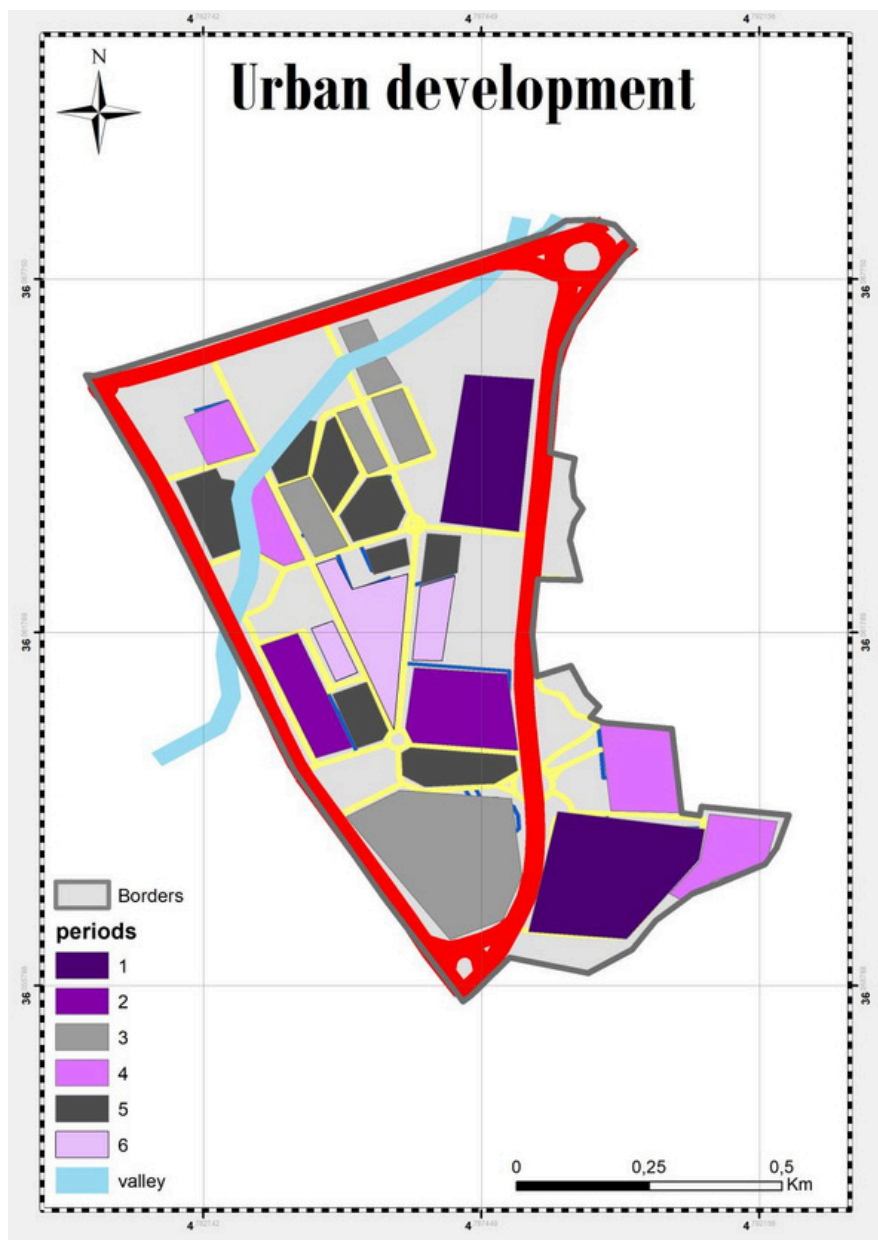
Third Stage: Construction of the passenger transport station.

Fourth Stage: Establishment of the paramedical training center and the police center.

Fifth Stage: Construction of collective housing units.

Sixth Stage: Further construction of collective housing units.

Fig N29: Stages of the Urban Development of Land Use Plan N°=07A



Prepared by the student-2025

### Demographic Data:

Population of the Neighborhood: According to the report of the land use plan and data processing, the population of the neighborhood is estimated to be 15,000 people.

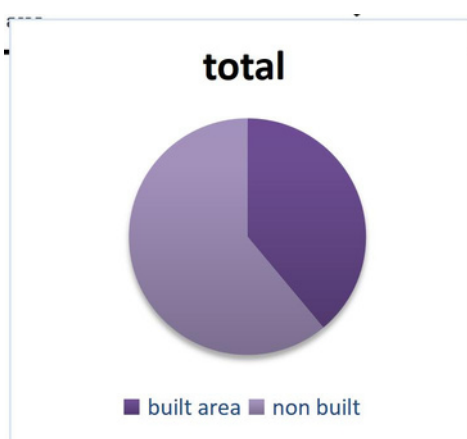
Population Density: The area of the neighborhood is 74 hectares, and the population is 15,000 people, which gives a crude population density of 202.7 people per hectare.

### Urban Study:

#### Built Environment:

The built environment occupies an area of 28.77 hectares, which is 53.89% of the total area, represented by collective housing units created to meet the housing needs of the population

Fig N30: Pourcentage of built + non built area



Prepared by the student-2025

Table N5: Type of buildings in POS07A

etat	surface	number	type
good	400	25	Type A
good	450	3	Type B
good	250	2	Type C
good	350	2	Type D
good	650	2	Type E
good	500	12	Type F

good	550	1	Type G
good	750	2	Type H
good	250	1	Type I
good	900	2	Type J
good	350	1	Type K
good	350	2	Type L
good	550	2	Type M

The table shows that Type A is the most widespread type, with 25 units, indicating its extensive use or high demand within the studied context. In contrast, Type G, Type I, and Type K are the least common, each having only one unit. This variation in distribution may reflect differences in function, importance, or even space requirements among the different types. It is worth noting that all types are classified as being in good condition, which indicates an overall maintenance of quality regardless of their quantity.

Fig N31:building type A



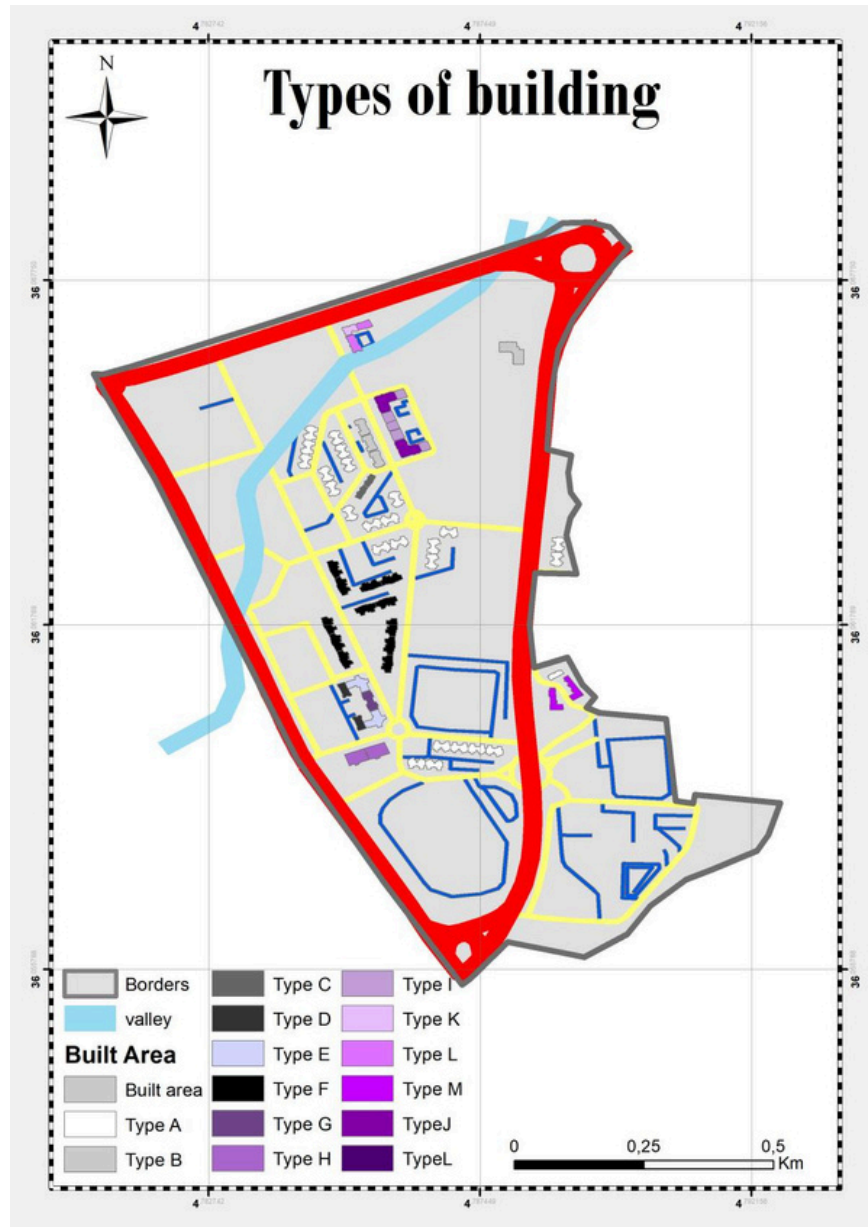
Fig N32:building type E



Fig N33:building type B



Fig N34:Types of buildings



Prepared by the student-2025

The map shows that the valley cuts through the urban area from the northwest to the southeast, passing through a built environment composed of various building types (A to M). It is evident that several types of residential structures are located very close to the valley, especially in the northwestern and central zones. Notably, a large number of buildings are situated in close proximity to the wadi's course, which exposes them directly to flood risks, particularly in the event of intense and concentrated rainfall—a frequent occurrence in the city. Additionally, the urban fabric surrounding the wadi lacks adequate setback distance from its natural flow path, indicating a shortage of protective planning or risk-based urban development. Furthermore, the concentration of Type C and D buildings (in black and dark gray) near the wadi in the western part of the map could represent critical zones during periods of flooding, as these densely built-up areas are more vulnerable to water intrusion.

Fig N35: Pourcentage of buildings types

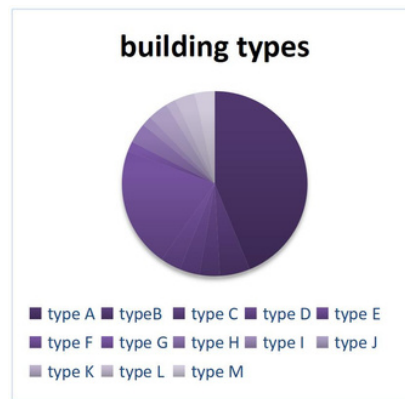
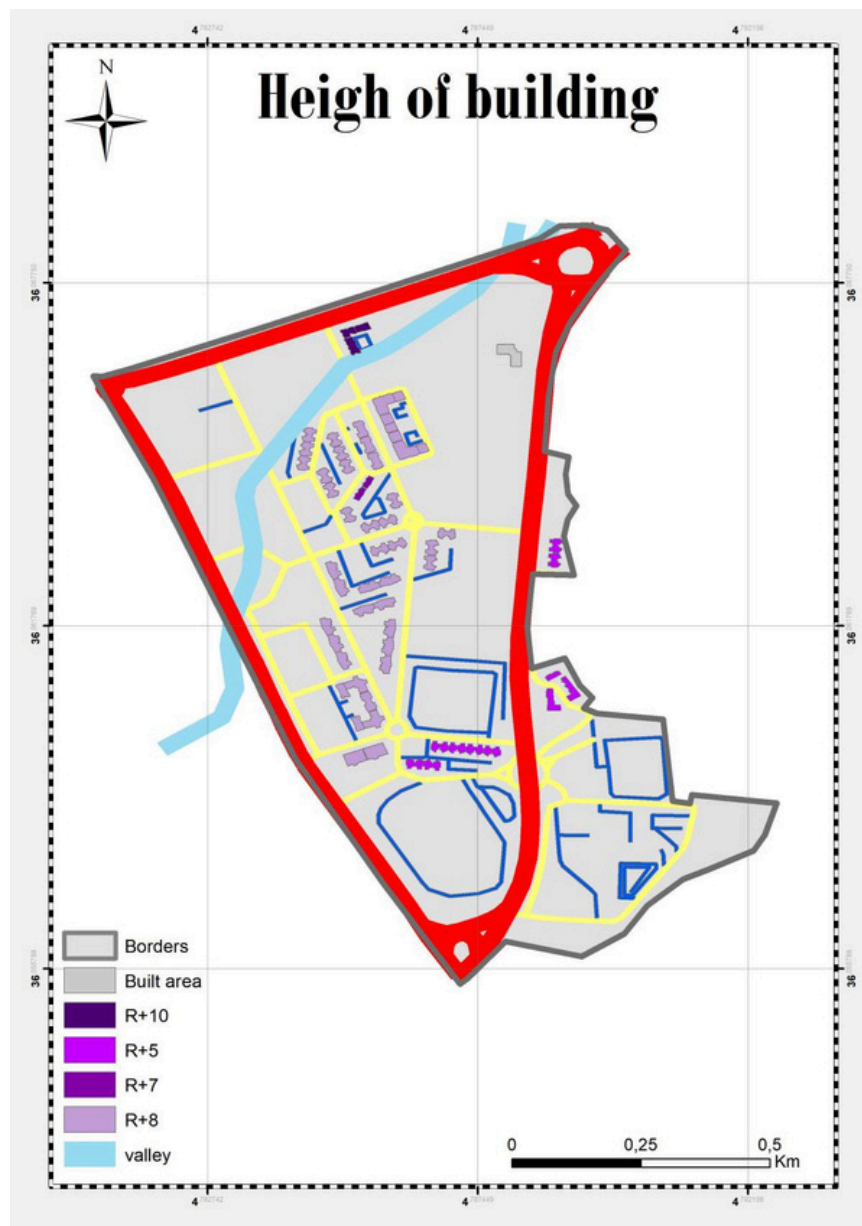


Fig N36: Building Height in Land Use Plan N°=07A



Prepared by the student-2025

"It is observed that the valley passes through areas containing multi-story buildings, particularly of types R+8 and R+10, which raises concerns about the potential impact of flooding on densely populated zones."

Fig N37: Building Height in Land Use Plan N°=07A

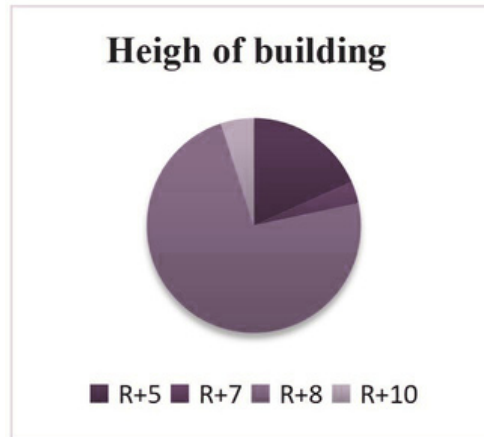


Fig N38: Building High R+8

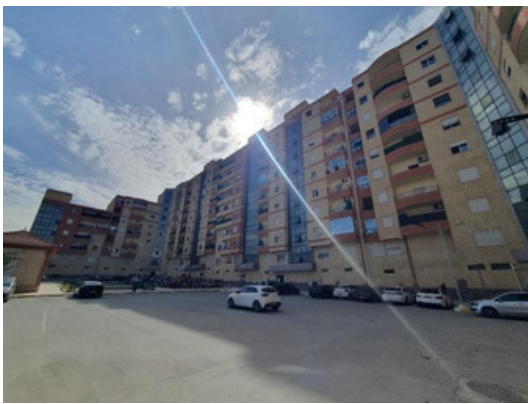


Fig N38: Building High R+5



Fig N39: Building Height R+10

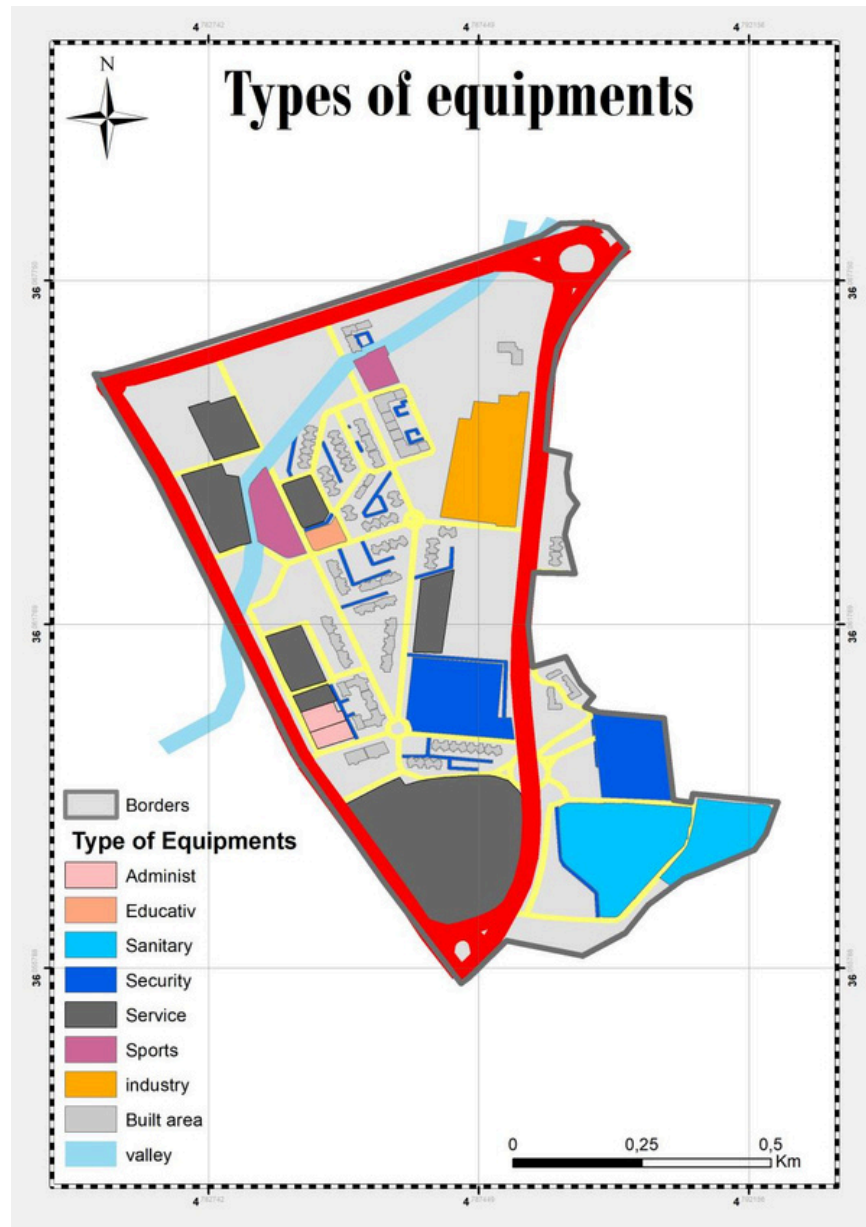


Took by the student-2025

### Equipments:

The equipment occupies a significant area estimated at 22.8 hectares of the total surface area.

"FigN40: Types of Equipmens in Land Use Plan N°=07A



Prepared by the student-2025

The map shows the distribution of various types of facilities (administrative, educational, sanitary, security, industrial, sports, etc.)

we observed that:

Several essential facilities (especially sanitary and industrial) are located near the valley, which exposes them to the risk of sudden flooding,

Other important facilities, such as educational and service institutions, are situated in relatively low areas toward the southeastern part near the valley, which could result in functional disruption of these infrastructures in the event of water overflow or flooding.

Table N6: Facilities in Land Use Plan N°=07A

Surface	Type of Equipment	Name of Equipment	Num
59514	Service	Ground Transportatin state	1
30800	Sanitary	hospital orthopedics	2
26112	Industry	samsung	3
21101	Security	Civil protection	4
17626	Security	Police station	5
15059	Sanitary	National Institute of Paramedical Training	6
10972	Service	Moda Love mall	7
8219	Sports	swimming pool and skating rink	8
8178	Service	National Security Hotel	9
7147	Service	Hotel	10
6793	Service	Library public reading	11
4392	Service	Association	12
3666	Sports	Aqua gym stangoula	13
2416	Administ	House of environement	14
2345	Educativ	school	15
2133	Administ	House of Traditional Industry	16
2058	Service	S P I for the Management of Landfill Centers	17

Fig N41:Aqyua Gym stangoula

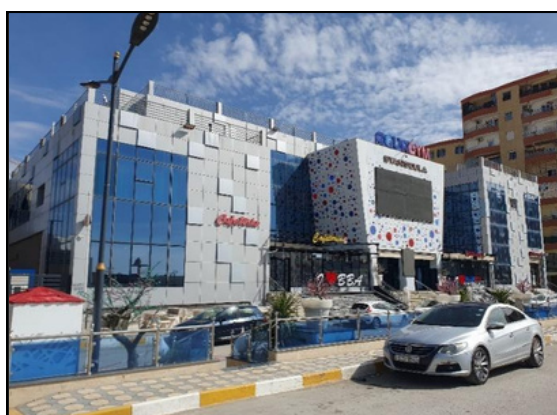


Fig N42: Transportatin state



Fig N43 : S P I for the Management of Landfill Centers



Fig N44 :Samsung



Fig N45:Hotel



Fig N46: hospital orthopedics



Took by the student-2025

## Unbuilt Framework:

### Road Network:

National Road No. 05: It borders the land use plan from the northern side.

Fig N47: National Road No. 05



Took by the student-2025

National Road No. 45: It borders the land use plan from the eastern side.

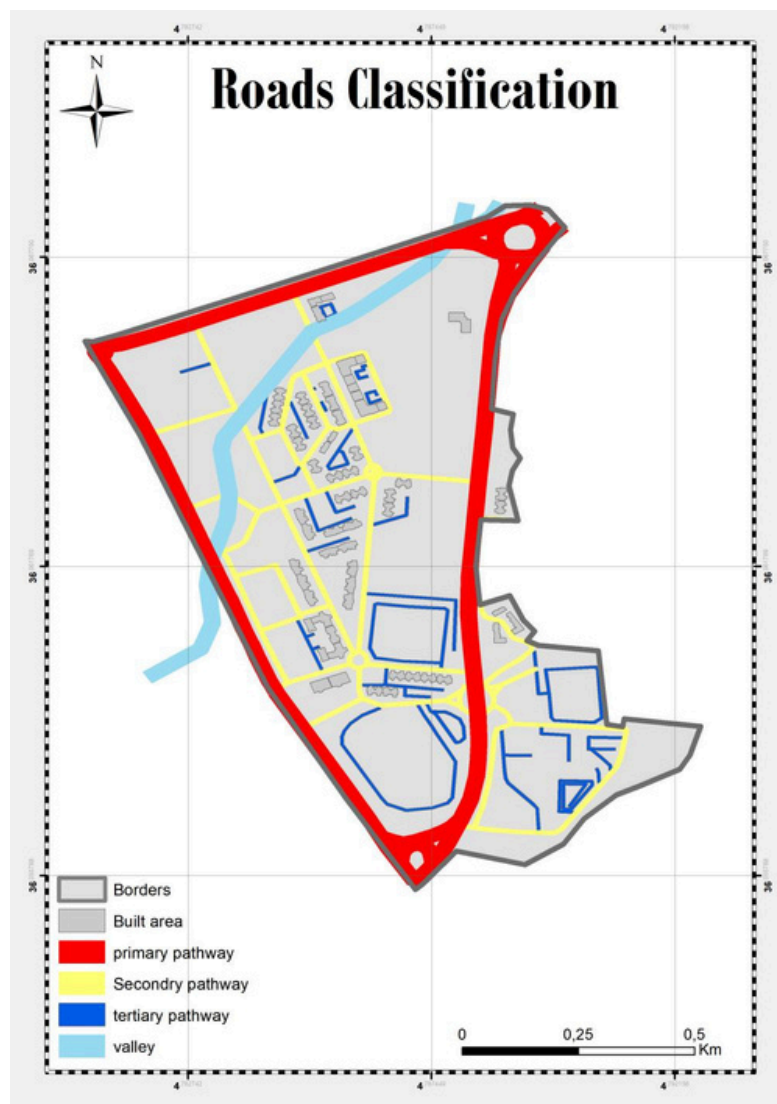
Fig N48: National Road No. 45



Took by the student-2025

The provincial road number 42: The land use plan is bounded on the western side.

Fig N49: Classification of roads in the study area.



Prepared by the student-2025

Table N7 :Roads classification inLand Use Plan N°=07A

	Lentgh	Area (ha	Conditions
Primary pathway	97.11	11.86	<b>Good</b>
Secndry pathway	11.75	6.06	<b>Medium</b>
Tertiary pathway	9.75	1.8	<b>Good</b>

Fig N50: Secndry pathway



Fig N51: Tertiary pathway



Took by the student-2025

### "Green Spaces:

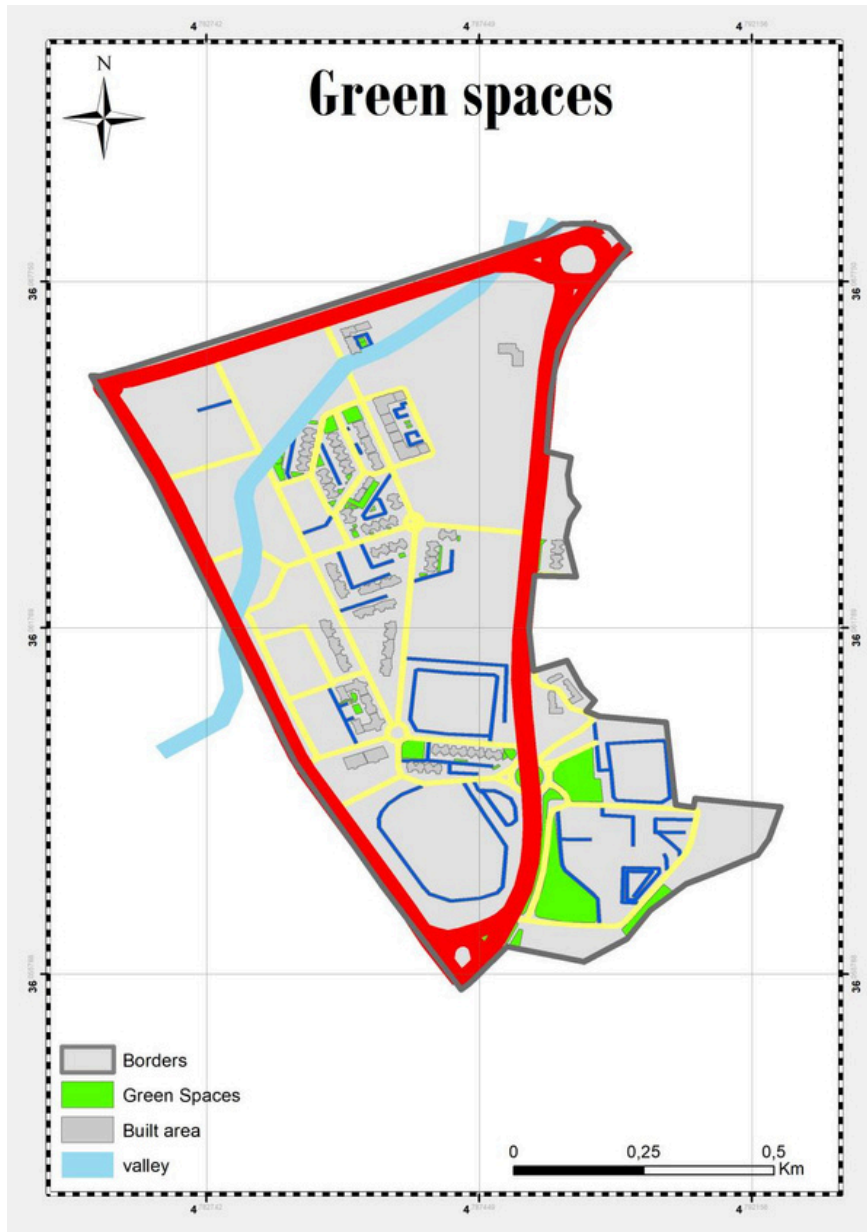
Green areas occupy a portion of the total land area, but their distribution within the land use plan is irregular and unbalanced."

Fig N52: Green Spaces



Took by the student-2025

Fig N53: Green Spaces in the study area



Prepared by the student-2025

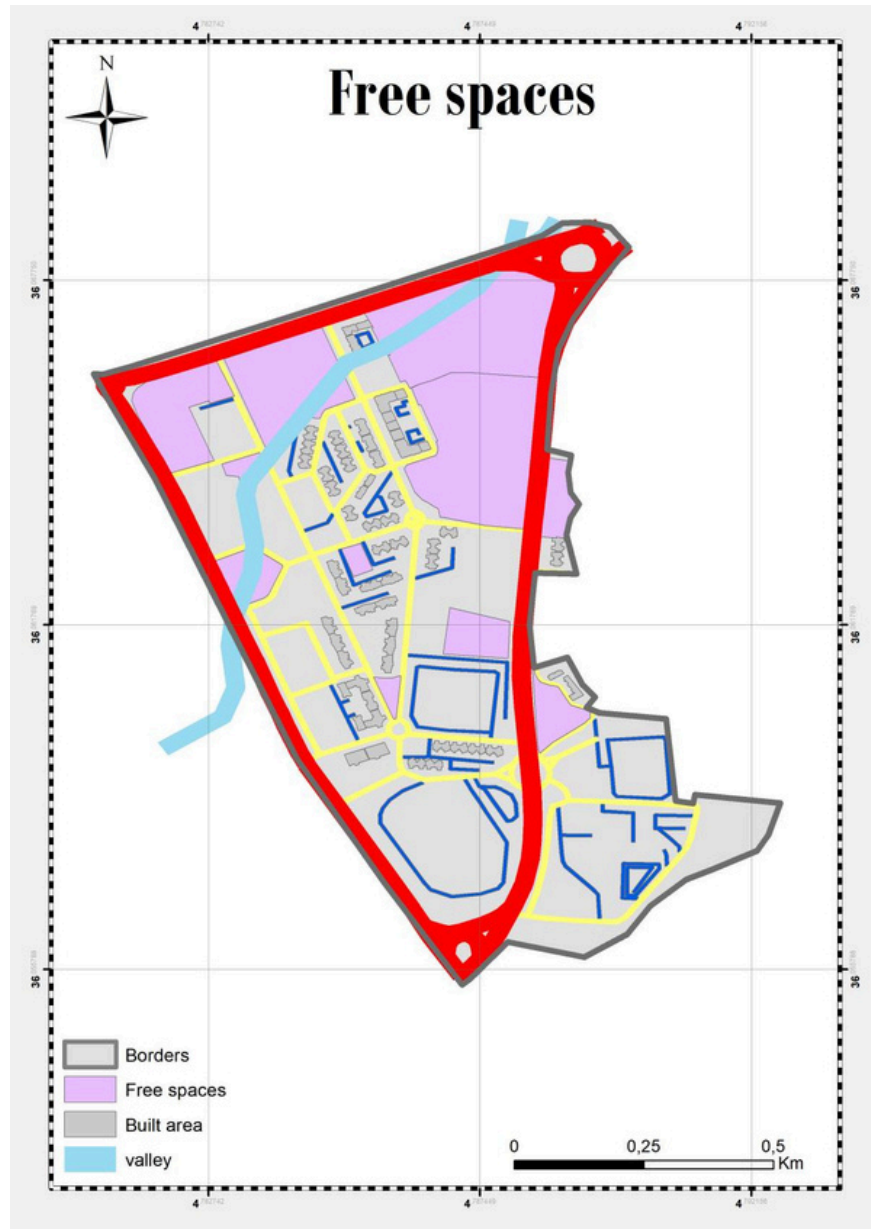
The map illustrates the distribution of green spaces within in the land use plan,we observe that These spaces appear sparse, fragmented, and relatively small in size.

Moreover, most of the green spaces lack proper planning and infrastructure, failing to function as effective recreational or ecological zones. This issue is particularly evident in the eastern section of the area,

The absence of well-designed and functional green spaces poses a challenge in terms of sustainable urban development and Risk management.

**Free spaces:**

Fig N54: Free Spaces in the study area.



Prepared by the student-2025

Fig N55: Free Spaces



Took by the student-2025

Fig N56: Free Spaces



Took by the student-2025

**Play Areas:**

The availability of play areas is very limited, to the point that they are almost non-existent

Fig N57: playground



Took by the student-2025

**Parking Spaces:**

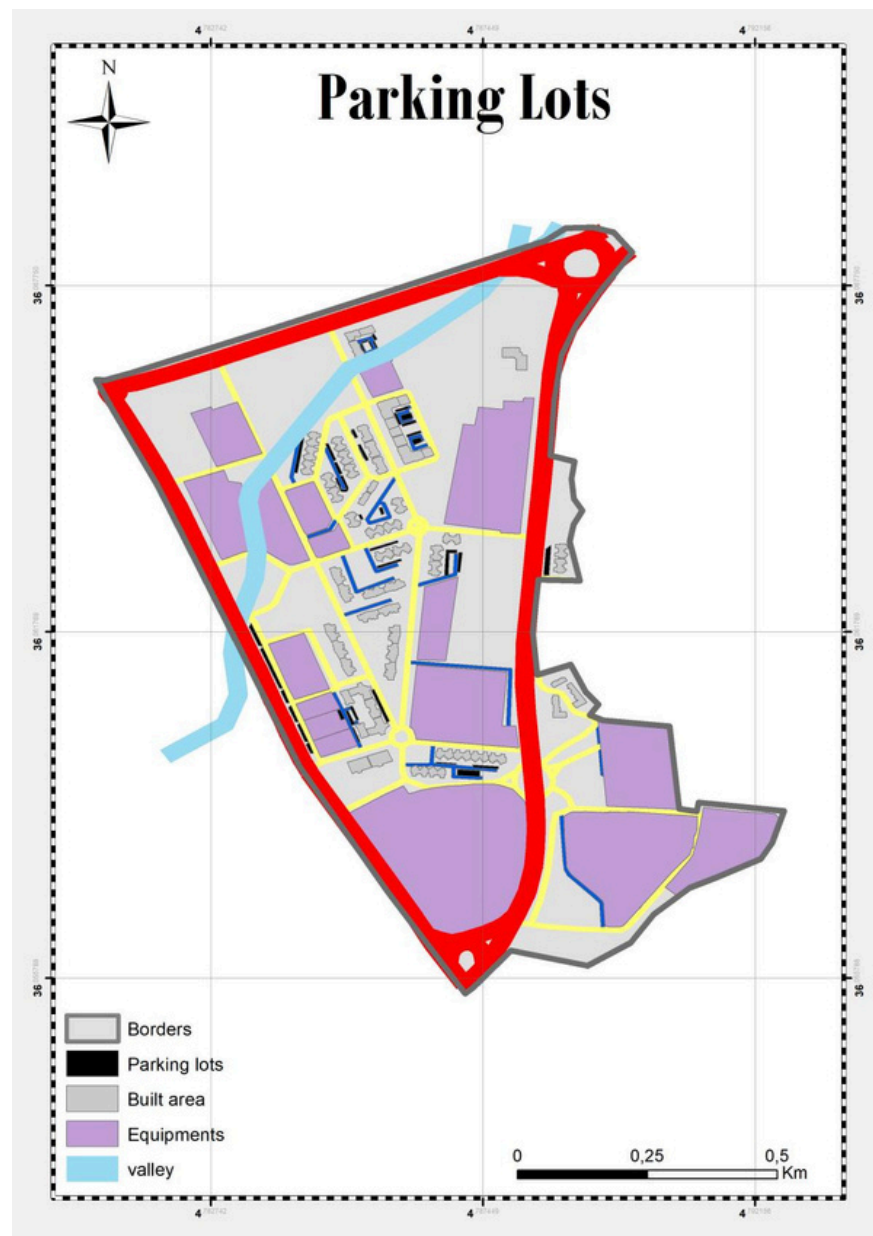
The land use plan includes both perpendicular and parallel parking spaces, some designated for residential units and others for facilities. These parking areas are sufficient and functional in terms of capacity and accessibility."

Fig N58: Parking Lots



Took by the student-2025

Fig N59: Playgrounds and Parking Areas



Prepared by the student-2025

### Sidewalks:

Sidewalks are a fundamental component of urban infrastructure, playing a vital functional role in organizing pedestrian movement and ensuring their safety within the urban space. That sidewalks are well-prepared and exhibit engineering and architectural features that meet standards of comfort and safety, making them accessible to various segments of society, including children, the elderly, and persons with special needs.

The good condition of these sidewalks reflects a significant effort by the relevant authorities in their planning and maintenance. It also highlights a growing awareness of the importance of developing urban facilities in line with the principles of sustainable urban planning.

However, some sidewalks in other areas remain poorly maintained or inadequately designed.

Fig N60: Sidewalks in abad condition



Fig N61: Sidewalks in abad condition



Fig N62: Sidewalks in a good condition

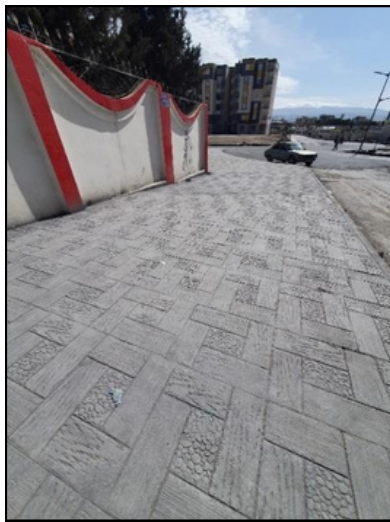
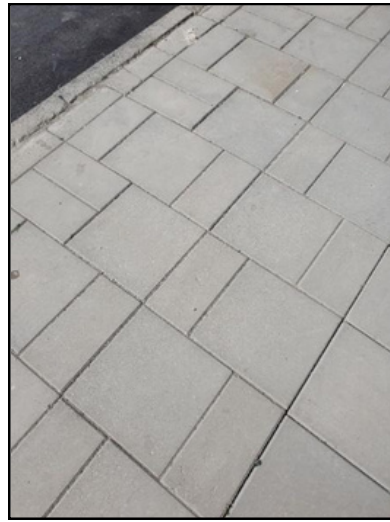


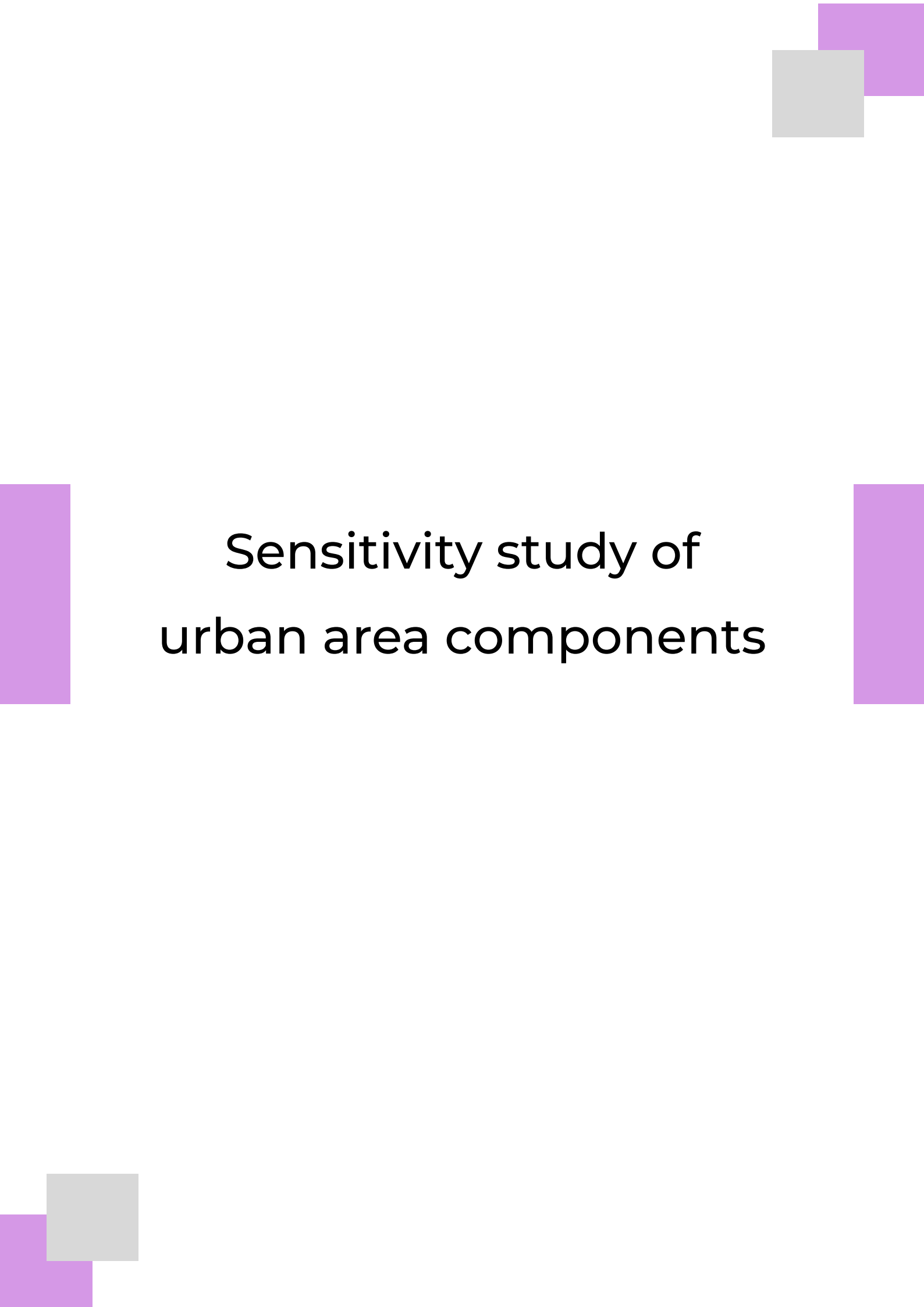
Fig N63: Sidewalks in agood condition



Took by the student-2025

**Conclusion:**

The analysis of Land Use Plan No. 07 using Geographic Information Systems and ArcGIS software has proven effective in understanding the spatial distribution of built and non-built areas, enabling a more precise diagnosis of the existing urban structure. Beyond its value in supporting planning and development decisions, this type of analysis is a fundamental tool for risk assessment, particularly in relation to urban hazards such as flooding or unregulated spatial expansion. By adopting this geographic approach, it becomes possible to identify vulnerable zones and propose more accurate and realistic preventive measures.

The page features a minimalist design with four decorative squares in the corners: a purple square in the top-right, a grey square in the top-right overlapping the purple one, a purple square in the bottom-left, and a grey square in the bottom-left overlapping the purple one. The main text is centered in a large, black, sans-serif font.

# Sensitivity study of urban area components

**Introduction:**

This study will focus on analyzing the elements related to flood risk within the scope of Land Use Plan No=07A, including soil type, which affects infiltration capacity and surface runoff, wadi characteristics such as slope and course, as well as the hydrological history of the wadi, including previous floods and their frequency. Based on this analysis, a sensitivity map will be produced to illustrate the vulnerability of both buildings and infrastructure, providing an accurate visualization of the most exposed areas and enabling the implementation of appropriate preventive measures.

## 1. Hazard Study:

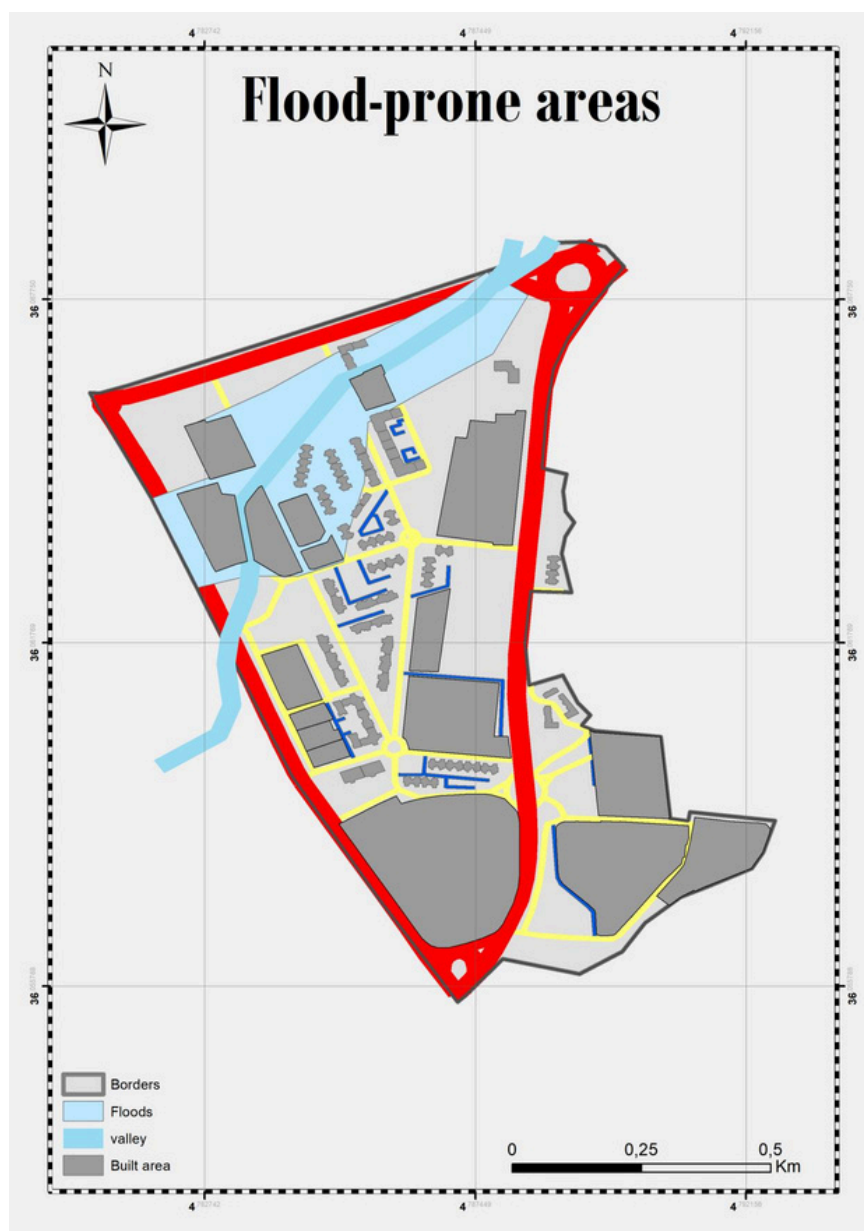
The study of any natural hazard and the vulnerability of humans and the environment to it, through Geographic Information Systems (GIS), involves two fundamental stages:

The study of the hazard source and the challenges associated with it, From this, it becomes possible to assess vulnerability and classify it accordingly.

### Flood History in the City of Bordj Bou Arréridj:

On September 23, 1994, floods occurred in the municipality of Bordj Bou Arréridj, affecting the four main rivers. The event caused significant human losses, with 16 fatalities, and considerable material damage, with approximately 800 houses damaged.

Fig N64: Flood prone AREAS in study Area



Prepared by the student-2025

Fig N65: Flood Disasters



Civil Protection 2020

Fig N66: Flood Disasters



Civil Protection 2020

### Boumergued valley:

Boumergued valley, located on the eastern side of the city, originates from Hassenaoua–Bir Sanoub and extends to the eastern exit of the city, near the 17 October neighborhood, covering a length of approximately 10 km. It represents a constant flood risk to the area. The catchment area of Wadi Boumergued spans 63.77 km<sup>2</sup>, making it the largest drainage basin within the city."

Fig N67: Boumergued valley



Civil Protection 2020

Fig N68: Boumergued valley



Civil Protection 2020

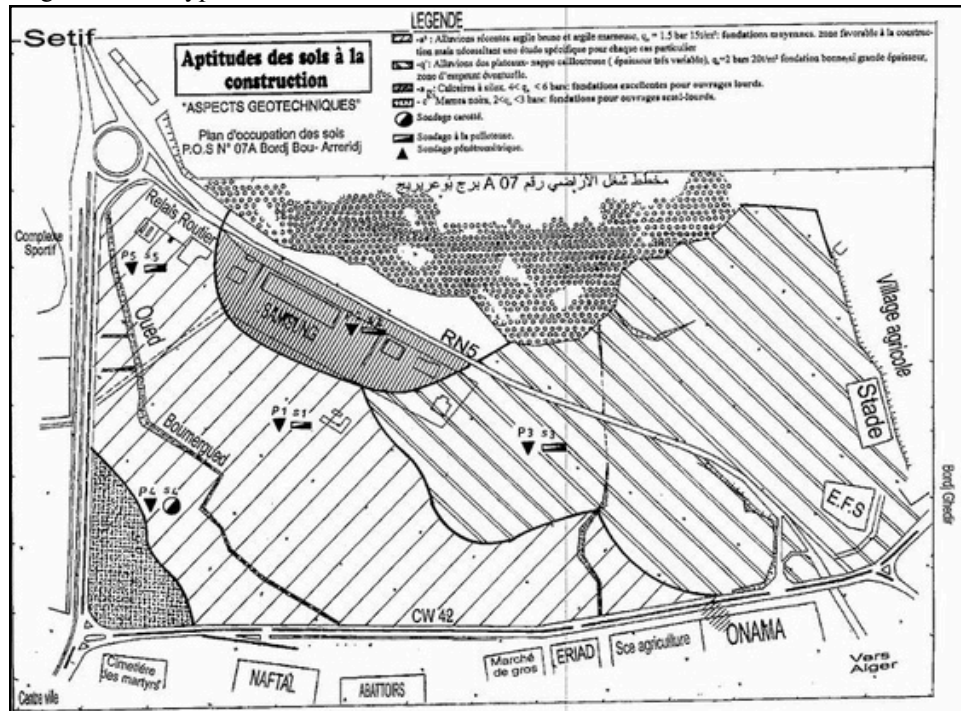
### Soil type:

This geotechnical map from the municipality of Bordj Bou Arreridj (P.O.S n°07A) shows soil types for building. It looks at the soil's physical and mechanical traits. The map divides soils into recent low-resistance alluvium (a1), terrace alluvium with good bearing capacity (a2), solid limestone (c1), and marly soil (m).

Marly soil is best for light buildings. Soil investigation points (S1 to S5) were found through drilling and probing. This helps us understand soil quality.

Knowing soil quality is key for choosing the right foundations. This is especially true near Highway A07 and National Road RN5. These areas have service stations, markets, and industrial zones. These data are crucial for urban planning. They help reduce geotechnical risks and keep structures safe.

Fig N69:Soil Type



POS report

### Topography:

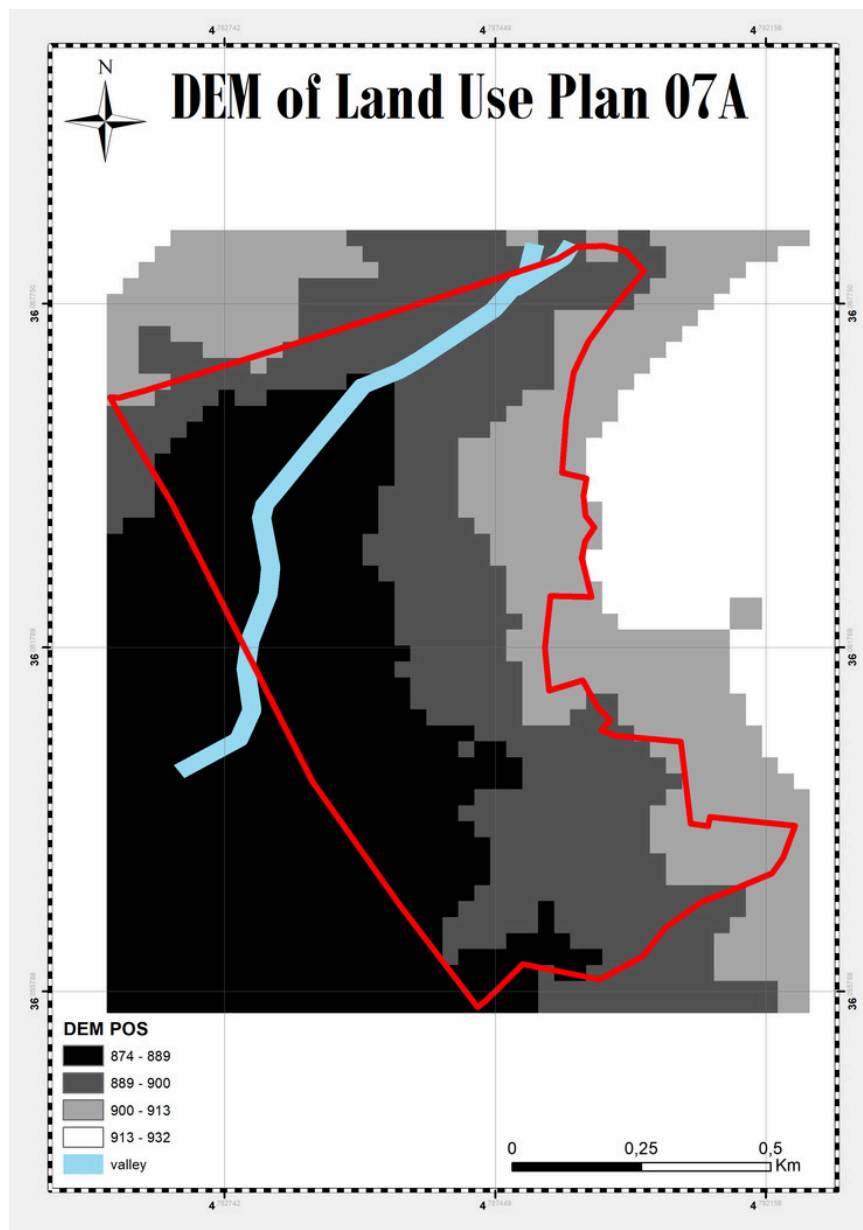
The longitudinal and cross-sectional profiles conducted in the study area revealed an uneven terrain, characterized by several slopes, particularly from the northeast to the southwest, which aligns with the path of the wadi. This topographic gradient contributes to the acceleration of surface runoff and flash floods toward the downstream areas, thereby increasing the flood risk in low-lying zones along this flow direction.

Fig N70: Croos section of the valley



Google Earth Pro

Fig N71:DEM of Land Use Plan 07A



Prepared by the student-2025

This map displays the Digital Elevation Model (DEM) of the study area, which is a digital topographic representation highlighting variations in land elevation with precision. This model is a fundamental tool for analyzing flood-related risks, as it illustrates how surface water is naturally drained and the direction of flow.

The highest point in the area is located at an elevation of 900 meters above sea level, situated in the upper part of the map, indicating elevated terrain such as hills or plateaus.

The lowest point reaches 874 meters, located in the lower part of the map, representing a low-lying area that likely forms the endpoint of surface runoff or a wadi outlet.

The elevation difference between these two points is 26 meters, indicating a natural slope that facilitates water flow from higher to lower elevations.

sk management plans

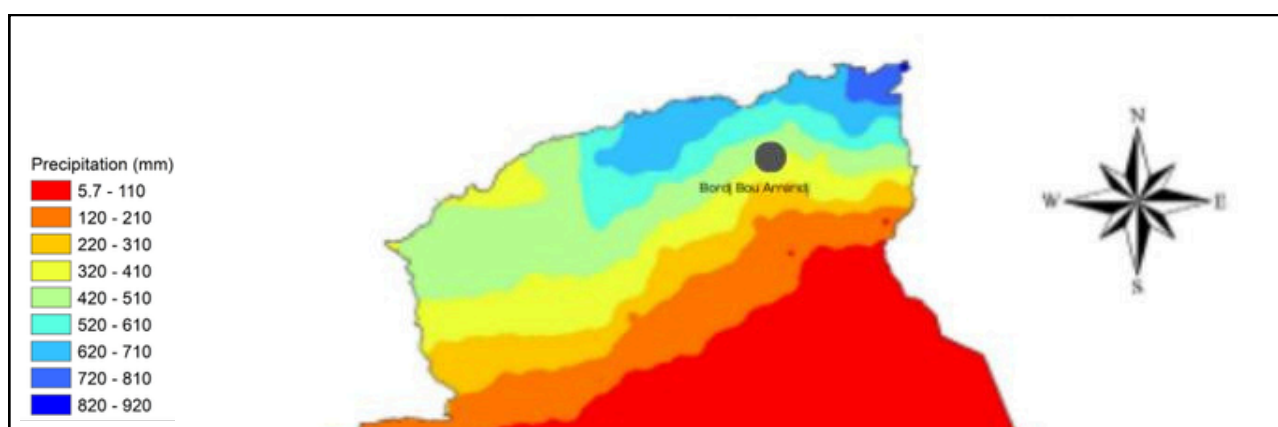
The direction of wadi flow follows this slope—from the elevated areas (900 m) down to the lower zones (874 m)—which corresponds to the natural drainage pattern during rainfall events. This gradient increases the likelihood of water accumulation or flooding in the downstream areas.

Understanding this topographic gradient is essential for identifying high-risk zones, particularly residential areas or facilities located near depressions or along watercourses, which may require appropriate preventive measures within flood risk management plans

### **Precipitation:**

Oued Boumergued is one of the main seasonal watercourses in the city of Bordj Bou Arréridj, and it represents a sensitive point in terms of the flood risk to the surrounding area. Although the stream remains dry for most of the year, the sharp increase in rainfall over short periods—especially during the autumn and winter causes it to quickly turn into an active watercourse, carrying large volumes of runoff from the surrounding highlands and nearby areas. The danger posed by Oued Boumergued lies in the nature of rainfall in the city, which often involves sudden and intense downpours, sometimes exceeding 30 to 50 mm in less than an hour. This leads to soil saturation and an increase in surface run off that surpasses the stream's drainage capacity. Consequently, the valley overflows, causing water to flood nearby residential neighborhoods, particularly due to unregulated urban expansion along its banks and the lack of appropriate urban planning within the stream's natural corridor. Therefore, the relationship between short-duration intense rainfall and the sudden activation of Oued Boumergued is among the key indicators of the area's vulnerability to flooding. This highlights the urgent need for accurate monitoring of rainfall data and proper management and planning of the stream's course to reduce future flood risks.

Fig N72: Precipitation in Bordj Bou Arreridj



**Type of vegetation cover:**

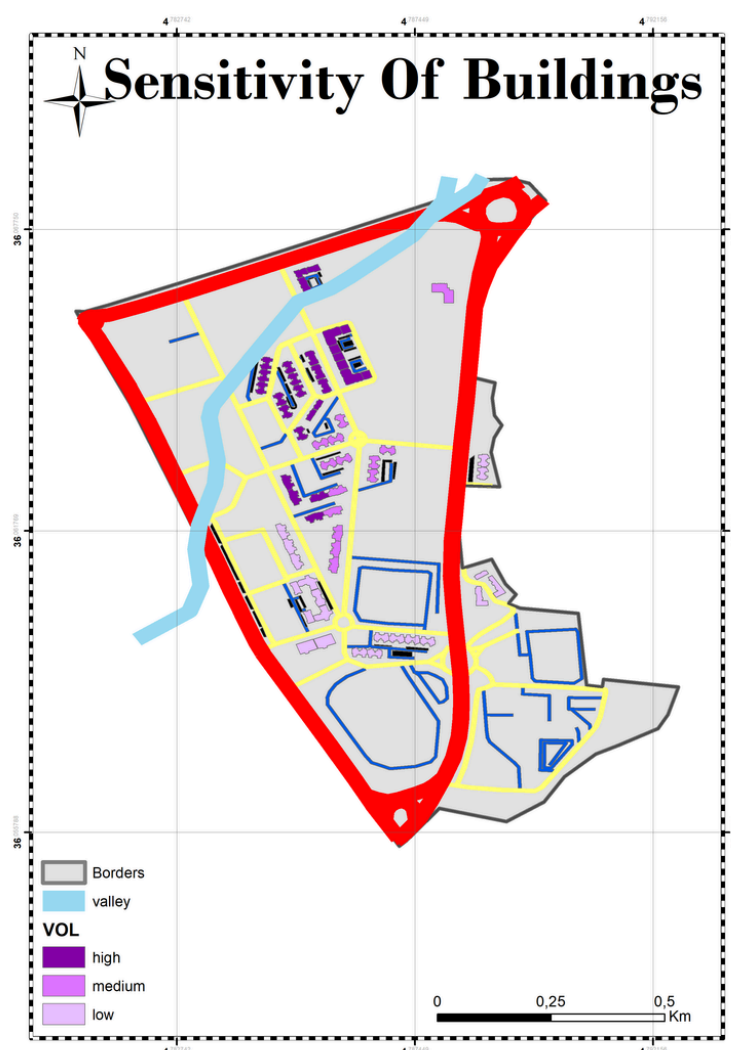
Thick, healthy vegetation protects the valley's soils, regulates water, reduces flooding, supports life, and keeps the valley stable.

Sparse or degraded vegetation makes valleys more vulnerable to erosion, floods, and ecological degradation.

## Sensitivity study of urban area components

As a part of the flood risk assessment, and after the analyse of both hazards (alea), that represented by flood intensity and probability by analysing all of those elements:DEM, precipitation,soil type,vegetation,Proximity to the wadi and Flood History in the City of Bordj Bou Arréridj+ in POS07A, and the challenges (enjeux), which included residential buildings and classified establishments within the study area. Each component was evaluated separately based on quantitative and qualitative criteria such as the number of units, surface area, type of activity, or population density. Then, both the danger and the challenges were overlaid on the same map using Geographic Information Systems (GIS), which enabled the creation of a sensitivity map. This map highlights the level of exposure of housing and classified institutions to flood risks, serving as an effective tool to identify sensitive areas that require priority interventions or preventive measures to protect lives and property.

Fig N73:Sensitivity of Buildings

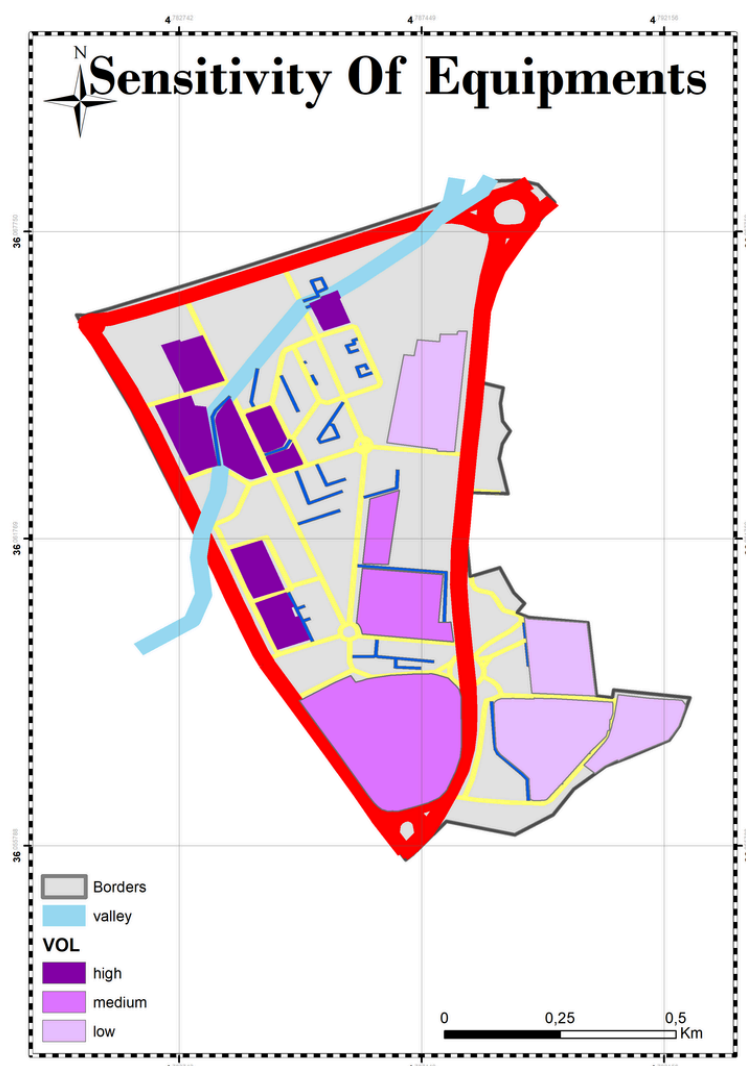


Prepared by the student-2025

### Sensitivity of Buildings:

The map illustrates the distribution of flood sensitivity for buildings within the POS 7A area, based on several criteria including slope, elevation, and proximity to watercourses. The color representation reveals that high-sensitivity areas are concentrated near the wadis, particularly in the southeastern part of the study area, where high population density intersects with topographical weakness and the absence of adequate drainage infrastructure. In contrast, areas located on higher ground or within well-planned urban zones show relatively low sensitivity. These findings highlight the importance of integrating risk considerations into urban policies to ensure safe and sustainable urban development.

Fig N74: Sensitivity of Equipments



Prepared by the student-2025

### Sensitivity of Equipments:

The Equipments sensitivity map in the POS 7A area illustrates the exposure level of key public and private infrastructures to flood risks, based on factors such as topographic location, proximity to watercourses, and the quality of surrounding infrastructure. The analysis reveals that some facilities fall within high-sensitivity zones, making them more vulnerable to damage in the event of flooding.

The following facilities are considered high-priority (first-degree) infrastructures and appear in sensitive zones on the map:

- National Security
- Hotel
- Moda Love Mall
- Swimming Pool and Skating Rink
- House of Traditional Industry
- House of Environment
- SPI for the Management of Landfill Centers
- Library of Public Reading
- Association
- School
- Aqua Gym Stangoula

These facilities are distributed across areas with varying sensitivity levels; however, the presence of several of them in high-risk zones particularly near wadis or in low-lying areas highlights the need for serious assessment of their protection . It is recommended to adopt preventive measures such as elevating structures, improving drainage systems, and updating emergency response plans to ensure the continuity of these essential services during flood events.

## 2. Phase of Precautionary and Preventive Measures:

This phase focuses on reducing flood-related risks through proactive planning and intervention. It involves evaluating potential natural hazards and integrating these risks into urban and land-use planning.

- **Urban Planning and Land Use:** Incorporating risk assessments into decisions about where to build, especially avoiding flood-prone areas. The main preventive actions include:
- **Environmental Protection:** Maintaining natural watercourses, preventing erosion, and addressing surface cracks and water infiltration.
- **Warning and Communication:** Setting up local alert centers and early warning systems to inform the public, supported by multiple contingency plans.
- **Evacuation Planning and Public Education:** Preparing evacuation strategies and educating residents on safe behaviors during floods.
- **Local Involvement:** Forming local committees and using local media to raise awareness.
- **Mapping and Documentation:** Creating cartographic documents that identify at-risk zones and the structure of the water drainage network.
- A key tool in this phase is the **PPRI Flood Risk Prevention Plan**, which are official documents in France and some francophone regions that identify flood-prone areas and regulate land use to prevent exposure to flood risks. These plans are essential for integrating flood risk considerations into urban development.

## 3. Phase of Intervention and Relief Measures:

This phase relies heavily on the brisk implementation of precaution and preparedness strategies including emergency planning, isolation of sectors, public warning, directing residents into shelters, mobilising and evacuating residents, de-occupying homes, and protecting the economic, cultural, and social assets that are at risk.

Field intervention and therefore disaster relief management involves at least the following operations:

- Search and rescue, medical aid Efficient delivery and distribution of equipment and resources
- Coordination of civilian and military reaction units based on task definition.

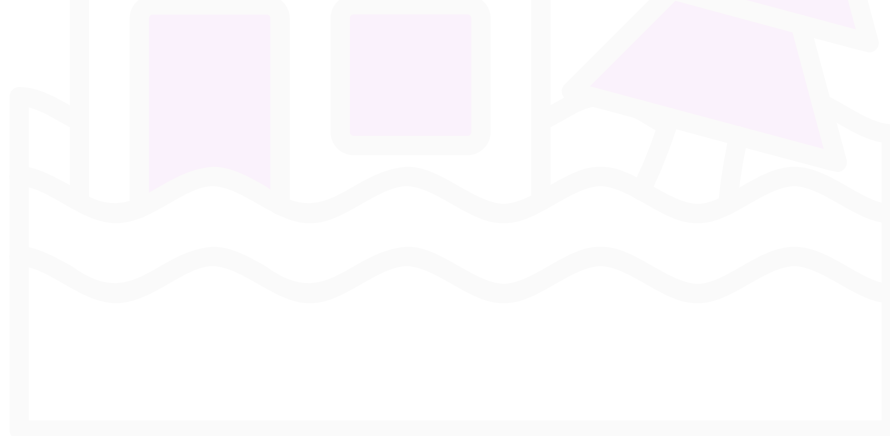
This phase will require the use of a suite of tools, particularly Geographic Information Systems (GIS), in order to manage spatial data; this will involve the following:

- Improve and integrate different early warning systems
- Administrative limitations, integrate early warning systems with GIS systems in order to develop systematic capabilities for monitoring and tracking risk to people and their assets

In this context, the **Flood Risk Prevention Plan (PPRI)** serves as a key reference for identifying high-risk areas, facilitating precise field decisions during interventions such as guiding relief teams, organizing evacuations, and distributing resources based on risk priority.

### General Conclusion:

In conclusion, the analysis conducted in this thesis highlights the necessity of integrating hydrological and morphological factors into urban development strategies, particularly within the rapidly expanding POSN°=07A zone in the municipality of Bordj Bou Arréridj. The catastrophic flooding of September 24, 1994 which resulted in 16 deaths and damage to over 800 homes due to the overflow of four wadis demonstrated that while natural causes may initiate such events, the scale of the disaster is largely influenced by inadequate urban planning and the absence of risk-informed land use policies. This study, centered on POSN°=07A, a zone characterized by intense housing demand and uncontrolled spatial expansion, utilizes field investigations and cartographic analyses to identify sources of hazard, vulnerable sectors, and exposure areas, with close attention to the region's morphological and hydrological features. The development of a flood sensitivity map offers a concrete tool for decision-makers to formulate targeted, evidence-based anti-flood strategies. Additionally, the **Flood Risk Prevention Plans (PPRI)** play a crucial role in this process by delineating high-risk areas and regulating land use according to hazard levels, thereby enhancing the effectiveness of preventive interventions and safe urban planning. Ultimately, the findings advocate for the implementation of sustainable urban protection measures including robust drainage systems, the preservation of non-buildable zones, and land management approaches that integrate natural processes and risk awareness to ensure long-term resilience and safety in urban expansion.



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الحمد لله الذي بنعمته تتم الصالحات

"Praise be to Allah, by whose grace good deeds are completed."