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« Causes and Consequences of The Exceptional Spatial Development of Chlef City or The Extraordinary Impact of Major Risks »

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Abstract

The spatial development of cities is a universal phenomenon influenced by several reasons, depending on the city's location and urban policy. Therefore, City planners need to manage urban expansion in a manner that aligns with the city's overall framework and enhances the living standards of its residents without posing any risks. This research project aims to shed light on the causes and consequences of the exceptional spatial developments of Chlef City. Additionally, this thesis explores the extraordinary impacts of the major risks posed by earthquakes and their relationship with the continuing urban expansions in the vulnerable Chlef. This research data was gathered by utilizing remote sensing technology to observe and analyze the urban expansion of Chlef City across various periods, and these rapid expansions have been correlated to historical events of seismic hazards and demographic data of the city. The causes that contributed to these expansions, which were discussed in this study, included the effects and impacts of the post-earthquake political decisions on the physical reconstruction of the city, and the economic aspect related to the costs associated with this process, as well as the subsequent influx of migrants into Chlef, which became an attractive area for the population. The results of these spatial developments have led to the emergence of various housing patterns, including prefabricated, current, and slum dwellings, as well as urban sprawl at the expense of agricultural land. All of these findings underscore the importance of collaboration among urban policy decision-makers, city planners, economic planners, and sociologists to devise effective strategies that take into account and address the recurrence of this phenomenon in the future. It also emphasized that careful planning is important to mitigate the vulnerability of Chlef City and make it more resilient to seismic hazards.

Keywords: Impacts, Risks, Spatial development, Urban expansion, Urban sprawl, Vulnerable.

Résumé

Le développement spatial des villes est un phénomène universel influencé par plusieurs raisons, en fonction de l'emplacement de la ville et de la politique urbaine. Par conséquent, les urbanistes doivent gérer l'expansion urbaine d'une manière qui s'aligne sur le cadre général de la ville et améliore le niveau de vie de ses résidents sans poser de risques. Ce projet de recherche vise à mettre en lumière les causes et les conséquences des développements spatiaux exceptionnels de la ville de Chlef. En outre, cette mémoire explore les impacts extraordinaires des risques majeurs posés par les tremblements de terre et leur relation avec les expansions urbaines continues dans la ville vulnérable de Chlef. Les données de cette recherche ont été recueillies en utilisant la technologie de la télédétection pour observer et analyser l'expansion urbaine de la ville de Chlef à travers différentes périodes, et ces expansions rapides ont été corrélées avec les événements historiques des risques sismiques et les données démographiques de la ville. Les causes qui ont contribué à ces expansions, qui ont été discutées dans cette étude, comprennent les effets et les impacts des décisions politiques post-séisme sur la reconstruction physique de la ville, et l'aspect économique lié aux coûts associés à ce processus, ainsi que l'afflux ultérieur de migrants à Chlef, qui est devenue une zone attrayante pour la population. Les résultats de ces développements spatiaux ont conduit à l'émergence de différents types de logements, y compris les préfabriqués, les habitations courantes et les bidonvilles, ainsi qu'à l'étalement urbain au détriment des terres agricoles. Toutes ces constatations soulignent l'importance de la collaboration entre les décideurs en matière de politique urbaine, les urbanistes, les planificateurs économiques et les sociologues afin de concevoir des stratégies efficaces qui prennent en compte et traitent la récurrence de ce phénomène à l'avenir. Elles soulignent également l'importance d'une planification minutieuse pour atténuer la vulnérabilité de la ville de Chlef et la rendre plus résiliente aux risques sismiques.

Mots-clés : Impacts, Risques, Développement spatial, Expansion urbaine, Étalement urbain, Vulnérable.

الملخص

التنمية المكانية للمدن ظاهرة عالمية تتأثر بعدة أسباب، تبعاً لموقع المدينة وسياساتها الحضرية. ولذلك، يحتاج مخطوطو المدن إلى إدارة التوسع الحضري بطريقة تتماشى مع الإطار العام للمدينة وتعزز مستويات معيشة المقيمين فيها دون أن تشكل أي مخاطر. يهدف هذا المشروع البحثي إلى إلقاء الضوء على أسباب ونتائج التطورات المكانية الاستثنائية لمدينة الشلف. وبالإضافة إلى ذلك، تستكشف مذكرة التخرج هذه الآثار الغير العادية للمخاطر الرئيسية التي تشكلها الزلازل وعلاقتها بالتوسعات الحضرية المستمرة في الشلف الهشة. وقد جمعت هذه البيانات البحثية باستخدام تكنولوجيا الاستشعار عن بعد لرصد وتحليل التوسع الحضري لمدينة الشلف على مدى فترات مختلفة، وترتبط هذه التوسعات السريعة بالأحداث التاريخية للأخطار الزلزالية والبيانات الديمغرافية للمدينة. حيث شملت الأسباب التي أسهمت في هذه التوسعات، والتي نوقشت في هذه الدراسة، لآثار و تأثيرات القرارات السياسية التي أتخذت بعد الزلزال من إعادة البناء المادي للمدينة، والجانب الاقتصادي المتعلق بالتكاليف المرتبطة بهذه العملية، فضلاً عن تدفق المهاجرين بعد ذلك نحو الشلف، والتي أصبحت منطقة جذابة للسكان. وقد أدت نتائج هذه التطورات المكانية إلى ظهور أنماط إسكان مختلفة، بما في ذلك المساكن الجاهزة والراهنة والأحياء الفقيرة، فضلاً عن التوسع الحضري على حساب الأراضي الزراعية. وتؤكد مجمل هذه النتائج أهمية التعاون بين صانعي القرارات في مجال السياسات الحضرية، ومخططي المدن، والمخططين الإقتصاديين، وعلماء الاجتماع لوضع إستراتيجيات فعالة تأخذ في الإعتبار تكرار هذه الظاهرة في المستقبل وتتصدى لها. كما شددت أيضاً على أن التخطيط الدقيق مهم للتخفيف من هشاشة مدينة الشلف وجعلها أكثر قدرة على مواجهة الأخطار الزلزالية.

الكلمات المفتاحية: الآثار، المخاطر، التنمية المكانية، التوسع الحضري ، الزحف الحضري ، الهشاشة.

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List of Abbreviations:

ANAT: «Agence Nationale d'Aménagement du Territoire» meaning "National Agency for Territorial Planning" in Algeria.

CTC: «Contrôle Technique de la Construction» meaning "Construction Technical Control" in Algeria .

DEM: Digital Elevation Model.

D.U.C.H: «Direction de l'Urbanisme et de la Construction et de l'Habitat » meaning "Direction of Urban Planning and Construction and Habitat" in Algeria.

DZD: "Dinar Algerian" is The currency code for Algerian unit of money.

GIS: Geographic information system.

GPD: Gross Domestic Product.

IBID: From the Latin « ibidem » meaning "in the same place" which means referring to the previous citation.

LULC: Land Use and Land Cover.

NO.: Number.

N°: Number.

ONS: «Office National des Statistiques» meaning "National Office of Statistics" in Algeria.

PDAU: «plan directeur d'aménagement et d'urbanisme» meaning "Master Plan for Development and Urbanism (MPDU)".

USGS: United States Geological Survey.

UTM: Universal Transverse Mercator.

UTC: Coordinated Universal Time.

WGS : World Geodetic System .

General Introduction:

The beginning of the first decade of the twentieth century was the point of change that the entire world witnessed because it changed the way of life in most countries. Since humans have been living in a rural way, they have now become civilised settlements living in cities. This urbanisation is still rising over time. This makes cities continue to grow both in terms of population and spatial development, which we mean to increase the physical size of cities. It was noted that, in most cases, the increase in the constituted percentage of the population was accompanied by a further increase in the percentage of urban areas, as the United Nations reported in "**World Urbanization Prospects 2018**" that more people are living in urban than in rural areas, where 55% of the world's population was present in urban areas, and that proportion was expected to rise to 68%, i.e. there could be about 2.5 billion more people in those areas by 2050, meaning that urbanisation was taking place at a rapid pace, 90 % of this increase will occur in both Asia and Africa (United Nations, 2019) .

This expansion may take several forms, including the exceptional form of what is known as "urban sprawling", which creates urban agglomeration ¹. This phenomenon is a problem for all countries of the world, whether developed or developing. The reasons for their occurrence, however, vary from place to place and it can be because of migration in search of jobs or because of personal lifestyle preferences, etc.

Due to these diverse reasons, my research will shed light on both the causes and consequences of the exceptional spatial development of risk ² areas, known to be areas of

¹ **urban agglomeration** identified by (United Nations, 2019): "*contiguous territory inhabited at urban levels of residential density*".

² According to the definition of (Birkmann, 2013) **risk** is: "*The specific risk of an element exposed (e.g., human life, house, infrastructure services, etc.) is seen as a product of the interaction of a hazard (e.g., floods, landslides, etc.) – including its probability and magnitude – and the vulnerability of the element exposed*", that mean ($risk=hazard*vulnerability$).

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population expulsion in most cases, whether these risks are natural hazards, such as earthquakes, floods, landslides, etc., or industrial hazards, such as pollution and chemical explosions, etc. However, I chose to focus my thesis on studying the urban development over time in Chlef City, which is considered a vulnerable ³ area because it is located in a seismic region, yet there is also notable urban expansion occurring at the same time in it. This has given me the desire to carry out this study so that I can find out the reasons behind this phenomenon and draw its consequences.

³ The (UNDRR, 2007) has identified ***vulnerability*** as: "*The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards*".

Introduction

1. Research Problem and Aims:

Urban development is of paramount importance to city planners. Most extensive scientific research has examined this issue, analysing how it develops across time and space, its causes, and its impact on cities, to guide urban expansion in a manner consistent with the city's framework and improve the living standards of its residents. However, most of these studies focused mainly on how urban expansion expands and its consequences, more than on its root causes, particularly in areas vulnerable to natural disasters, such as earthquakes. To address this research gap, my study aims to deepen the root causes of urban expansion in earthquake-prone areas and find out the consequences obtained as a result of these causes. My analysis focuses precisely on the agglomeration of the city of Chlef, Algeria.

2. Thesis Objective:

The object of this study is:

1. To determine both the causes and the consequences of this extraordinary urban expansion in Chlef City.
2. To identify the impacts of the earthquake threat to which the region is frequently exposed and its relationship with the urban expansion of the agglomeration of Chlef.
3. To find and recommend potential solutions to this phenomenon.

3. Thesis Questions:

To proceed, we ask the following questions to respond to them in our thesis:

- **The main question :**

- A. Why is the Chlef City experiencing continuous urban expansion, despite its presence in a seismic geographical area? And what are the consequences of this phenomenon?

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- **Secondary questions :**

- B. How do seismic hazards impact Chlef City?
- C. How can the challenge of Exceptional urban expansion in seismic Chlef be radically resolved or made an acceptable risk?

4.Thesis Assumptions:

Based on the earlier questions asked, we have come up with the following hypotheses that we will validate through our study:

- a) Chlef City, which is located in a seismic zone, has a unique pattern of urban expansion that can be attributed to several causes such as:
 - ✓ The repeated urban reconstruction due to repeated earthquakes over time and space.
 - ✓ Migration resulting from post-earthquake benefits in terms of providing social and economic opportunities.
 - ✓ Demographic growth and availability of land for real-estate development.
- b) The consequences of this urban development and the potential impacts of an earthquake on urban expansion are reflected in:
 - ✓ Unplanned urban expansion led to slums and low living standards.
 - ✓ Increasing the vulnerability of the city of Chlef could cause risks.
- c) The impact of seismic threats on the city of Chlef is human, material and economic losses.
- d) The challenge of Exceptional urban expansion in seismic Chlef can be resolved radically by transferring it to a new city at another location where the risk is acceptable.

5.Research Significance:

This research study makes an important contribution to the knowledge of the exceptional spatial development in earthquake-prone areas. By highlighting and identifying the causes and

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consequences of this urban expansion and the impacts of the earthquake's hazards. This will help fill a significant gap in the current body of research, particularly in the "Chlef ". Its findings will be of great value to institutions operating in these dynamic environments, as well as to urban policy decision-makers and city planners, as it will enable them to use the results of this study to develop future effective strategies for managing and Accurately planning for this phenomenon. They can also present the potential for geographic information systems "GIS" ⁴ using remote sensing ⁵ data to monitor and analyse urban expansion over time and space.

6.Study Limitations:

Any scientific research is expected to have limitations that reduce the accuracy of its results.

Therefore, the limitations of my thesis are:

- The Time & Budget constraints and The study area located far away from the Author.
- The limitation of data on the study area and the inaccuracy of demographic data because it's only estimates.
- Lack of previous local studies on the same subject.
- Most data, information, and all study area maps are available only in French.
- Constraints in selecting scientific terms for the research field and accurately identifying their meaning in English.

⁴ ***GIS*** is defined as: “*a computer system that analyzes and displays geographically referenced information. It uses data that is attached to a unique location*”(USGS, n.d.-a).

⁵ ***Remote sensing*** is defined as: “*the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance (typically from satellite or aircraft). Special cameras collect remotely sensed images, which help researchers "sense" things about the Earth*”(USGS, n.d.-b).

7. Structural Outline:

This thesis begins with a general introduction which addresses the research problem and aims. Additionally, it will explore the thesis objectives, assumptions, significance, and study limitations. And will also provide an outline of the overall research structure.

The thesis is divided into five (4) chapters:

Chapter 1: In this chapter, we will delve into the literature review of urban expansion, encompassing its various types, and patterns. we will also explore the explanations of urban sprawl and its patterns, shedding light on the underlying causes of this phenomenon.

Chapter 2: In this chapter, we will elucidate the research method, source and tools utilized in this thesis and delve into an analysis of the case study area. This will involve an exploration of its geographical, historical, and natural aspects, including topographical, slope, and hydrographic features. Additionally, we will focus on the risk study of natural hazards in the city of Chlef.

Chapter 3: The primary focus of this chapter is to analyze the urban expansion over time in Chlef City and to assess the impacts of earthquakes, the causes of spatial development, and their consequences.

Chapter 4: It represents the summary of the main research funding, addresses the research questions, studies the validity of the initial assumptions, and provides general recommendations. Furthermore, it suggests future research and ultimately concludes the thesis with a general conclusion.

Chapter 1

Literature Review

1.Introduction :

Urbanisation is a global phenomenon that results in the creation and expansion of cities to large urban agglomerations. The scale of this phenomenon can vary from city to city, It occurs due to various factors such as population growth, availability of land, urban development plans, etc. In this chapter, we will explore the concept of urban expansion, its types, and patterns. We will also identify the meaning of urban sprawl and associate its patterns, with an indication of the causes of this phenomenon.

2.Definition of urban expansion :

The term "urban expansion" refers to the spatial and physical expansion of built areas, where it is one of the main indicators for measuring urbanisation density, According to (Heidarinejad, 2017). However, (Eslahi, 2019) clarifies that urbanisation can occur outside urban clusters and is called "peri-urban" areas, where these areas are closely linked to urban areas and are outside the city. In some cases, Urban expansion can also go beyond administrative boundaries, making the city the centre of the surrounding municipalities, forming a metropolitan area with one distinct central city, such as nuclei (Dyah, 2016).

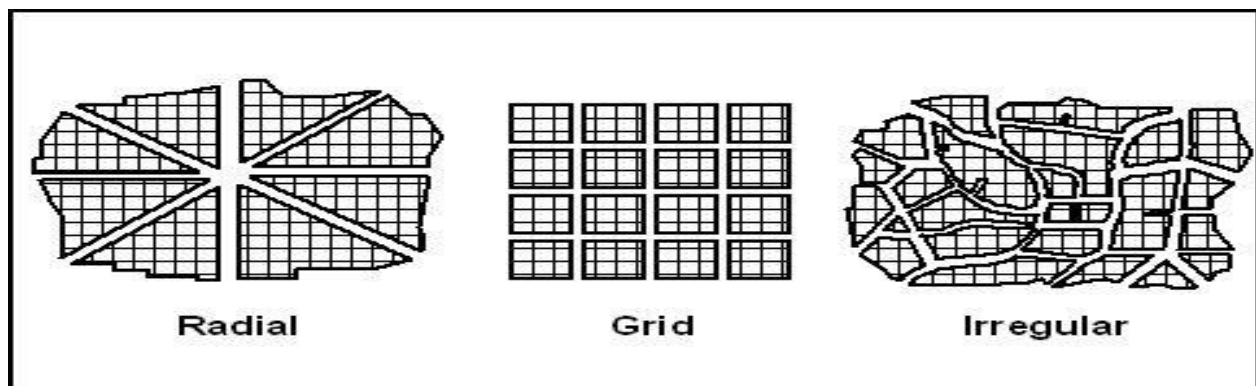
3.types of urban expansion "urbanisation" :

we can essentially discern the existence of two major types of urbanisation based on how it happens:

3.1.Planned urban expansion "urbanisation":

We refer to planned urbanisation as an expansion based on the strategic and systematic development of cities in an orderly and sustainable ⁶ manner. The aim is to improve living conditions and address challenges such as migration, lack of services, pollution, housing, climate change, etc. City planners focus on determining the city's pre-development environment under the concept of smart growth ⁷ (Shlomo, 2021), This involves creating a structured framework for future growth by proactively preparing land-use patterns and using different urban forms and types of street network patterns, such as grids, radial, organic or irregular, etc (see Figure 1). The main objective is to ensure road rights and plan for different infrastructure, such as water and sanitation, lighting, etc. to provide for the diverse needs of the population.

Figure 1: Street Network Patterns



Source:(Chua, 2013).

⁶ As endorsed by " the United Nations" in the Report of the World Commission on Environment and Development: Our Common Future in (1987), *sustainability* refers to: “*meeting the needs of the present without compromising the ability of future generations to meet their own needs.*”(United Nations, n.d.).

⁷ As advocated by the "EPA" the United States Environmental Protection Agency, *Smart growth* defined as: “*is an overall approach of development and conservation strategies that can help protect our health and natural environment and make our communities more attractive, economically stronger, socially diverse, and resilient to climate change.*”(US EPA, 2013).

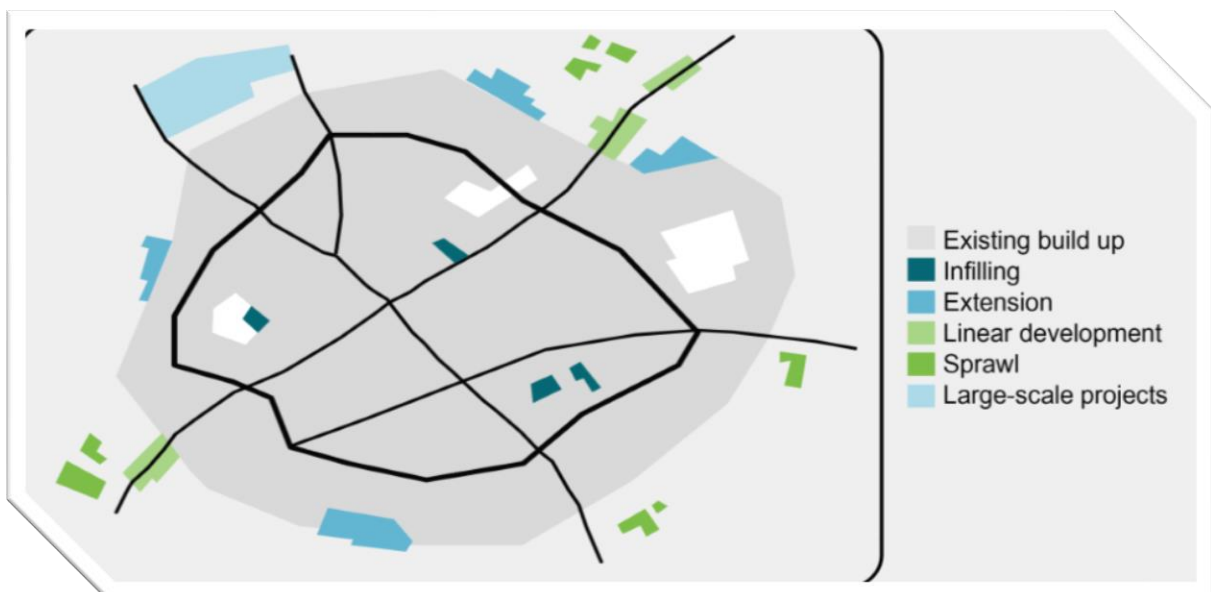
3.2.Unplanned urban expansion "urbanisation":

unplanned urban expansion refers to the lack of specific criteria for planning and organizing urban space often resulting in informal settlements lacking the necessary infrastructure and services needed by the population. This creates diverse risks, including environmental, social, and health risks (Ribeiro, 2021). According to the World Health Organization (WHO), most of the top ten causes of death are closely linked to rapid and unplanned urbanisation, and poor urban design and planning, especially in low-middle-income countries with rapid and uncontrolled urban expansion (World Health Organization, 2023).

4.Urban expansion patterns

The pattern of urban expansion by its shape varies from country to country due to various social influences or the decisions made by city planners. However, Dr. Jean-Paul Rodrigue in his book "The Geography of Transport Systems" has classified them into five main forms that the urbanisation of land uses can take (refer to Figure 2) :

Figure 2: Urban Expansion Patterns



Source : (Rodrigue, 2020).

- a. **Infilling:** It means new developments in areas and sites that have not been used in advance or previously used, but that have been redeveloped for new uses. For example, the potential for urban expansion of this type is manifested in areas where there is a particular redevelopment because it has lost its economic significance, old industrial sites, abandoned ports (waterfronts or railway basins), shopping centres, etc.
- b. **Extension:** This type of expansion is typical and occurs close to current land uses. For example, urbanisation in new infrastructure is an extension of development, such as many existing network facilities and roads.
- c. **Linear development:** This refers to the expansion that takes place mainly on main roads and transit lines (light rail, subway), it is similar to the extension. But in this case, this expansion enables it to take direct advantage of the smooth and easy access advantage provided by the various transport infrastructures.
- d. **Sprawl:** It is the standard form of development in suburban areas, where it is famous for scattered lots, and this development benefits from existing plots of land, but without attention and consideration for the urban pattern that exists.
- e. **Large-scale projects:** are typically infrastructure projects that are very different from existing areas, and require a significant amount of land, such as ports, airports, multimodal railway stations, and logistics or industrial zones. They often drive the development of new surrounding areas, but their operational logic differs from existing land uses. As a result, integrating them into already established areas can be limited and challenging.

However, based on most of the studies we've reviewed, the biggest issue in many cities around the world is what's known as "urban sprawl," which is a result of the urban expansion forms

that we mentioned earlier. But what exactly is urban sprawl? We'll explore this further in the next section No.5.

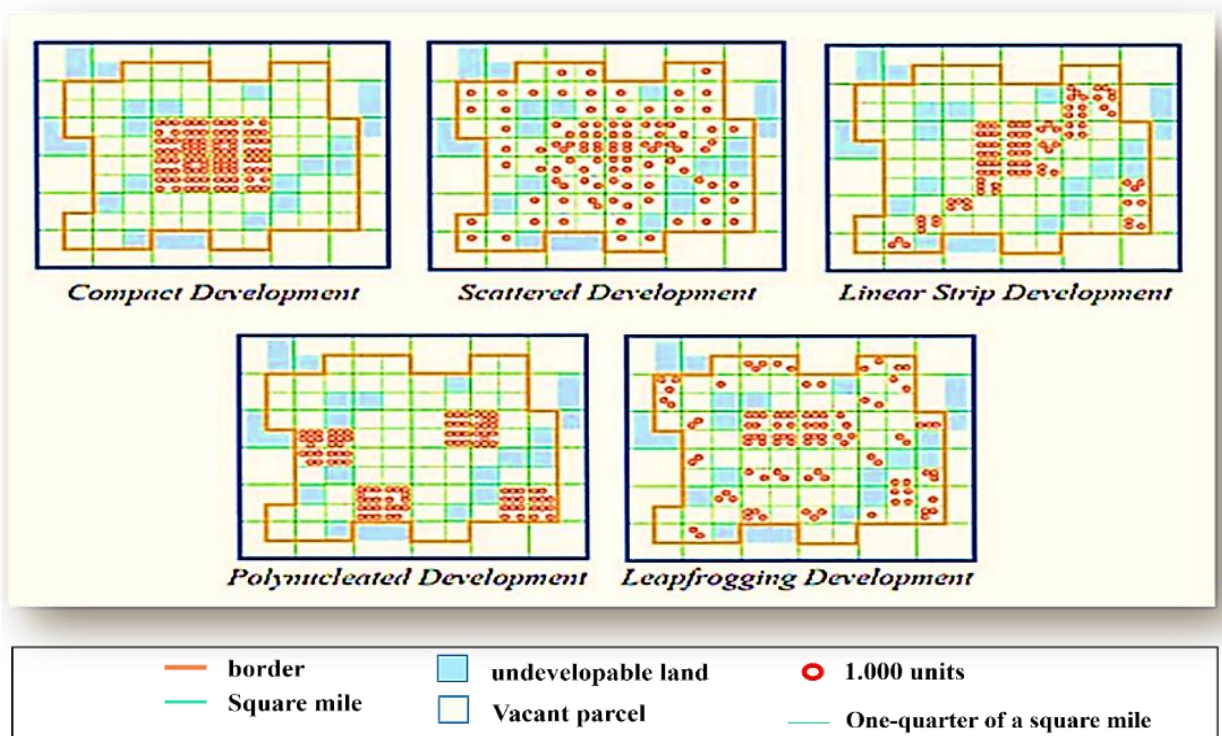
5.Urban sprawl :

It's an extension of urbanisation so that non-urban lands become urban lands, especially in the surrounding areas, and it indicates that they consume physical space excessively and testify to the absence of all planning and regularity (Bekele, 2005). As stated by (Ewing, 2008) it's a pattern of the use of unrecoverable land. It was achieved for the first time in the late 1950s in the United States, where agricultural areas were transformed into areas where industry, commerce and housing existed (J. P. Rafferty, 2024), and then affected the various countries of the world, both developed and developing. However, developing countries, particularly Africa and Asia, are more affected by this phenomenon of "urban sprawl" than developed countries, and that is because of the growth of urban population and migration (Omasire et al., 2020; L. Zhang et al., 2023). It can be defined by (Karakayaci, 2016) as : “ a hinterland between rural and urban areas ”, or as mentioned by (Habibi & Asadi, 2011), which the Oxford Dictionary defines as :“ the disorganized and unattractive expansion of an urban or industrial area into the adjoining countryside ”.

5.1.Urban sprawl patterns:

Cities expand in various ways. One of the most common ways is through the expansion in their peripheries. However, cities can also grow by increasing their central density resulting in the creation of a compact city (Eslahi, 2019). Additionally, other forms of urban expansion are characterised by their distinctiveness morphology. The study of (Galster et al., 2001) has classified this urban sprawl into five major physical patterns, which can be seen in Figure 3 :

Figure 3: Urban Sprawl Physical Patterns



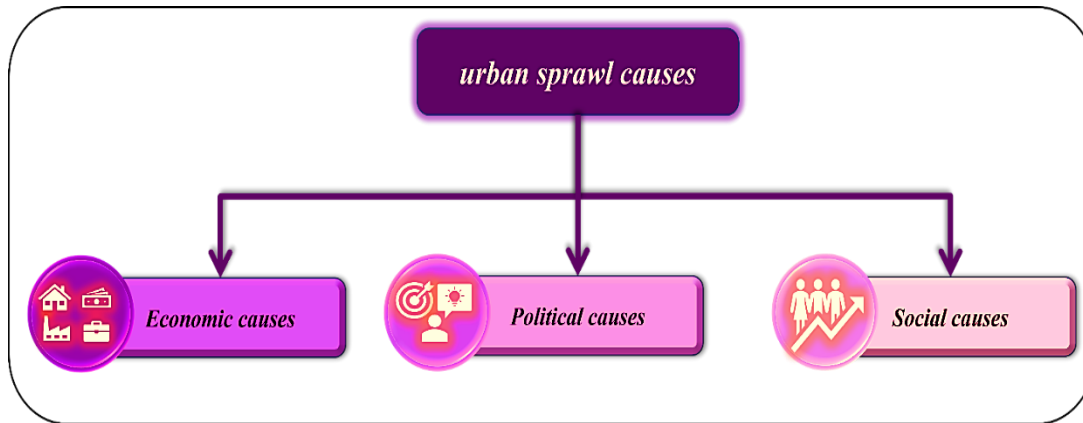
Source: (Galster et al., 2001).

"**Compact Development**" is when the boundaries of cities are expanded from their centre where the density decreases as we move away from the centre of the city, while this sprawl can occur along the linear areas under what is called "**Linear Stript Development**", and this is because of the specificity of these attractive areas, which can be roads or rivers. In the case of non-continuing urban growth, which is considered fragmented peri-urban development, it leads to extensive development in which buildings are spread within agricultural, natural or forest areas, such as the pattern of "**Scattered Development**", and can also be carried out in the form of scattered areas spread throughout the city, such as "**Leapfrogging Development**", or in the form of satellite groups such as the pattern of "**Polynucleates Development**". (Eslahi, 2019) Urban sprawl has taken these different forms because it is influenced by several different factors that are seen as the driving force for its occurrence, such as social, demographic, economic, etc., which will be described in detail in section 5.2.

5.2. Urban sprawl causes:

(Maier et al., 2006) points out that it is necessary to understand the reasons behind urban sprawl before considering its consequences. These causes are multiple, but we categorise them into three basic aspects as a driving force for urban sprawl (see Figure 4):

Figure 4: Driving Forces Urban Sprawl



Source: Author 2024.

5.2.1. Economic causes: The economic factor plays a significant role in determining the size of urban sprawl in cities. All sprawling is related to this aspect. The Britannica Encyclopedia explained that this could happen because of Low land and house prices in suburban ⁸ areas (J. Rafferty, 2019), as well as because of the availability of jobs and investments in urban centres, which attract people from many places far away.

5.2.2. Political causes: Government policy decisions play a key role in how cities expand. Its policy on taxes and land prices and their availability have a significant impact on urban sprawling (T. Zhang, 2000). Sustainable plans of different durations, whether short-, medium- or long-term, have an effective role

⁸ *Suburban* is defined by Jean-Philippe Antoni in his book "Lexique de la Ville" as: "the development of land whose shape and location are still very close to the city centre, with a relatively continuous and full land occupation". (Antoni, 2009).

to play in mitigating and combating this phenomenon (Sellers, 2002). Land use control gives urban institutions the ability to develop typical housing density, location and size, etc. However, the absence of such surveillance may lead to the growth of urbanisation in the form of large-scale urban sprawling.

5.2.3. Social causes: One of the reasons for the expansion of cities is demographic growth resulting from natural population increase, as well as migration. People are attracted to cities due to the availability of various services, amenities, and security provided by urban areas, as well as technological advancements that are not commonly found in rural areas (Siedentop & Fina, 2010). Additionally, people may immigrate for lifestyle reasons, such as desiring a lifestyle closer to nature or wanting to escape traffic or noise (J. Rafferty, 2019). All of these factors, both conscious and subconscious, contribute to urban sprawl in cities.

6. Summary:

The above text has helped us understand urbanisation, its various types and patterns, and the urban sprawl phenomenon. We now know that urban sprawl can take different forms depending on the geographical area and the reasons behind its occurrence. This understanding will prove useful in analysing Chlef City, which has experienced exceptional expansion despite being in a naturally risky area. By examining the causes behind its growth, we can determine if it falls under the same reasons we discussed earlier or if it has its unique causes, which we will explore in the Third Chapter.

Chapter 2

Case of Study

1. Introduction :

The city of Chlef holds great significance among the major cities of northern Algeria. In this chapter, I will delve into the geographical and historical profile of this city, outline its various characteristics, study its topographical and hydrographic features, identify its challenges, and assess the natural hazards that pose a threat to its stability and future urban development, and mention the legislative aspect of its risks. This will be accomplished by analysing various maps created with ArcGIS 10.1 and maps obtained from the directorate. However, before I delve into this discussion, I will first explain the research method, source and tools employed in this thesis, which has assisted in analysing this chapter and the following chapter 3.

2. Research Method, Source and Tools:

My research employs a methodology that draws on references from various sources, including books, articles, and scientific research on spatial development and the earthquake's impact on them. I analysed two types of data: quantitative data, consisting of information on historical events in the region about the threat of the earthquake and the events behind it, and various demographic data, including natural demographic growth and population migration, collected over different periods in the geographical area of the Chlef agglomeration, collected through the Chlef Monograph in the website of «Ministry of Interior, local collectivities, and Territory planning» and various directorates ONS, ANAT...etc After collecting and organising this data, I analysed it using tables and charts to identify changes in population growth rate, and migration patterns. Remote sensing data extracted from Landsat (5 & 8) over the following periods (1987 and 2023) was collected from the Earth Explorer, United States Geological Survey "USGS" website. Details of this data are presented in Table 1 with all the information. This data has helped me to produce maps of "LULC" to identify the sprawling and extract the built-up area. Due to the absence of Landsat data for 1949 and 1980 in my study area, the creation of the LULC map of this

CHAPTER 2: Case of Study

period was based on the spatial expansion of the city of EL-ASNAM map data from the "D.U.C.H "Directorate of Algeria (see Appendix A). All the maps were created using Arcis 10.1 software, as well as a map of Chlef City's Location, hydrographic, topographic and slope maps, which helped me to understand, analyse and identify the nature of the Chlef City, which I used the digital elevation model "DEM" that I downloaded from the same website mentioned above "USGS", and the details of these data are available in Table 2. The results of all these data were combined to understand the causes and consequences of the extraordinary spatial development "urban expansion "in seismic areas of Chlef and to determine the earthquake's impact on it.

Table 1: Details of Satellite Imagery data

| Type of Satellite | Image ID | Acquisition Date | Spatial Resolution (m) |
|---------------------|--|------------------|------------------------|
| Landsat 5 TM (1987) | LT05_L1TP_197035_19870612_20211114_02_T1 | 1987/06/12 | 30 |
| Landsat 8 (2023) | LC08_L1TP_197035_20230615_20230622_02_T1 | 2023/06/15 | 30 |

Source: Author based on data from (USGS, 2024), 2024.

Table 2: Details of Digital Elevation Model data

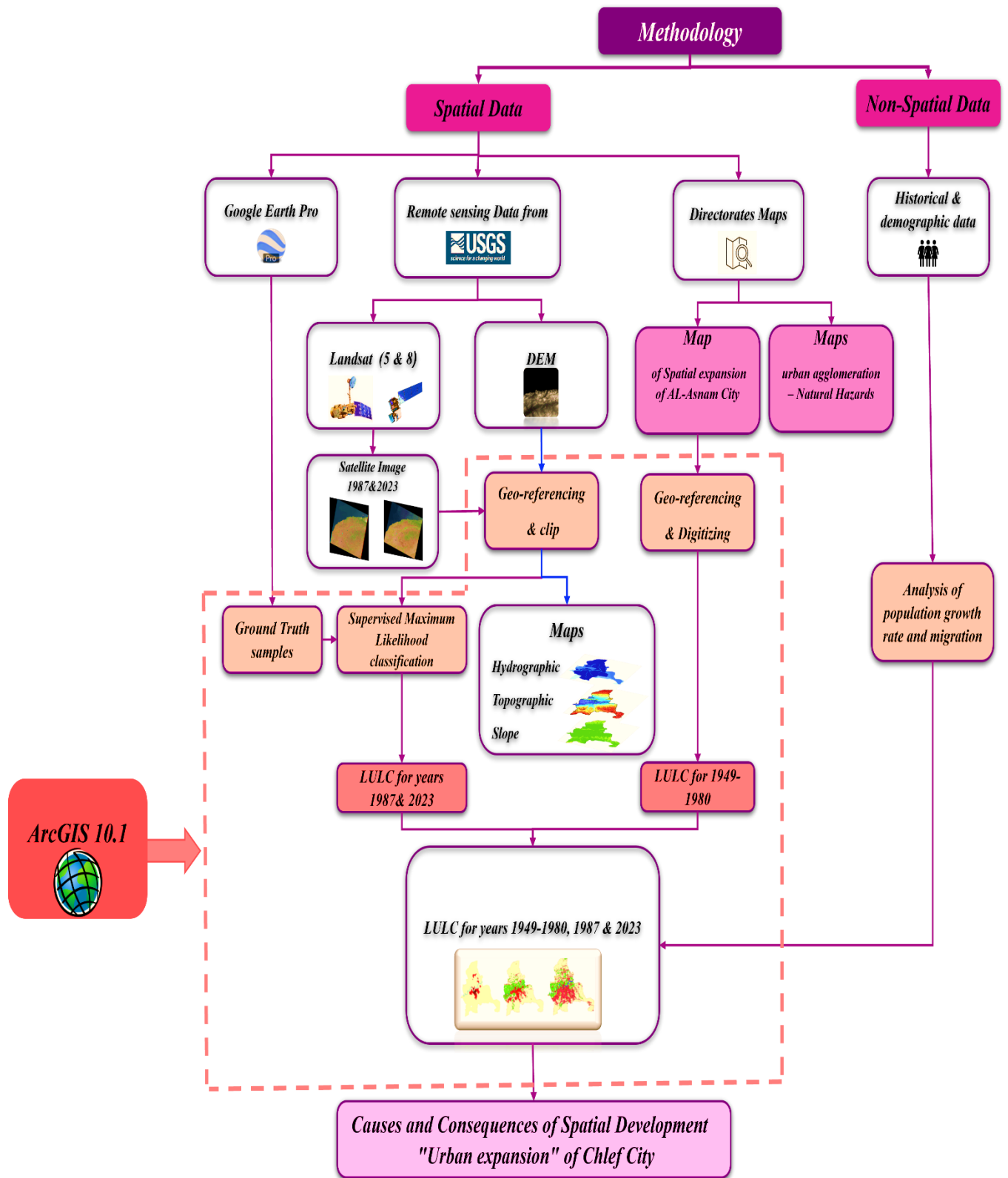
| Data | Entity ID | Acquisition Date | Resolution (m) |
|------|----------------|------------------|-----------------|
| DEM | SRTM1N36E001V3 | 2000-02-11 | 30 |

Source: Author based on data from(USGS, 2014), 2024.

2.1. Remote sensing data processing and analysis:

The satellite images that were downloaded had been geo-referenced in the UTM coordinate system with the local system zone "zone 31N" for the Chlef area. The boundaries of the municipality of the Chlef were digitised as a shapefile, which the author drew based on the Google Earth Pro base map. Two satellite images, obtained from 1987 and 2023, were then clipped based on this boundary. These images were classified into four categories: agricultural land, water body, built-up and empty land, using Supervised Maximum Likelihood classification in ArcGIS. To classify the images, Ground truth data were taken into account, when comparing the classified Landsat images. In total, 90 samples for ground truth were obtained for each of the four categories, and these samples are random points at known coordinate points and specific locations based on the grid layout in Google Earth Pro. The final output of this exercise was the LULC Map of the Chlef City for 1987 and 2023. Figure 5 shows the full methodological framework of this study.

Figure 5: The Research Methodology Outline

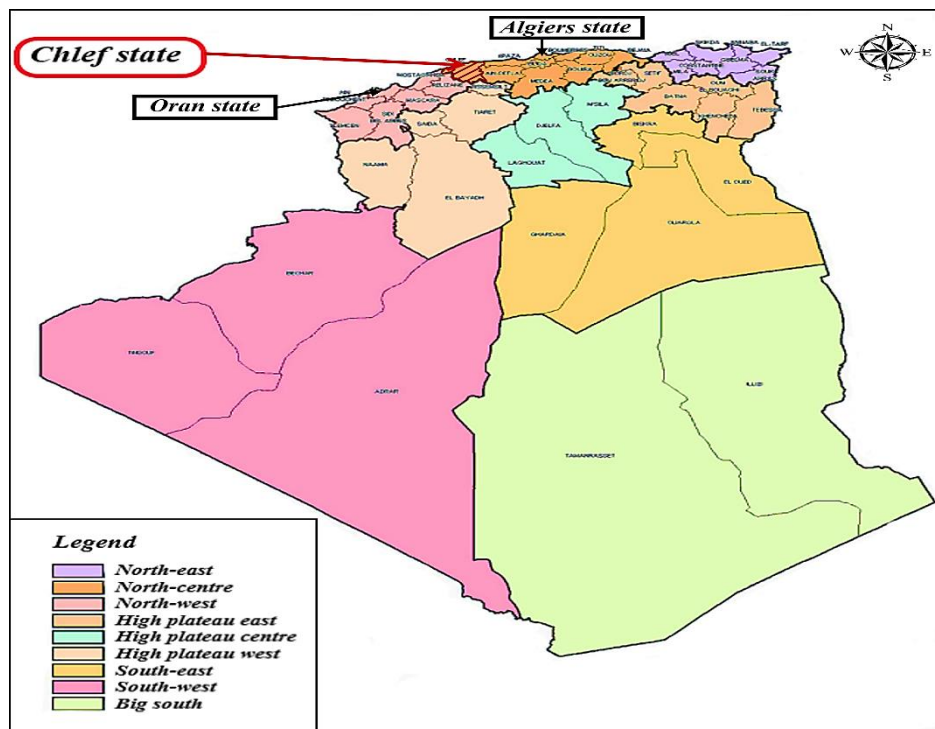


Source: Author, 2024.

3.Chlef state location and general information :

The state of Chlef is situated in the northcentral region of Algeria (refer to Map 1) . It is located at a distance of 208 km from Algiers and comprises 13 districts and 35 municipalities. The state is bordered by the Mediterranean Sea to the north, Tissemsilt to the south, Aïn El Defla and Tipaza to the east, and Relizane and Mostaganem to the west. (see Map 2).

Map 1: Chlef State Location



Source: ((SNAT) 2030., n.d.) + Modified by Author,2024.

The region is known for its diverse geomorphology, which divides the terrain into four distinct natural areas. The northern part is home to the Dahra Mountains and is adjacent to the coastal area. The coastline stretches over a distance of 129 km. Moving towards the central area, we come across the fertile plains of the Chlef plain, which extends up to the state of Relizane. Finally, the southern region is marked by the Ouarsenis mountain range (*Our Wilaya | Direction Of Tourism And Handicrafts Chlef, 2021*).

CHAPTER 2: Case of Study

The Chlef region is known for its agricultural character, covering an area of 262,511 hectares , representing 64% of the state's total area. Its strategic location between Algiers and Oran makes it a vital economic hub. The region has a population of 1,356,151 inhabitants, making it the sixth largest in the country, with a population density of 333 inhabitants per square kilometre as of 31/12/2021. The estimated annual growth rate of the population is 1.70%, which is higher than the national growth rate of 1.60%. Despite its small area of only 4074 km², the region has a high concentration of urban communities (79%) compared to scattered areas (21%), which may limit its future urbanisation (see Table 3) (*Monograph of the State of the Chlef Population and Employment, 2021*).

Table 3: Distributing People by Dispersions in Chlef State

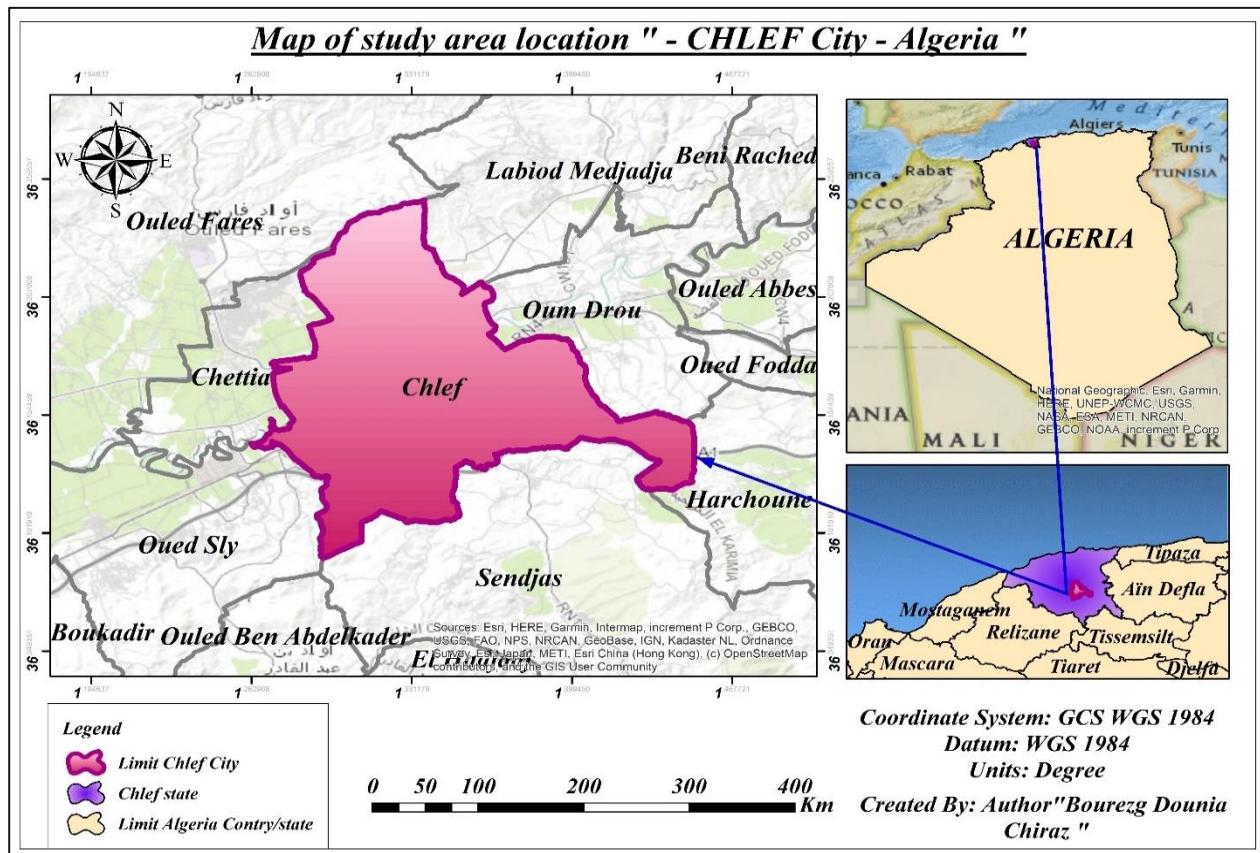
| DISPERSIONS | POPULATION | % | |
|------------------------------|------------------|------------|-------|
| Central urban Agglomerations | 704.076 | 51,92 | 78,67 |
| Secondary agglomerations | 362.803 | 26,75 | |
| Dispersed Area | 289.272 | 21,33 | |
| TOTAL | 1.356.151 | 100 | |

Source : (*Monograph of the State of the Chlef Population and Employment, 2021*) .

4.Location of the Chlef City (study area):

The city of Chlef is a significant hub as it accommodates both the municipal and district headquarters, as well as the state. It covers an area of 127.05Km². It is centrally located, surrounded by Ouled Fares and Labiodh Medjaja in the north, Oum Drou and Harchoun in the east, Chettia and Ouled Sly in the west, and Sendjas municipality in the south (refer to Map 2).

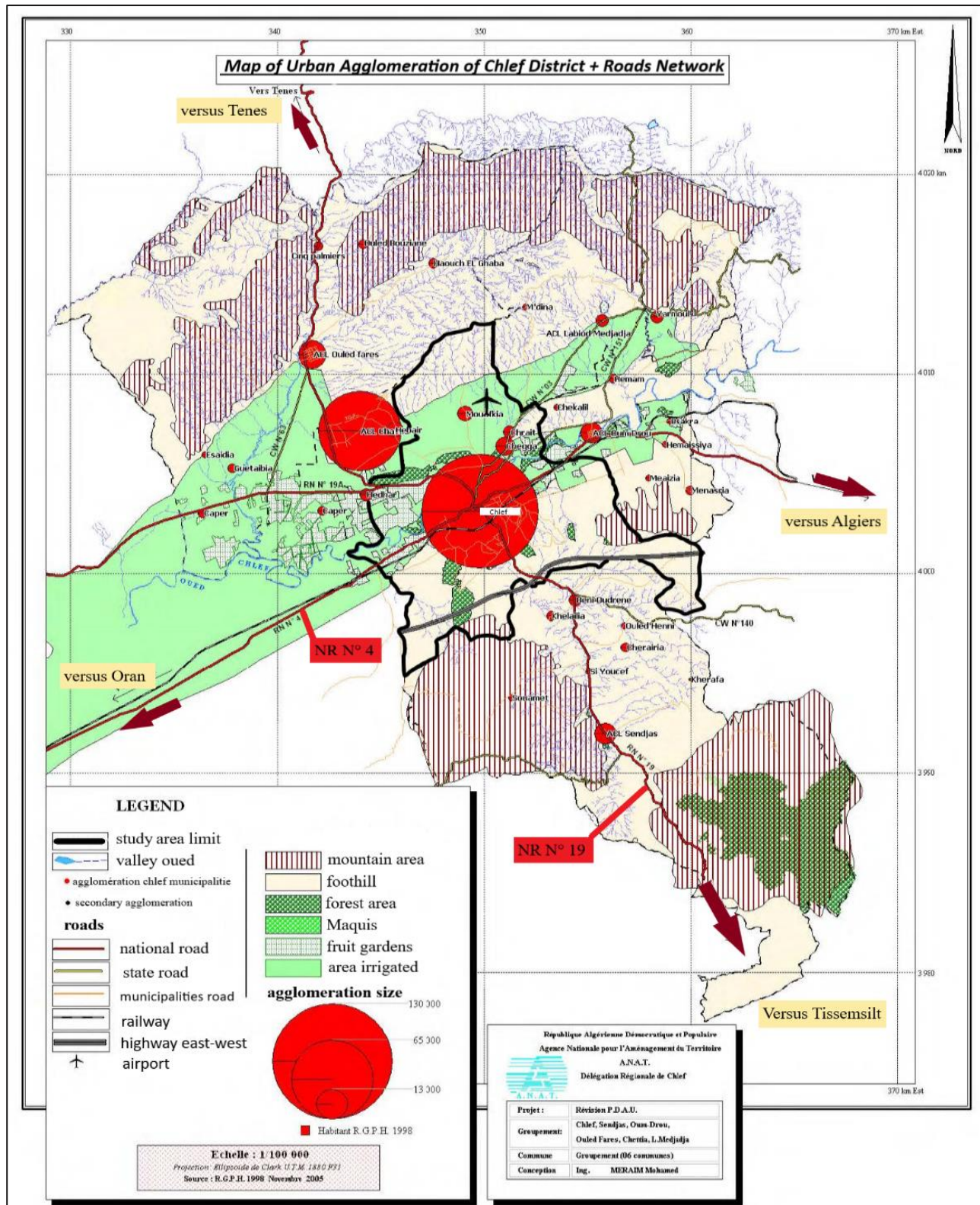
Map 2: Study area location " -CHLEF City- Algeria "



Source: Author,2024.

Chlef City is the largest urban agglomeration in the Chlef district and the only major urban area in the municipality of Chlef. This region holds great significance due to its critical network of national roads, which offer exceptional connectivity across the states. Two primary traffic hubs are situated here, linking the east to the west via National Road (N°4) and the north to the south via National Road (N°19). Furthermore, given its strategic geographical location, the east-west highway passage adds to its importance. (refer to Map 3).

Map 3: Urban Agglomeration of Chlef District + Roads Network



Source : (Pdaou,2020), Modified by Author,2024.

5. Historical overview of the city of Chlef:

The city of Chlef boasts a fascinating past, which can be divided into four distinct periods. The first period dates back to the **(Roman era)**, during which the Romans took control of the region from the Phoenicians and that's where the city of the Chelf first appeared, which was called "Castellum Tingitanum."

Following the Roman and Wendel eras, the **(Islamic period)** began, during which people settled in the plain of the shilling. The city's name was changed to "AL-ASNAM," owing to the idols or sculptures built by the Romans (El djamhouria, 2008).

In 1830, the **(French colonisation)** began, and the Ottoman regime was overthrown. The designation "AL-ASNAM" was altered, and in 1843, the French repurposed the ancient Roman site to establish a military installation. This location later developed into a significant city named "Orléansville" as a tribute to the Orléan city in France.

After the Algerian Liberation War and **(Algeria's independence)**, the name "AL-ASNAM" was restored, but it was changed again after the 1980 earthquake to the current name of "Chlef." The city was named after the Chlef Valley "Oued" that runs through it (*Our Wilaya | Direction Of Tourism And Handicrafts Chlef*, 2021).

6. Natural study:

6.1. Climatic factors:

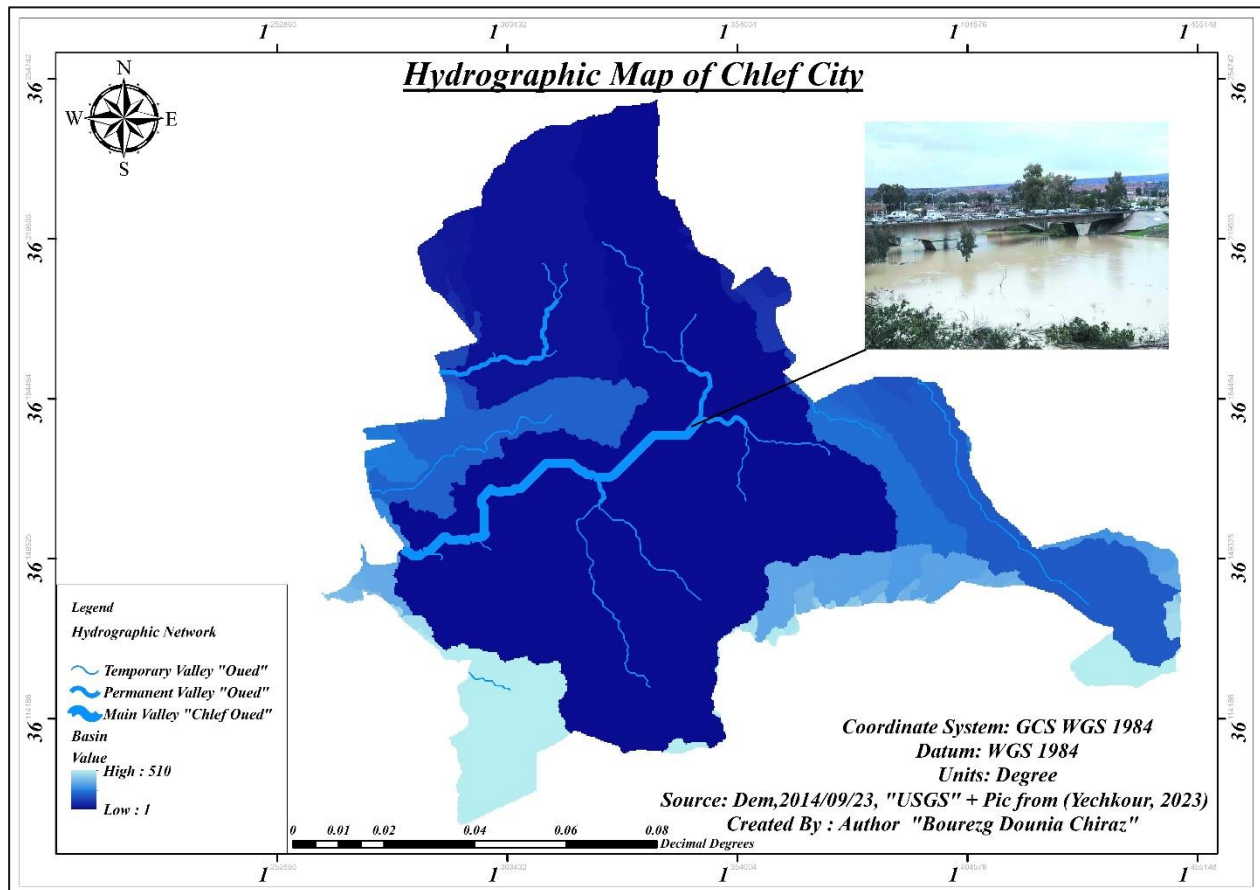
Chlef City, which is located approximately 40 kilometres from the Mediterranean Sea. has a climate that is classified as semi-arid, with a hot summer and wet winter. During the winter, the temperature dips to a low of 10.6 degrees Celsius, while in the summer, the temperature reaches a high of 37.7 degrees Celsius (*Monograph of the State of the Chlef Physical Framework*, 2021).

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6.2. Hydrographic:

The City of Chlef is distinguished by a medium-water network, but is traversed by Algeria's principal river, the Chlef Valley "Oued," which extends 750 km across the national territory. Originating from the Saharan Atlas, 70% of its annual runoff happens between December and April (Elmeddahi et al., 2016), contributing to meeting the city's water needs.

Map 4: Hydrographic of Chlef City



Source: Author, 2024 & Pic from (Yechkour, 2023).

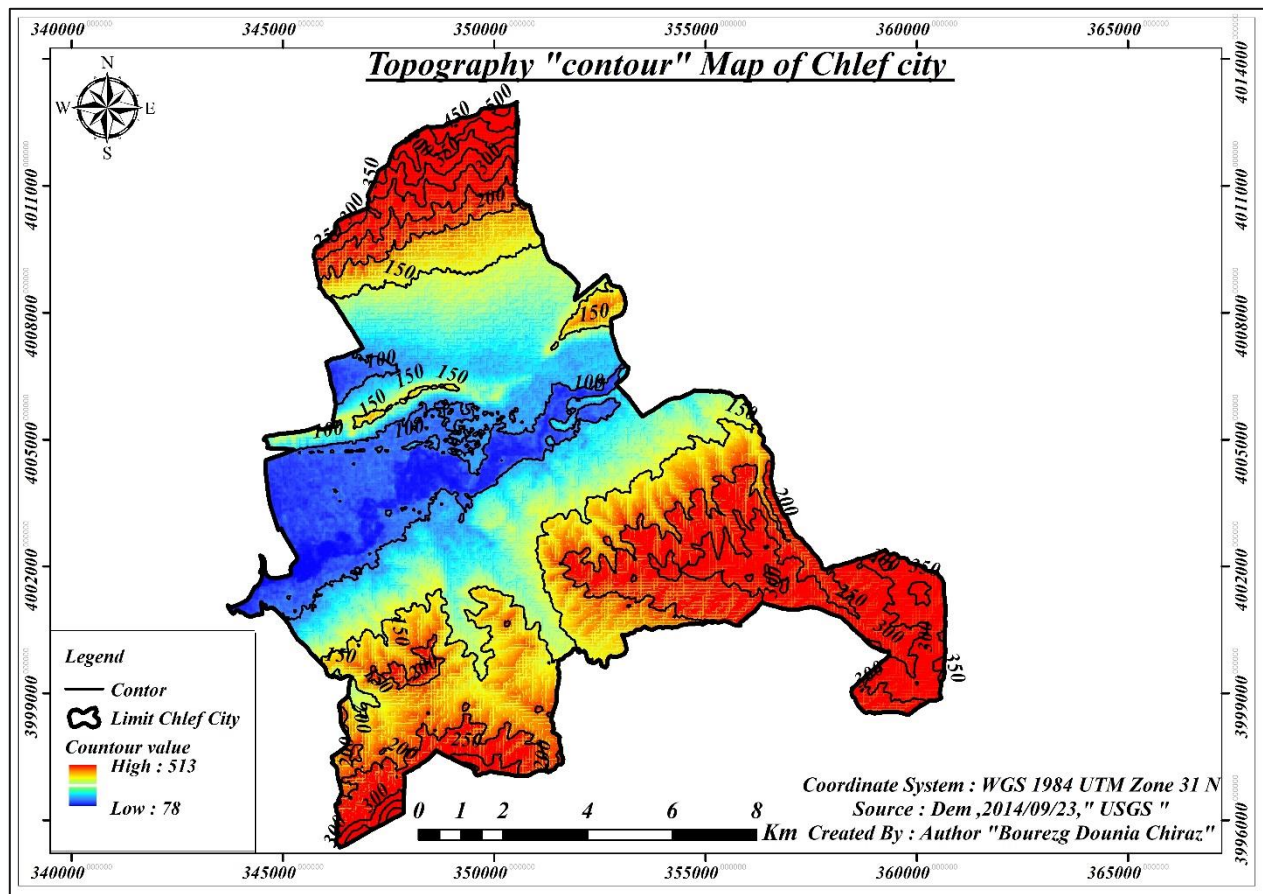
6.3. Topographic study:

The topographical map shows that the area under study is relatively flat, with varying terrains indicated by different elevation features. The northern and southern parts of the city display distinct geomorphological characteristics, as evidenced by the contour lines (refer to Map 5). In the northeastern region, the contour lines are closely packed, indicating higher elevations reaching up

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to 513 meters. On the other hand, the northwestern and southern parts of the city range from 200 to 350 meters at the highest points. The central part of the study area consists mainly of flat terrain, with elevations ranging from 100 to 150 meters, and the lowest point at 78 meters, representing the Chlef Valley "Oued". This analysis allows us to identify the slopes in the area, which will aid in our assessment of the surface conditions and help identify areas suitable for expansion and reconstruction, as discussed in the following section.

Map 5: Topography "contour "of Chlef City

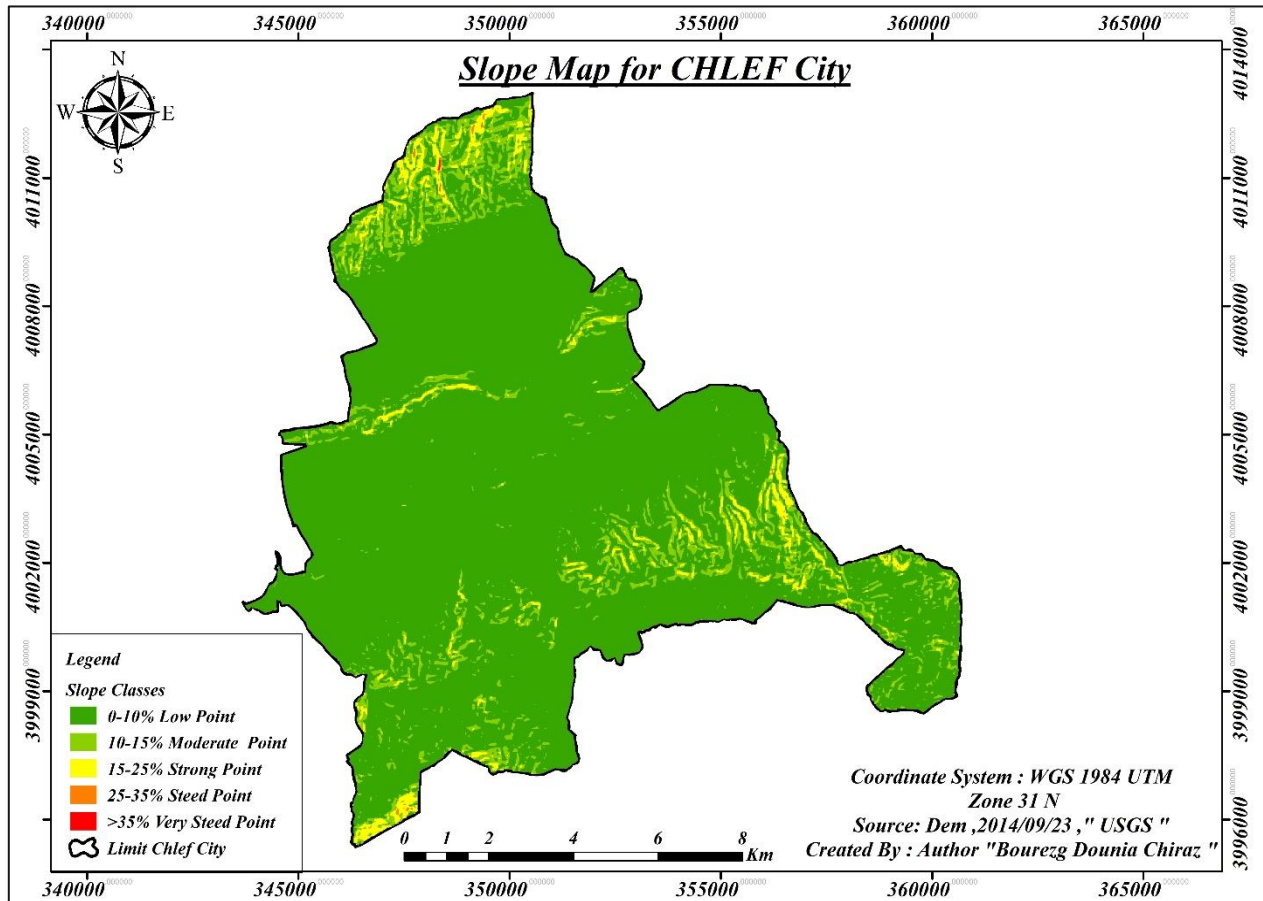


Source: Author,2024.

6.4.Slope in the study area:

The slope map divides the study area into five areas of different slopes, as follows (refer to map 6):

Map 6: Slope of Chlef City



Source: Author,2024.

- a. **Low point:** This is the trend that dominates the study area by 0 to 10 %, and is particularly concentrated in the central region, spanning 109,471 km², which represents 86.16% of the total Chlef area (see Table 4). This region is ideal for future development and construction due to its lack of topographic obstacles.
- b. **moderate point:** on average, it is 10 to 15 %, distributed throughout the study area. it is more prevalent in both the northern and southern highland regions, covering 13.459 km²,

making it the second-largest class with 10.59 % of the total study area, Construction can take place but must adhere to the conditions set by the regulations.

- c. **strong point:** the 15-25 % slope, classed third in terms of area (refer to table 4), is an area of 4.013 km², or 3.16 %. This topographical feature is present in both the northern and southern regions of the study area.
- d. **steed point :**In the northern and southern regions of the study area, it is only 25 to 35 %, making it an unbuilt area, classified as fourth in terms of area, with an area of 0.098 km², or 0.08 %.
- e. **Very steed point:** present only in the northern region of the study area, which represents all trends above 35 % (>35.5 %). This area is classified as fifth and last, covering 0.009 km², which is 0.01% of the total area. And it can't be built in it.

Table 4: Slope Classes of Chlef City

| | Slope classes | Area Km ² | Percentage | Classes Number |
|---|------------------|----------------------|------------|----------------|
| 1 | Low Point | 109.471 | 86.16% | first |
| 2 | Moderate Point | 13.459 | 10.59% | second |
| 3 | Strong Point | 4.013 | 3.16% | third |
| 4 | Steed Point | 0.098 | 0.08% | fourth |
| 5 | Very Steed Point | 0.009 | 0.01% | fifth |

Source: Author, 2024.

7.Risk Study:

7.1.Natural Hazards in Chlef City:

According to the Pdau "Master Plan for Development and Urbanism (MPDU)", there are two natural hazards in the study area of Chlef City: flood risk and earthquake risk. However, we will focus on the threat of earthquakes :

7.1.1.Flood Risk:

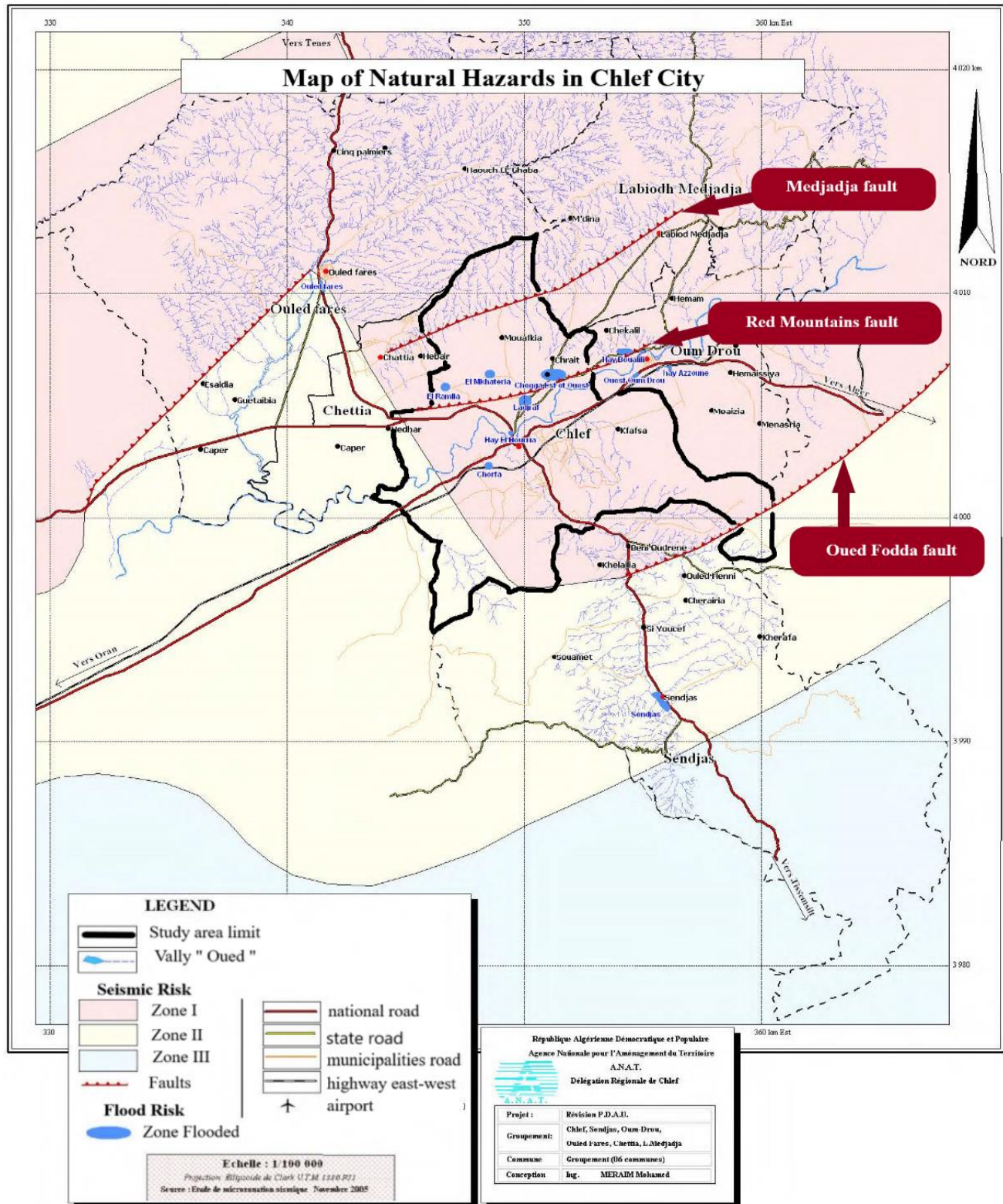
As per the abovementioned hydrographic study, the study area has a medium hydrographic network. However, it is prone to flooding in six specific locations during heavy rainfall, according to (refer to map 7). These areas are listed below:

- 1- Chorfa.
- 2- Hay El Hourria.
- 3- Ladjraf.
- 4- Chegga east and west.
- 5- El Mkhateria.
- 6- El Ramlia.

7.1.2.Seismic Risk:

The Chlef State, located in Zone 3, is considered a high-risk area as per the Algerian earthquake regulations RPA 99 version 2003 refer to Appendix B. This region is at the convergence point of the African and Eurasian tectonic plates (Derder et al., 2011) and has numerous faults, as detailed in Appendix C. The Chlef city most of her area is located in zone one "I" which is particularly susceptible to seismic activity and is traversed by three faults - the "Medjadja fault" in the north, the "Red Mountains fault" in the centre, and the "Oued Fodda fault" in the south. You can locate these faults on Map 7.

Map 7: Natural hazards in Chlef City



Source:(Pdau, 2020) it was modified by Author,2024.

CHAPTER 2: Case of Study

Geological and seismic research conducted in the Chlef region indicates that earthquakes have occurred regularly for the past 1,500 years. There is a warning from scientists that a powerful earthquake may occur in the future (Boutaraa, 2013a). These are the biggest and most significant seismic events that the city has ever experienced, you can refer to Table 5 :

- ❖ The devastating Orléansville earthquake of 1954, measuring 6.7 on the Richter scale, remains one of the most tragic events in the history of Chlef. It caused the loss of 1,243 lives, more than 5000 injuries and the destruction of 20,000 homes (Ouyed, 1981).

Table 5: The most significant and powerful Earthquake in Chlef City

| Earthquake Name | Date | Time UTC | Intensity | Magnitude | Fault +long Km |
|-----------------|------------|-----------|-----------|-----------|---------------------|
| Orléonville | 09/09/1954 | 1h 04 min | X | 6.7 | - |
| Al-Asnam | 10/10/1980 | 12h25min | XI | 7.3 | Oued Fodda 47 Km |

Source: Author Based on the data mentioned above,2024.

- ❖ The 1980 AL-Asnam earthquake measuring 7.3 on the Richter scale, was caused by the 47-kilometre "Oued Fodda fault." It resulted in the loss of 2,633 lives, 8,369 injuries, 348 missing persons, and 478,948 people becoming homeless according to (Ayadi et al., 2021; Negulescu et al., 2018).

7.1.2.1. Earthquake Risk Legislation in Algeria:

After Algeria's independence from French colonialism, Algeria had no laws on risk, but after the earthquake of El-Asnam 1980s, the legislative authorities enacted a series of laws regulating and operating cities in situations of risk. The most important of these laws are as follows:

- ✚ the first Algerian seismic code (RPA) appeared in 1981 following the earthquake in El-Asnam. This code was revised in 1983 (RPA83), 1988 (RPA88) and 1999 (RPA99) and relates to regulations for the design of buildings.

Following the earthquake in Boumerdes on 21/05/2003, the code was revised to RPA99/Version 2003 by order of the MHU (Ministry of Habitat and Urban Planning), and it is mandatory for all buildings, whether public or private.

- ✚ Decrees 85-231 and 85-232 (promulgated on 19 August 1985) respectively defining the organization and procedures of crisis management from the establishment of the ORSEC plan (organization of interventions and rescue), on the one hand, and the disaster risk prevention at the national, state and municipal levels, on the other.
- ✚ the Ordinance of 03-12 on 26 August 2003 concerning the obligation of insurance for natural disasters and compensation for victims.
- ✚ the Executive Decree No.04-181 of 24 June 2004 on the establishment of a communication committee on major natural and technological risks.
- ✚ the Executive Decree No. 04-268 of 29 August 2004 on identifying natural disasters to be covered by insurance and disaster reporting methods.
- ✚ Law No.04-20 of 25 December 2004 on prevention of major risk and disaster management, in the context of sustainable development.

8. Summary:

Upon thorough analysis of Chlef, including its geography, history, and hydrography, as well as taking into account the natural hazards affecting the region and the laws on earthquake risk in Algerian legislation, we could identify our area of study more precisely. We have concluded that Chlef city has a strategic location and has been identified as the largest agglomeration in the state of Chlef, despite its location in a powerful seismic region that experiences frequent earthquakes destroying the city and its physical environment. Notable examples include the Orléonville earthquake of 1954 and the Al-Asnam earthquake of 1980. In the following chapter, we will delve into the issue of continued urbanisation in the region, despite the challenges posed by its location in a high-risk seismic area, and explore its underlying reasons.

Chapter 3

Chlef Urban Expansion

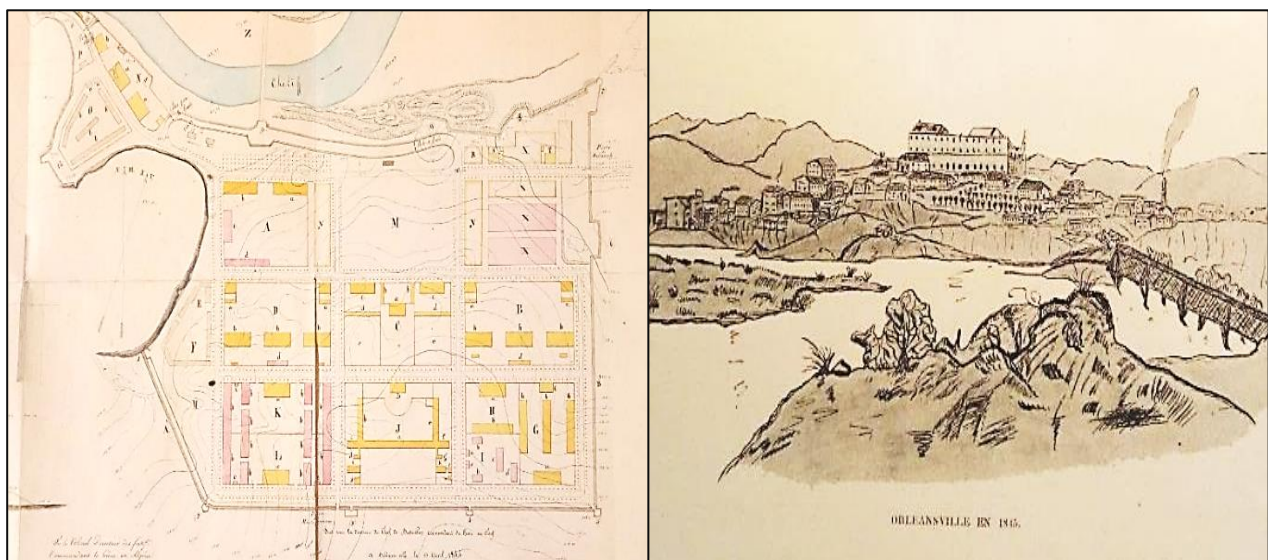
1.Introduction:

The history of the city of Chlef, which we discussed in Chapter 2, demonstrates that it has gone through several periods of spatial development, so in this chapter, my focus will be on the fundamental periods of urbanisation that took place from the French colonial era to the present day, and this to focus in the extraordinary impact of the devastating earthquakes that hit the region, including the Orléansville earthquake of 1954 and the AL-ASNAM 1980, on its spatial development so we will be able to find out the causes for the Exceptional expansion of this city and its consequences. To analyse this, I will be using the research methodology discussed in the previous chapter, "Chapter 2".

2.Chlef Urban Expansion:

The city has undergone several periods of urbanization and was officially established on 16 May 1843, when a wall was built around it and it was given the name Orleansville. Initially, the city consisted only of its centre (see Figure 6), but it has since continued to expand.

Figure 6: The 1844 general plan of Orléansville on the left & The 1954 city drawing on the right



Source: (ALI AICHOUBA, 2017).

This expansion was divided into three main periods :

2.1. First period 1849-1954:

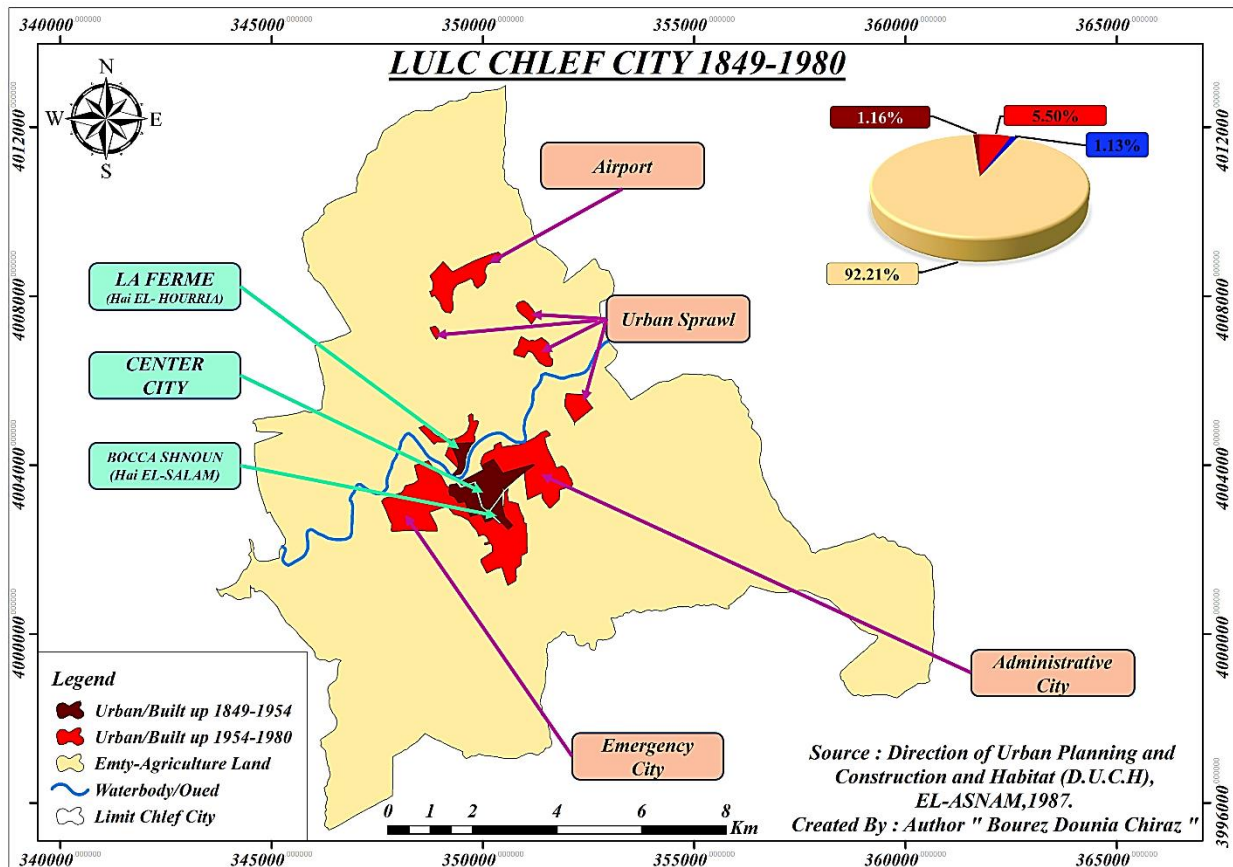
Before the Orléansville earthquake (see Figure 7), the city had expanded into three regions: "**La Faram**" in the north (now known as "Hai EL-HOURRIA "), "**Booca Shanoun**" in the south (now known as "Hai EL-SALAM") these regions were reserved for Algerian residents and "**the centre of the city**" for European residents. The Built-up area of the city was 1.47 km², which represents 1.16% of the total area of the municipality (refer to map 8).

Figure 7: Orléansville in 1953



Source: *.(Orleansville Vue Générale Aérienne"cote Ouest", 1953).*

Map 8: LULC Chlef City 1849-1980



Source: Author based on map data from D.U.C.H cited in (Bouzouaid, 1984), 2024.

2.2. Second period 1954-1980:

After the earthquake of September 1954, the city of Chlef expanded by approximately 6.98 Km², representing 5.50%. Most of the expansion took place on the outer edges of the city's former borders, particularly in the southern part of the city. Additionally, an airport area emerged in the north as a "Large-scale project", while the eastern part of the city experienced an urban sprawl of "Polynucleates Development" which I explained in section 5.1 in chapter 1 (see map 8) The rest of the area was made up of both the "Oued Chlef", which took 1.13% and Empty land mixed with agricultural land (since there was no accurate information on the agricultural and empty land area at that time, I combined them), which takes the largest portion of the area, with 92.21% occupying

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117.16 Km² of the total area 127.05 Km². Unlike before between 1849-1954 it represented 97.71%, which means that this area was reduced by urbanization. For more specific details (see table 6).

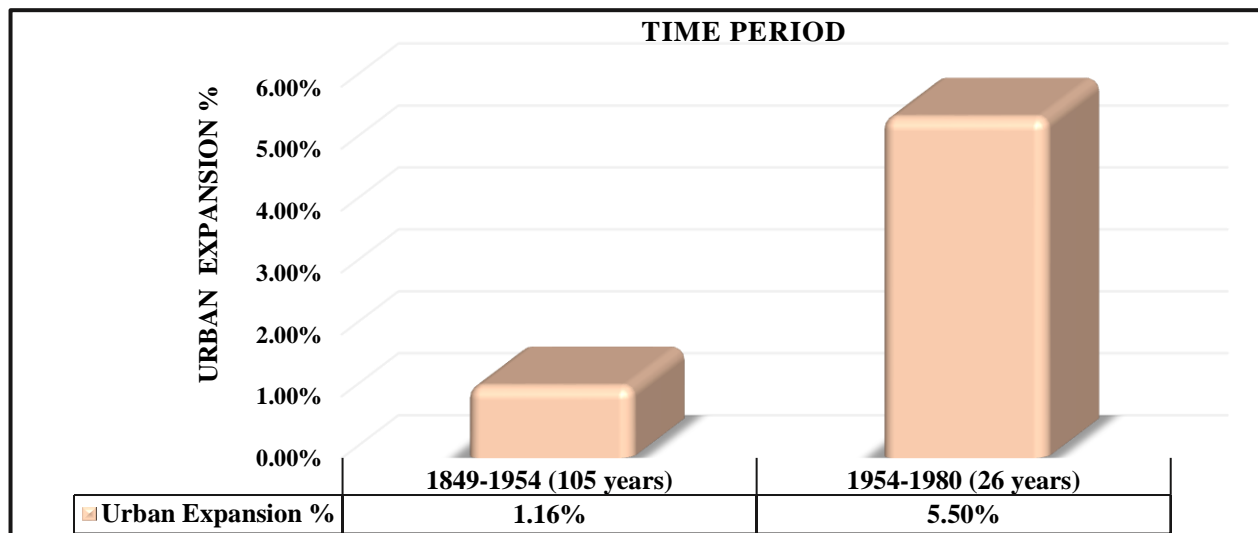
Table 6: LULC Classification of CHLEF City 1849-1980

| Classification | Area Km ² | Percentage % |
|----------------------------|----------------------|--------------|
| Urban / Built-up 1894-1954 | 1.47 | 1.16 |
| Urban/Built up 1954-1980 | 6.98 | 5.50 |
| Waterbody/Oued | 1.44 | 1.13 |
| Empty-Agriculture Land | 117.16 | 92.21 |
| Total | 127.05 | 100 |

Source: Author, 2024.

In comparison to the previous period, it has been observed that the current period has shown a significant increase of 5.50% in just 26 years as opposed to the first period which spanned across 105 years and showed an urban expansion of 1.16% (refer to Figure 8). This sudden surge in urbanization during this period can be attributed to the impact of the post-Orléansville earthquake, which will be elaborated on in the following section 2.2.1.

Figure 8: Urban Expansion enter 1849-1954 & 1954-1980

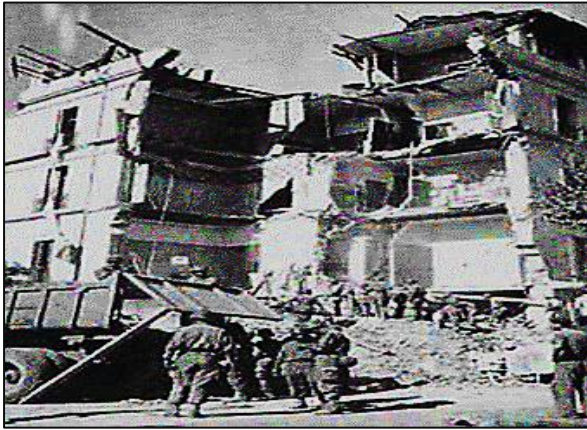


Source: Autor, 2024.

2.2.1. Impacts of the 1954 earthquake disaster (causes of spatial development):

Following the 6.7 magnitude earthquake, 20,000 houses were destroyed and significant changes were made to the city's urban structure (refer to Figure 9). After the disaster, the responsible parties quickly took action to rebuild the area. They organized services to manage the rebuilding process, developed legal measures to rehabilitate reusable buildings, and implemented temporary and permanent construction programs. To achieve this, the French colonial government issued Decree No. 54-992 on 6 October 1954 (Decrees N°54-992, 1954).

Figure 9: Photos of Orléansville after the 1954 earthquake (Hotel Baudoin on the left & Aerial photo of the city on the right)



source: (Orléansville, 1954).

The Office of Studies **SOCOTEC** commissioned the reconstruction⁹ projects, under the rules for the prevention of earthquakes (AS/55). the city development plan was prepared and implemented within one year (Boutaraa, 2013b; Watez, 1958), as follows:

2.2.2. Economic aspect & physical reconstruction (after the 1954 earthquake):

The reconstruction process was divided into two main categories "urban housing" and "rural housing", and Each category had two phases of implementation :

⁹ As advocated by the (Oxford Advanced American Dictionary, n.d.) *reconstruction* is defined as: “*the process of changing or improving the condition of something or the way it works; and putting it back into the state that it was in before*”. it means either “*the activity of building again something that has been damaged or destroyed*”.

2.2.2.1. The first phase (temporary reconstruction):

Which was emergency-based. Initially, "Tents" were used, as shown in Figure 10. Later, "pre-fabricated houses", were used as a more efficient solution. However, the price of the pre-fabricated houses was set at 500,000 francs ¹⁰, which was very high at that time, especially considering the large number of them that had been used. This amount was sufficient to build permanent housing. Meanwhile, efforts were made to repair buildings that could be saved (Bouzouaid, 1991).

Figure 10: Emergency accommodation "tents" after 1954 earthquake



Source: (Orléansville, 1954).

2.2.2.2. The Second phase (Permanent reconstruction):

A plan for development and urban expansion was studied based on a population of 50,000 inhabitants divided into four regions, the urban centre and new surrounding areas: the **administrative city** of the east in 1954. It is the urban centre, where the temporary dwellings are for the European inhabitants, the **emergency city** to the west which was built in 1955-1956, was allocated to the indigenous population of "Algerians" and two suburbs: **La Ferme** and **Bocca Sahnoun** (now called Hai EL-SALAM) (see Map 8) and were linked by bridges and roads.

¹⁰ *Franc* is: "The standard unit of money used in France, Belgium, and Luxembourg before the introduction of the euro, and also used in Switzerland and many African countries"(Cambridge Dictionary, 2024).

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However, efforts have been focused on the reconstruction of the administrative city, where all the facilities have been planned for the economic revitalisation of the city where it came (Hotel Baudoin + Hotel des Postes + City Ville + Saint – Réparatus Shopping Complex + Culture and Sports Complex, etc.), and Physical reconstruction which has come with Various housing such as groups of (H.L.M) of 72 housing and cité est (C.I.A) of 88 housing, etc (Behel & Blanchard, 1958). If we compare the population taken into account in this plan with the population of 1954, estimated at 25.266 inhabitants (refer to table 7). An estimated increase of 24.734 inhabitants has been taken into account.

During this time, teams of Architects and urban planners were working on improving rural housing conditions by allocating 120,000 francs per family (Bouzouaid, 1991) to build houses instead of the houses known as " gourbi " ¹¹. However, the urbanization process in this affected area has been difficult due to several limitations, because it is:

- A delicate operation subject to the rules of a new anti-earthquake construction.
- An urgent operation to provide housing for residents as quickly as possible, and the restoration of basic activities for work.
- A difficult process due to the chaos and turmoil caused by this period's compatibility with the beginning of the national liberation war, as well as demographic growth and migration, which we will discuss in section 2.2.3 below.

2.2.3. Demographic growth and migration (after the 1954 earthquake):

As a result of the Orléansville earthquake, entire families have migrated to other cities to escape from the disaster. However, this phenomenon of external migration has led to internal migration by the inhabitants of the nearby suburbs towards the urban centre to exploit the dwellings

¹¹ *Gourbi* is defined by the Dictionary of (Larousse, n.d.) as: “*In traditional North Africa, the elementary home, is only illuminated by the door, and it is the habitat of the disadvantaged classes*”.

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left by immigrant families, as well as to live in their pre-fabricated housing, which was to be demolished after the population was relocated to their permanent residence. But, for this reason, they have not been demolished, as well as they have constructed "Toub" houses in the city, which has led to further urban expansion than expected.

In my demographic analysis of the urban area of Orléansville, I noticed a doubling of its total population, which was made up of Europeans and "Algerian" Muslims. This is illustrated by the table on the general development of the population (see Table 7) and the table on the rate of population growth ¹² (see Table 8).

Table 7: Evolution of the Chlef City Population From 1926 to 1977

| YEARS | POPULATION | | |
|-------|--------------------|-----------|--------|
| | "Algerian" Muslims | Europeans | Total |
| 1926 | 5.186 | 3.500 | 8.686 |
| 1936 | 7.420 | 3.850 | 11.270 |
| 1948 | 14.835 | 4.000 | 18.835 |
| 1954 | 20.390 | 4.876 | 25.266 |
| 1966 | 51.632 | - | 51.632 |
| 1977 | 79.965 | - | 79.965 |

Note: The population in this table includes both the urban population and the migrant population towards the urban agglomeration of Chlef.

Source: (Bouzouaid, 1991).

¹² **Note:** The population rates we give here are the Average annual growth rate for different periods using the "geometric formula", and then we multiply the result by 100 to get the final growth rate % (Vandeschrick, 2022).

the formula is: $r = \sqrt[t]{\frac{P(t)}{P(0)}} - 1$

r: Growth rate.

P (t): Estimated population in the new period.

P (0): Estimated population in the old period.

t: Period amplitude.

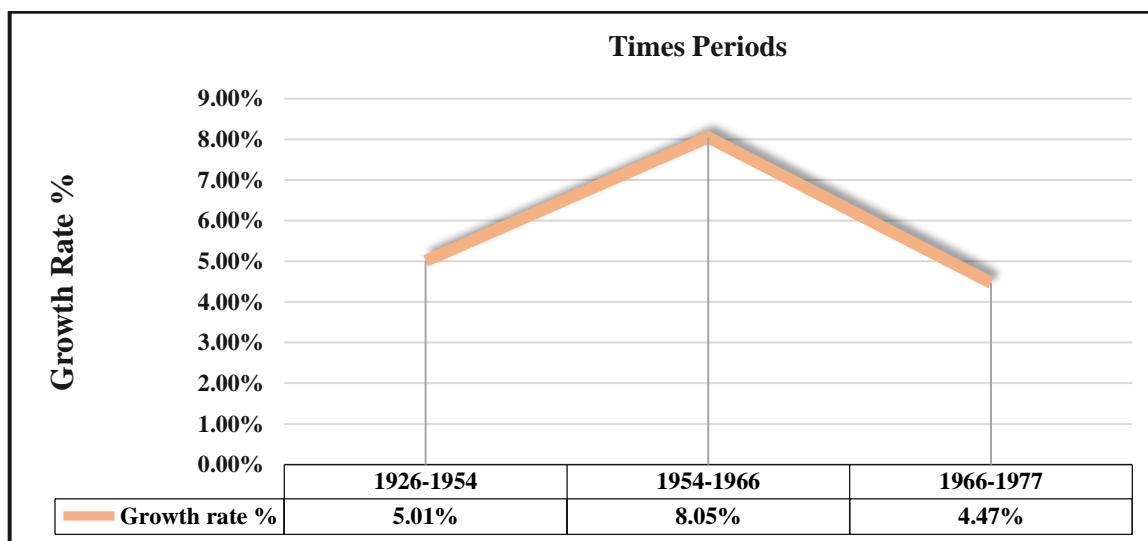
Table 8: Growth Rate of Chlef City During (1926-1954),(1954-1966),(1966-1977)

| Times Periods | Growth Rate % | |
|------------------|---------------|-----------|
| | Algerian | Europeans |
| 1926-1954 | 5.01 | 1.19 |
| 1954-1966 | 8.05 | - |
| 1966-1977 | 4.47 | - |

Source: Author based on data in table 7,2024.

The Algerian population grew more than the European population between 1926 and 1954. In 1926, Algerians made up 59.70% of the population, which increased to 80.70% by 1954. This indicates that they grew by 21%, with a growth rate of 5.01% in just 28 years(see Figure 11). On the other hand, the European population declined from representing 40.29% in 1926 to only 19.29% in 1954 of the total population, which is an estimated 1.19% growth rate. The indigenous population experienced a higher growth rate due to their natural population dynamics compared to the Europeans.

Figure 11: Growth Rate curve during periods (1926-1954),(1954-1966),(1966-1977)



Source: Author based on table 8,2024.

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Between 1954 and 1966, the Algerian population grew rapidly from 20,390 to 51,632 inhabitants (we focused on an Indigenous population" Algerian" only because we didn't have data about the European population after 1954), which means that in 12 years the population increased by 31.242 inhabitants, and with a growth rate of 8.05%. This rapid increase in the population is due to the large-scale migration that occurred from rural to urban areas, with an estimated 23.163 migrants arriving during this period, accounting for 74.1% of the total (return to Table 9), bringing an average of 1,930 additional people annually.

While the natural urban population (without migration) represented 8.079 inhabitants or only 25.9%, therefore, the majority of the population increase during the 1954-1966 period was due to immigration.

Table 9: Population growth of Orléansville during the periods 1954-1966 and 1966-1977

| Times Periods | POPULATION MOVEMENT | | | | | |
|---------------|---------------------|------|---------|------|--------|-----|
| | Migration | % | Natural | % | Global | % |
| 1954-1966 | 23.163 | 74,1 | 8.079 | 25,9 | 31.242 | 100 |
| 1966-1977 | 8.160 | 28,8 | 20.173 | 71,2 | 28.333 | 100 |

Source: (Bouzouaid, 1991).

If we look at the period between 1966 and 1977, there was an estimated increase of 28.333 inhabitants with a growth rate of 4.47%, this increase was lower than the previous period due to a decrease in migration to only 8,160 migrants. that means that only 816 people were brought on average annually.

The estimates are based on the previous *ibid* to the causes of why these changes have occurred:

a. **From 1954 to 1966:** migrations due to the impact of the September 1954 earthquake.

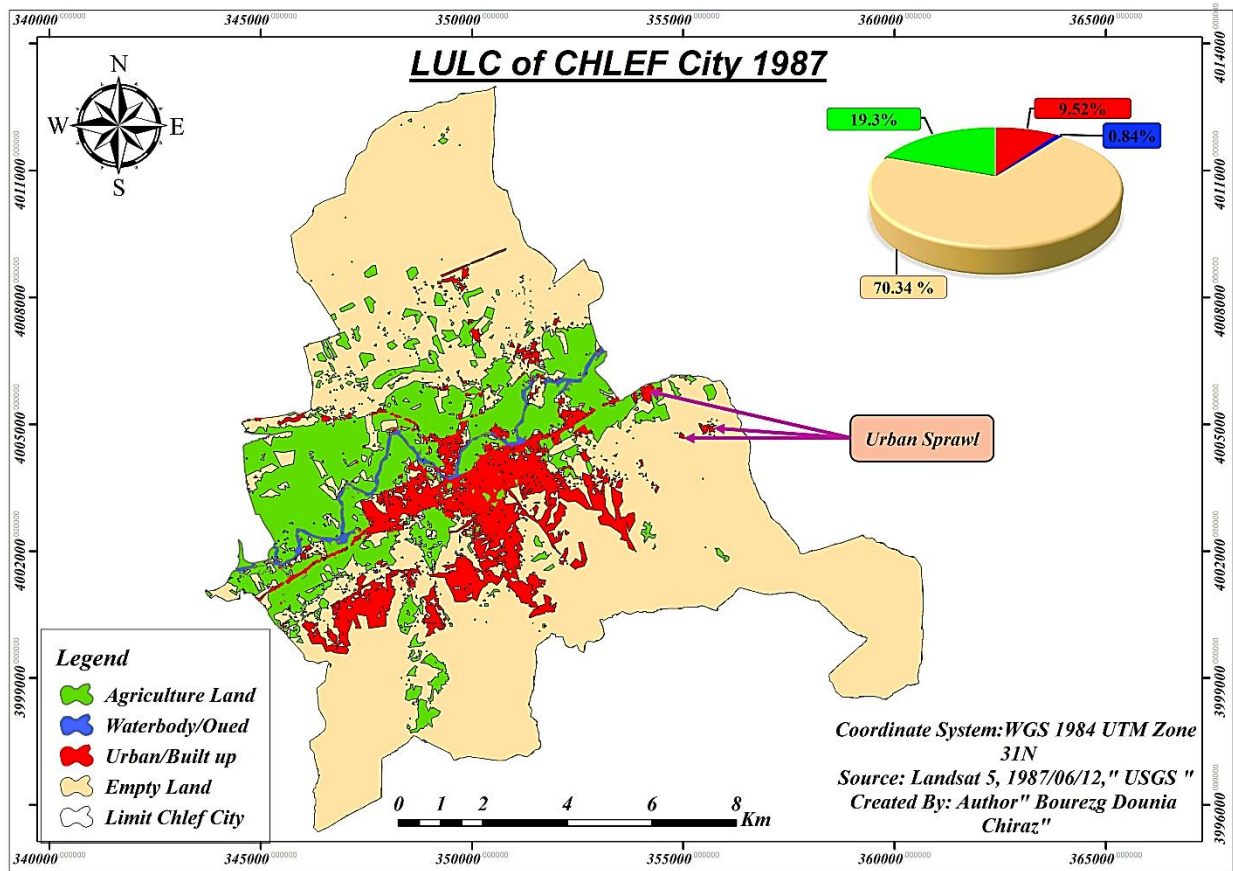
The earthquake led to the attraction of the population towards areas that were offering emergency relief programs, reconstruction, housing, economic development and employment opportunities (building workers, etc.). Additionally, after Algeria's independence in 1962, there was further migration towards the areas that were previously occupied by Europeans. The purpose of this migration was to benefit from the welfare, employment opportunities, facilities, and services that these areas provided to the population. As mentioned earlier in section 2.2.3, If we compare these urban areas to the countryside, the countryside is at a disadvantage.

b. **From 1966 to 1977:** migration was primarily driven by people's aspirations to secure a better life and seek employment opportunities. This reason remained consistent with the previous period. However, during this time, migration rates were low due to the trend of migration to larger cities, such as the capital city "Algiers", Oran, and even overseas to France.

2.3. Third period 1980-2023:

At this period, there have been many changes in the spatial development of Chlef, which in turn have been divided into two substages, from 1980 to 1987 and from 1987 to 2023. Still, I will analyse them together for comparison. So I noticed that since the total mass area of the agglomeration was 8.45 km² in 1980, accounting for 6.66 % (see Map 8 & Table 6), by 1987, this area had expanded to 12.1 km², representing 9.52% of the city's total area (see Map 9).

Map 9: LULC CHLEF City 1987



Source: Author, 2024.

The majority of this expansion was towards the southern part of the city. In addition, there was an urban sprawl in various parts of the city, with its spread to agricultural areas, which make up 24.51 km², or 19.3% (see Table 10). This represents the second largest area after the empty land, which covers 89.37 km², or 70.34%, while the smallest area is the Chlef Oued, accounting for only 0.84%.

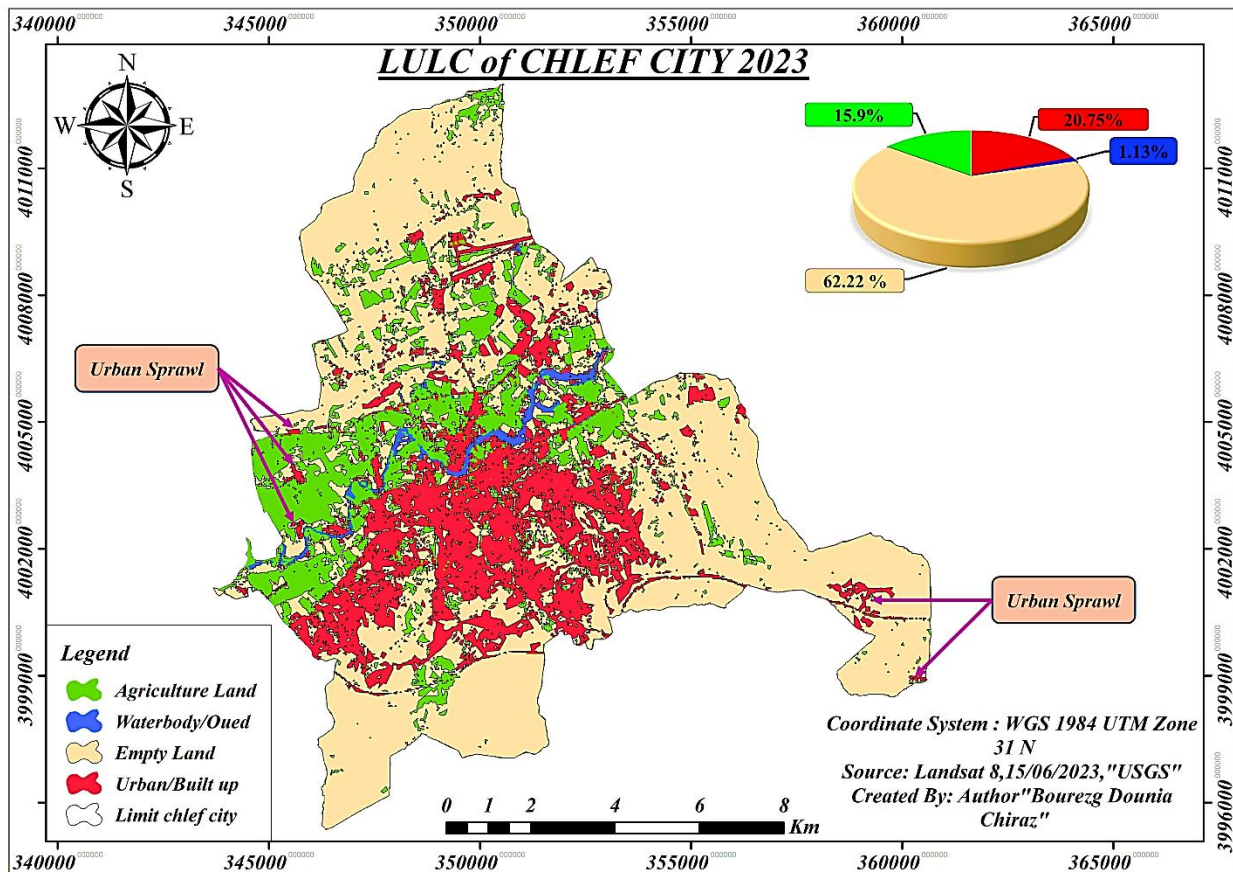
Table 10: LULC Classification of CHLEF City 1987

| Classification | Area Km ² | Percentage % |
|------------------|----------------------|--------------|
| Urban/Built up | 12.1 | 9.52 |
| Waterbody/Oued | 1.07 | 0.84 |
| Agriculture Land | 24.51 | 19.3 |
| Empty Land | 89.37 | 70.34 |
| Total | 127.05 | 100 |

Source: Author based on data from GIS automatic calculation (see Appendix D), 2024.

In comparing the built-up area between this period 1987 and 2023, we observed that in 2023 it covers 26.36 km², representing 20.75% (see Map 10). This indicates that urban sprawl has spread throughout the city, particularly in previously empty areas, which decreased from 89.37 km² in 1987 to 79.06 km² in 2023, a reduction of 10.31 km² (see Table 11). Additionally, there has been a decrease of 4.31 km² in agricultural land in 2023.

Map 10: LULC CHLEF City 2023



Source: Author, 2024.

Table 11: LULC Classification of CHLEF City 2023

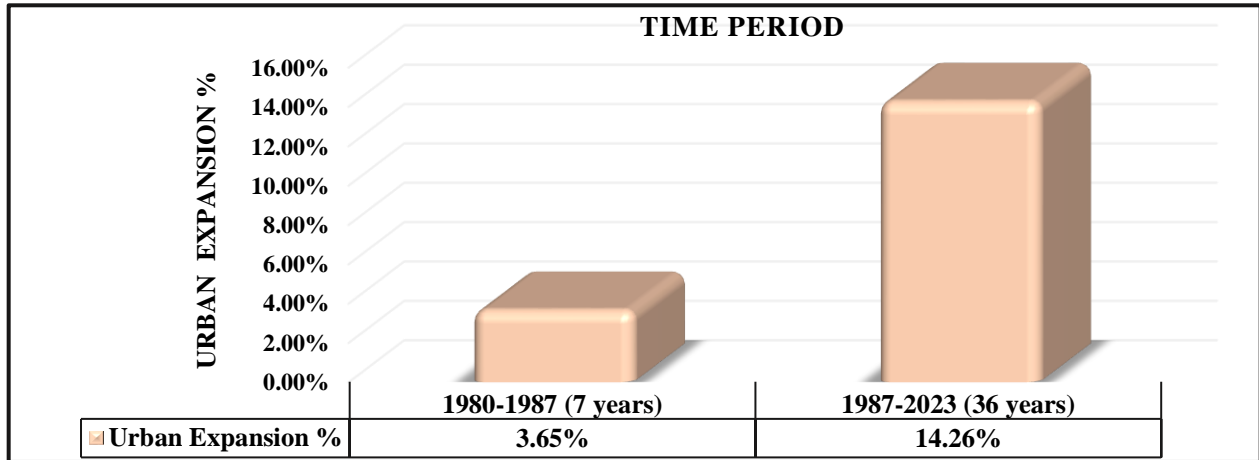
| Classification | Area Km ² | Percentage % |
|------------------|----------------------|--------------|
| Urban/Built up | 26.36 | 20.75 |
| Waterbody/Oued | 1.43 | 1.13 |
| Agriculture Land | 20.2 | 15.9 |
| Empty Land | 79.06 | 62.22 |
| Total | 127.05 | 100 |

Source: Author based on data from GIS automatic calculation (see Appendix E), 2024.

However, taking into account the length of time per period, the built-up area from the ellipse from 1980 to 1987 increased by an estimated 3.65 km², which means an average increase of 0.5

km² per year. From 1987 to 2023, it increased by 14.26 km², which means it increased by an average of 0.4 km² per year (see data Figure 12). These rapid expansions occurred in only seven (7) years, outpacing the growth over 36 years, due to the impact of the 1980 AL-ASNAM earthquake in the region.

Figure 12: Urban Expansion enter 1980-1987 & 1987-2023



Source: Autor, 2024.

2.3.1. Impacts of the 1980 earthquake disaster (causes of spatial development):

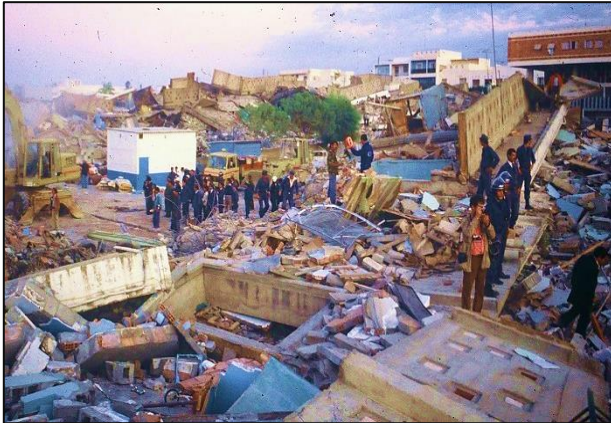
In 1980, AL-ASNAM City had just witnessed its last phase of rebuilding because of the Orléansville earthquake 26 years ago, but it was again destroyed in 10/1980, leaving 60,000 damaged houses and 140,000 destroyed houses (see Figure 13 & Figure 14).

Figure 13: Photos of Destroyed Infrastructure in EL-ASNAM after the 1980 Earthquake



Source : (Boutaraa, 2019).

Figure 14: Photo of Destroyed Building in EL-ASNAM after the 1980 Earthquake



Source:(Hichem, 2018).



Source:(saliha, 2014).

In the face of this disaster, one day later, the President of Algeria established an Inter-Ministerial Reconstruction Commission (UN-HABITAT & IFRC, 2009) to save lives, evaluate losses and formulate a policy for the reconstruction of AL-ASNAM in the shortest possible time with a view to the resettlement of the population and the resumption of both social and economic activities of the agglomeration.

2.3.2.Economic aspect & physical reconstruction (after the 1980 earthquake):

After the discussion with the committee appointed, a decision was taken to maintain the current location of AL-ASNAM City, but a requirement was made that a seismic microzonation ⁸ the study should take place before the reconstruction And that's under (RPA81). The plan took two basic phases:

2.3.2.1.The first phase (temporary reconstruction):

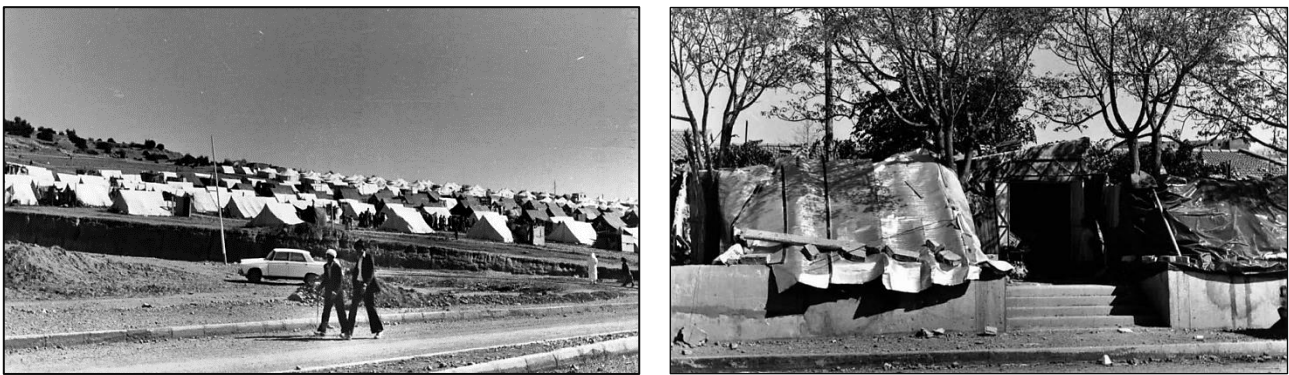
Similar to the previous disaster, the emergency shelter relied on tents and self-built shelters for one year (see Figure 15) before new sites with prefabricated housing were established. This

⁸ *seismic microzonation* is defined by (Walling & Mohanty, 2009) as: “*the subdivision of a region that has relatively similar exposure to various earthquake-related activities or the identification of individual areas having different potential for earthquake effects*”. In following this area zoning, the nature of land uses is changed. For example, built-up lands can become green spaces, vacant spaces, or vice versa.

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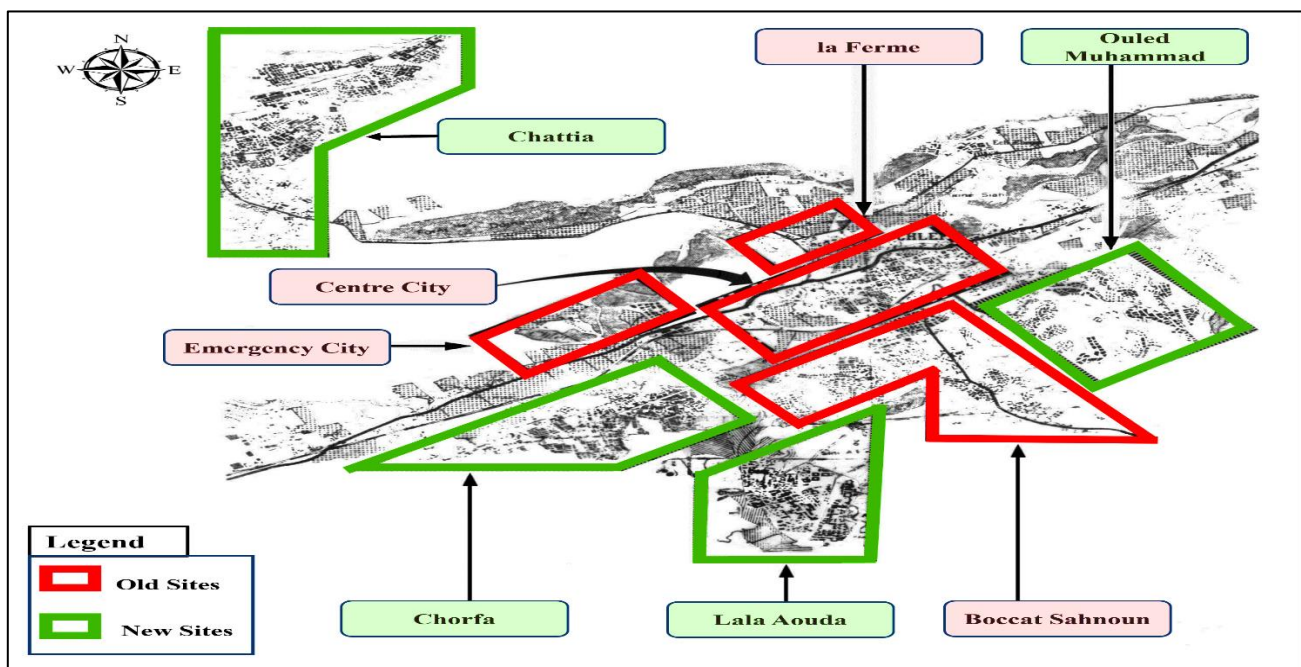
program involved the installation and assembly of 20,000 prefabricated dwellings (Refer to the same ibid), distributed for temporary use (expected 20-year occupancy) to four sites. Three of these sites were located on the perimeter of the destroyed city (the Ouled Muhammad neighbourhood, the Lala Aouda neighbourhood, and Chorfa), while the fourth site (Chattia) was located 10 kilometres outside the city, separated by agricultural areas, providing it with autonomy (see Figure 16).

Figure 15: Tents on the left & self-built Shelters on the right



Source: photo taken by " Giles Whitcombe " (UN-HABITAT & IFRC, 2009).

Figure 16: The Old & the New Sites of EL-ASNAM-CHATIA



Source: (Bouzouaid, 1986) it was modified by Author, 2024.

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The selected areas have been chosen for construction based on seismic considerations and have been contracted to be built by various foreign companies for a total of 19.180 billion francs (refer to Table 12). Additionally, at this stage, 20,000 housing units were planned to be constructed in rural areas, but none of them were built due to two reasons:

1. It is challenging to distribute construction materials to numerous locations due to the dispersed and inaccessible nature of rural housing.
2. The construction of these houses must adhere to earthquake resistance regulations, necessitating modern techniques and various resources, particularly in rural areas. However, these may not be readily available to the responsible authorities for program implementation.

Table 12: Emergency Programme (Temporary housing) for Prefabricated housing and its builder

| country | FIRMS | NUMBER OF HOUSINGS | TOTAL in Franc |
|----------------|----------------|----------------------------|----------------|
| FRANCE | Batimex | 3.000 | 5.000 |
| | Leroy | 1.000 | |
| | Prisme | 600 | |
| | Emile Houot | 400 | |
| ITALY | Officine Saira | 1.000 | 4.278 |
| | Coprel | 900 | |
| | Bortolazo | 850 | |
| | Sciel | 828 | |
| Denmark | Architettura | 700 | 3.100 |
| | Jespersen | 1.000 | |
| | Roslev House | 900 | |
| | Hosby House | 600 | |
| BELGIUM | Homes | 600 | 2.800 |
| | Nobels | 1.400 | |
| | Lamy | 800 | |
| | Acoma | 400 | |
| CANADA | Immoly | 200 | 1.774 |
| Treco | 1.774 | | |
| PORTUGAL | A+P | 1.028 | 1.028 |
| GREAT BRITAIN | Guildway | 400 | 800 |
| | Adda System | 400 | |
| SWISS | Durisol | 400 | 400 |
| SPAIN | Dragados | Educational Establishments | - |
| LUXEMBOURG | Luxtrening | Educational Establishments | - |
| TOTAL in Franc | - | - | 19.180 |

Source: OPGI & ANAT cited in (Bouzouaid, 1986) .

At this stage, activities involving services, schools, etc. were resumed before the end of 1982.

2.3.2.1.1. The spatial distribution of the population of AL-ASNAM (after the 1980

earthquake):

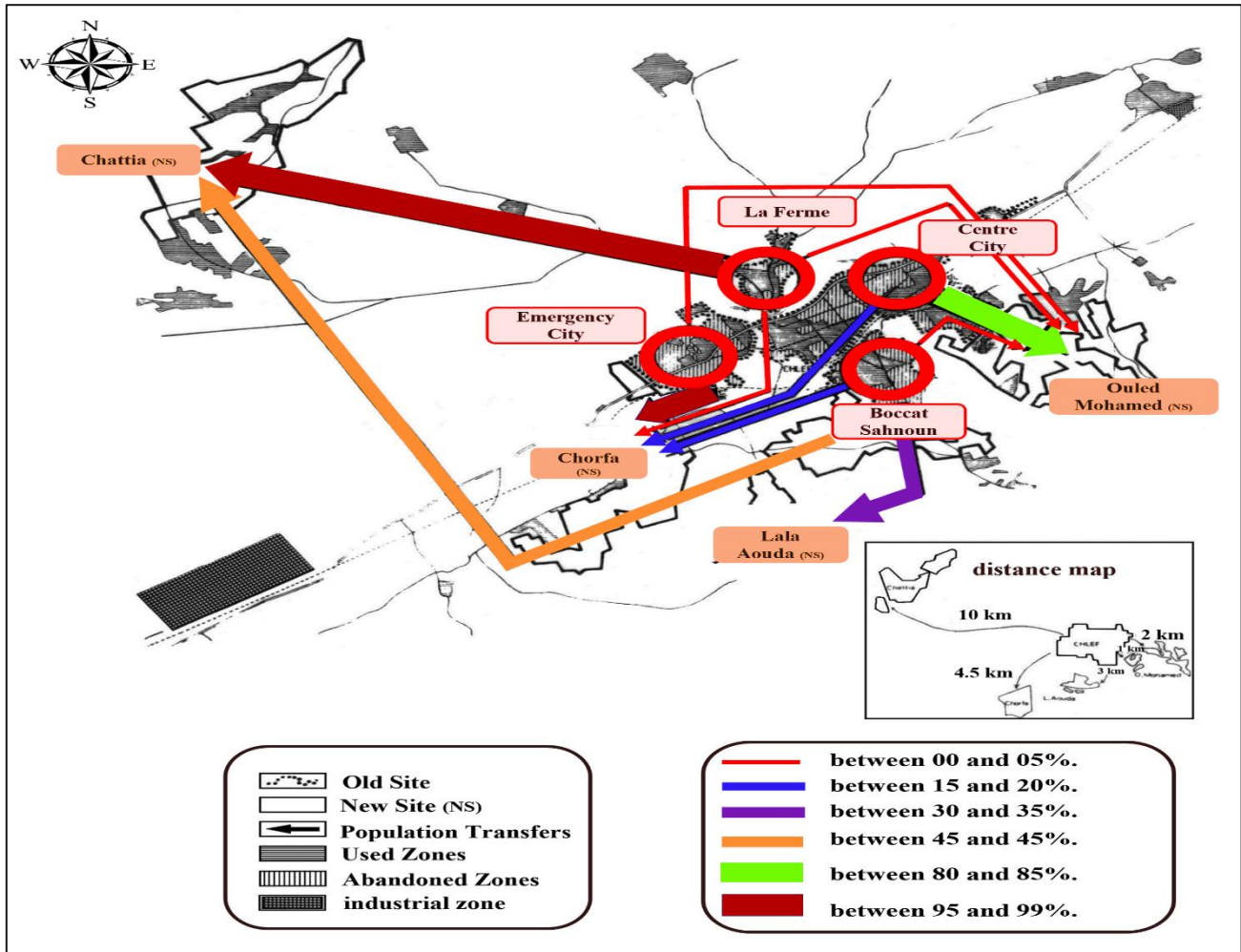
Due to the division of the city of AL-ASNAM into four major sites around the perimeter of the ancient urban sites. The relocation of the population at this stage has been carried under the concept of "**unity of the neighbourhood**," which means The government has relocated families to areas closer to their previous neighbourhoods. People from the same previous urban environment have been housed together in these new areas, meaning an attempt by the authorities to re-produce the old urban fabric (central city, la Ferme, Boccat Sahnoun and the Emergency City) by distributing the population of these areas to the four new sites (Ouled Muhammad, Chattia, Lala Aouda, and Chorfa) respectively. However, the new sites cannot accommodate the same population as the old sites. For that reason, the distribution process has not been followed consistently (refer to Table 13 & Figure 17) shows how citizens from each region have been allocated to the new prefabricated housing areas.

Table 13: Distribution of the population of the old sites across the new sites

| Old Sites % | Prefabricated Sites % | | | |
|----------------|-----------------------|---------------|--------|------------|
| | Chattia | Ouled Mohamed | Chorfa | Lala Aouda |
| Centre City | - | 82,9 | 17,1 | - |
| Boccat Sahnoun | 46,8 | 01,3 | 19,5 | 32,4 |
| La Ferme | 98,1 | 01,1 | 00,8 | - |
| Emergency City | - | 01,4 | 98,6 | - |

Source : *(Bouzouaid, 1986)*.

Figure 17: The Rehousing Sites for the Residents of EL-ASNAM

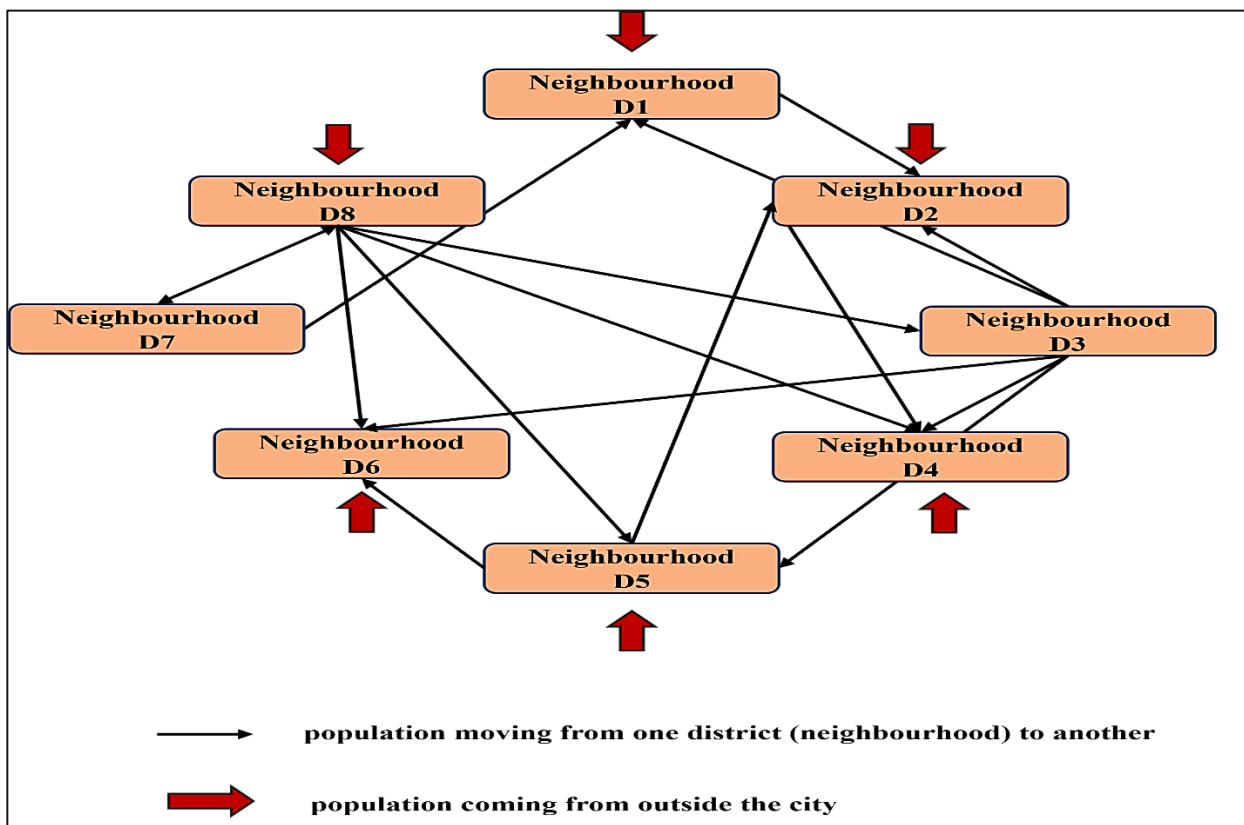


Source: same source mentioned before, it was modified by Author based on table 13,2024.

The population of the central city has been distributed to each of Ouled Muhammad by 82.9% and to Chorfa by 17.1%, in La Ferme the residents were distributed as follows: 98.1% in Chattia, 01.1% in Ouled Muhammad, and 00.8% in Chorfa. Given the large size of the Chattia site, 46.8% of the site was occupied by the residents of Boccat Sahnoun. The remaining population was distributed to other sites as follows: 01.3% to Ouled Muhammad, 19.5% to Chorfa, and 32.4% to Lala Aouda. Furthermore, 98.6% of the residents of Emergency City were transferred to Chorfa, while the remaining 01.4% were transferred to Ouled Muhammad.

According to the 1983 report of Schema director of planning and urbanism of Echlef, the temporary sites have all public utilities and small-business activities. However, the various economic sectors, including the administrative, economic, cultural, and social sectors, are still located in the old centre. This indicates that these new sites will remain secondary terminals under the old core pole. This creates another phenomenon of population movements and migration between the old and new sites illustrated in (Figure 18).

Figure 18: Movements & Migration between Neighbourhoods



Source: same source mentioned before, it was modified by Author, 2024.

2.3.2.2. The second phase (Permanent reconstruction):

At this stage, a programme of economic and social restoration of the city has been developed, whereby it has been set up in a subsidiary form in both secondary and dispersed communities, mainly in the main urban area, as well as to rebuild large numbers of public buildings and stimulate productive relations.

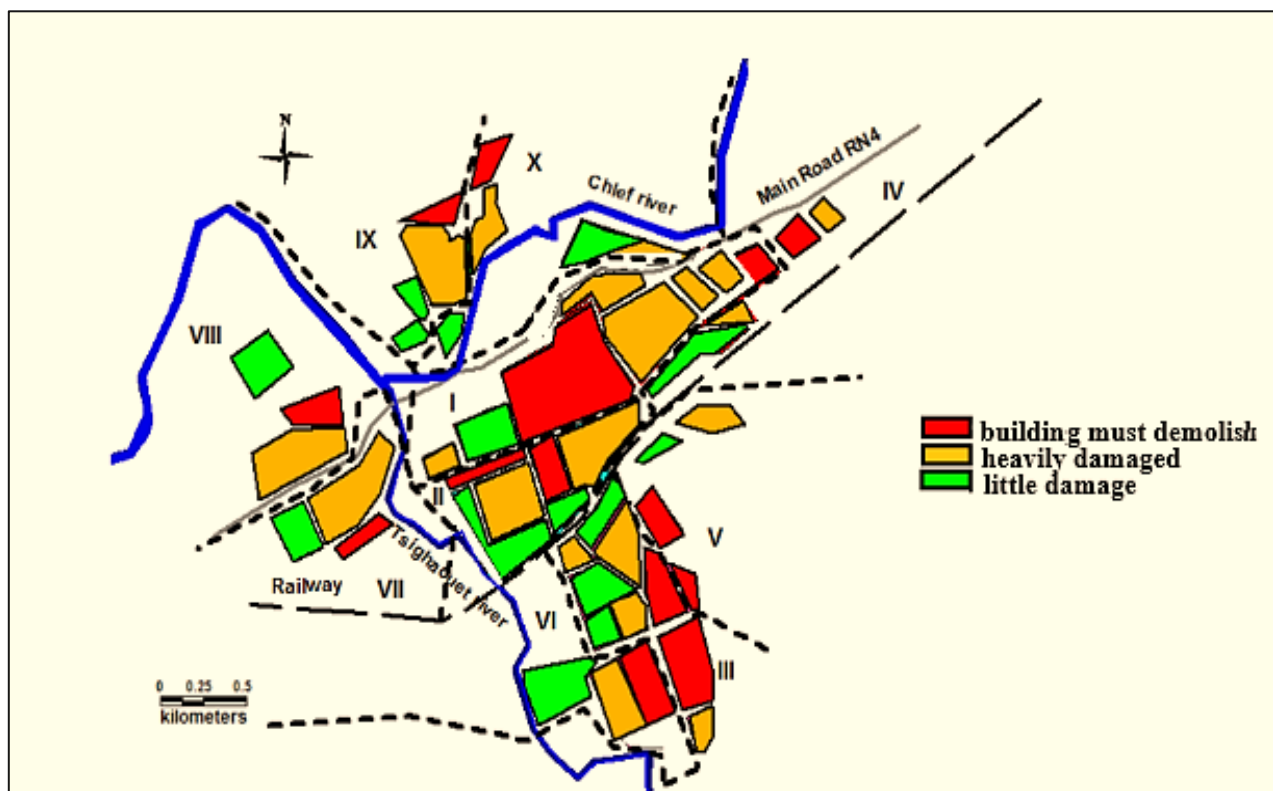
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Furthermore, renovating⁹ and reconstructing buildings that can be recovered in the main old urban sites of AL-ASNAM have also been completed. CTC divided the city into 10 areas according to the risk level (see Figure 19) and all buildings in each region were classified into three basic categories (see Table 14):

- Green buildings: they have little damage and they need small repairs.
- orange buildings: they're heavily damaged and require major repairs.
- red buildings: they can't be repaired and they need to be destroyed.

In addition to the existence of undefined buildings, these are ungraded dwellings.

Figure 19: Zones & Building Damage Classification of EL-ASNAM City after 1980 Earthquake



Source: (Boutaraa, 2019) based on the plan in Appendix F.

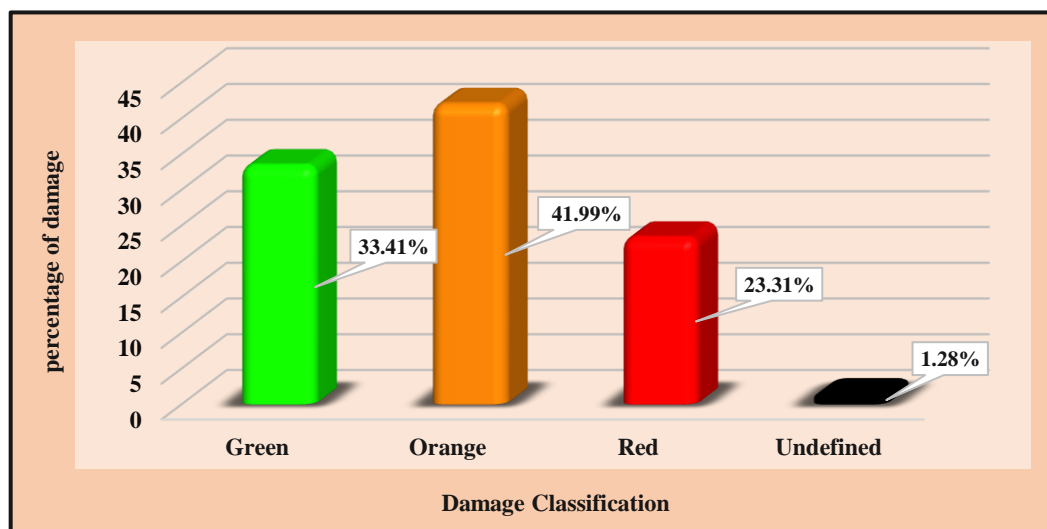
⁹ **Renovating** is defined by (Britannica Dictionary, n.d.-a) as: “to make changes and repairs to (an old house, building, room, etc.) so that it is back in good condition”

Table 14: Zone & Building Damage Classification of El-Asnam City after 1980 Earthquake

| Zones | Total Number of Buildings | Damage classification | | | | | | | |
|-------|---------------------------|-----------------------|-------|--------|-------|--------|-------|-----------|------|
| | | Green | | Orange | | Red | | Undefined | |
| | | Number | % | Number | % | Number | % | Number | % |
| I | 566 | 108 | 19.08 | 341 | 60.24 | 116 | 20.49 | 1 | 0.17 |
| II | 360 | 112 | 31.11 | 164 | 45.55 | 80 | 22.22 | 4 | 1.11 |
| III | 715 | 154 | 21.53 | 322 | 45.03 | 238 | 33.28 | 1 | 0.13 |
| IV | 256 | 97 | 37.89 | 98 | 38.28 | 61 | 23.82 | 0 | 0.00 |
| V | 686 | 219 | 31.92 | 253 | 36.88 | 214 | 31.19 | 0 | 0.00 |
| VI | 964 | 429 | 44.50 | 389 | 35.16 | 185 | 19.19 | 11 | 1.14 |
| VII | 343 | 161 | 46.93 | 132 | 38.48 | 38 | 11.07 | 12 | 3.49 |
| VIII | 367 | 156 | 42.50 | 157 | 42.77 | 40 | 10.89 | 14 | 3.81 |
| IX | 490 | 136 | 27.75 | 243 | 49.59 | 99 | 20.20 | 2 | 2.44 |
| X | 384 | 146 | 38.02 | 109 | 28.38 | 129 | 33.59 | 0 | 0.00 |
| Total | 5,131 | 1,718 | 33.41 | 2,158 | 41.99 | 1,200 | 23.31 | 55 | 1.28 |

Source : (Bertero & Shah, 1983).

Figure 20: Column of Building Classification in EL-ASNAM City



Source: Author based on table 14, 2024.

Through the table above and the figure No.20, we note that "Orange Buildings" rank first at 41.99%, followed by "Green Buildings" at 33.41%, "Red Buildings" rank third at 23.31% and finally "Undefined Buildings" at 1.28%.

Regarding the financing of reconstruction, the State has implemented two approaches:

CHAPTER 3: Chlef Urban Expansion

1. At its Self-funding and independent execution for infrastructure, public buildings, employee housing, and municipal facilities.
2. Providing partial financial support and oversight for privately owned residences where residents are responsible for restoration ¹³ and repairs. The amount of assistance is determined based on the extent of damage to the dwelling (refer to Table 15 for details).

Table 15: The amount of assistance for improving or repairing private dwellings in old sites

| AMOUNT OF COMPENSATION (In DA) | | | | | |
|--------------------------------|---------------------|-----------------------------------|---------------------------------------|---------------------------------------|-------|
| REPARATIONS | | 7.000-7.200 8.400-9.600 (A) | 10.000-10.800 14.800-18.000 (A) | 10.000-10.800 14.800-18.000 (B) | Total |
| Completed | Old perimeter | 23.5 | 04.4 | 02.7 | 30.6 |
| | Prefabricated Sites | 20.2 | 03.5 | 01.4 | 25.1 |
| Non Completed | Old perimeter | 12.8 | 05.2 | 03.0 | 21.0 |
| | Prefabricated Sites | 20.9 | 01.3 | 01.1 | 23.3 |
| Total | | 77.4 | 14.4 | 08.2 | 100% |

Note: (A) ➡ A single allowance for a single dwelling unit in the old perimeter.

(B) ➡ Two members of the family received an allowance in the same housing unit.

Source: (Bouzouaid, 1991).

Regarding the owners of destroyed real estate, the Government has provided alternative properties while following the rights of each individual. Furthermore, the Government has offered partial assistance for rural housing. As part of the urbanization plan in AL-ASNAM city, divided the various structures into three categories before rebuilding them, according to the seismic microzonation, namely:

¹³ **Restoration** is defined as: “the act or process of returning something to its original condition by repairing it, cleaning it, etc” (Britannica Dictionary, n.d.-b).

CHAPTER 3: Chlef Urban Expansion

Category 1 (important structures): includes hospitals, official buildings, etc. It can only be built in areas that are not in danger of earthquakes.

Category 2 (common structures): include housing, schools, administration, etc. It's in areas where the seismic threat is low.

Category 3 (microstructures): includes storage stores, warehouses, etc. They are in high-risk areas.

However, regardless of the location of the structures and buildings, their techniques must conform to seismic regulations.

2.3.3. Demographic growth and migration (after the 1980 earthquake) :

The disaster devastated a segment of the city's population, but it ultimately led to a subsequent population surge, particularly following the resettlement of residents in new areas. This trend is evident in Table No.16. In 1980, the population stood at 120,000 inhabitants (representing the survivors of the disaster), while the total number of migrants was -1,119, indicating the migration of affected inhabitants from AL-ASNAM to safer regions. From 1981 to 1983, there was a natural population growth of 16,633 inhabitants, reflecting an estimated growth rate of 6.60%, alongside a noteworthy surge in the number of immigrants to the city, estimated at 11,537 inhabitants.

Table 16: Overall population growth & migration in EL-ASNAM during the period 1980-1983

| Years | Populations | Migration |
|-------|-------------|-----------|
| 1980 | 120.000 | -1.119 |
| 1981 | 122.000 | +4.147 |
| 1982 | 130.030 | +3.550 |
| 1983 | 138.633 | +3.840 |

Source: (Bouzouaid, 1984).

We return these forces of attraction to AL-ASNAM for several reasons:

- Migration causes in the (temporary reconstruction period):

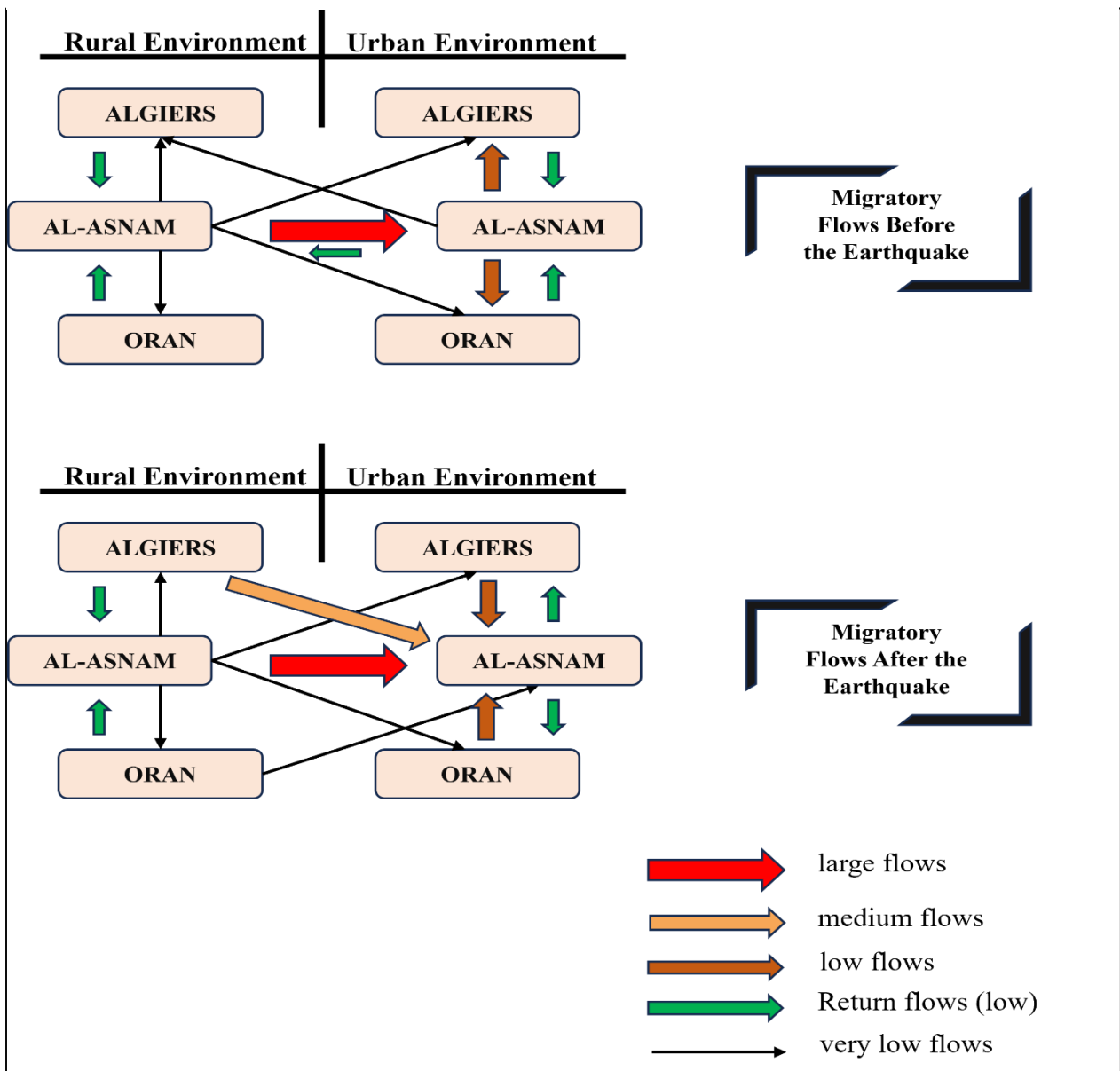
- People from rural areas such as (Sendjas, Ouled Fares, etc.), or other places go to AL-ASNAM to enquire about the fate of their relatives (refer to Figure No.21).
- Taking advantage of the benefits provided to the victims of the earthquake (such as food, medical supplies, clothing, etc.), caused a lack of accuracy in the numbers of the victims.
- To take advantage of the prefabricated dwellings in the new areas and the facilities and small businesses they contain, which is because the authorities have prioritised providing relief to the city of AL-ASNAM in particular, unlike in rural areas.

- Migration causes in the (permanent reconstruction period):

- The migration of the deceased's family members to AL-ASNAM to assert their rights over their property, particularly in light of the land confiscations and compensations being granted to the local population during this period. Due to the prolonged administrative processes, the presence of these relatives has become a permanent fixture.
- The migration for work is due to the reconstruction of the old site, which is a labour-intensive operation. The country has spent \$5.2 billion on this project, which is estimated to be 22% of the GDP of the country at the time (*El Asnam Algeria 1980, 2016*).
- The return migration of inhabitants who temporarily emigrated in the first period, as well as the migration of people from rural areas of major cities like Algiers and Oran to AL-ASNAM (refer to Figure No.21), is aimed at enhancing their standard of living

by accessing the services, infrastructure, and overall well-being that this revitalized region has to offer.

Figure 21: Intensity of Migration Flows between EL-ASNAM, ALGIERS & ORAN (Urban & Rural)



Source : (Bouzouaid, 1991) it was modified by Author, 2024.

CHAPTER 3: Chlef Urban Expansion

When comparing the capacity inhabitants by the initial city's urban plan (AL-ASNAM with the Chattia area) which ranges from 170,000 to 180,000 inhabitants to the population in 1980, it is clear that this is more than the population at the time, which means that they took into account an increase of between 50,000 and 60,000. However, considering the continuous population growth and the anticipated utilization of the available lands, it's clear from Table No.16 that the population has increased from 120,000 in 1980 to 206.177 inhabitants in 2002, more than the urban plan anticipated.

Table 17: Population growth in the city of EL-ASNAM with CHATTIA during the period 1980-2023

| Years | Populations | | |
|-------|-------------|---------|---------|
| | AL-ASNAM | CHATTIA | Total |
| 1980 | - | - | 120.000 |
| 2002 | 146.157 | 59.960 | 206.177 |
| 2008 | 178.166 | 71.408 | 249.574 |
| 2023 | 250.575 | 100.183 | 350.758 |

Source: Author based on data from ONS population estimates for Chlef state in 1980, 2002, 2023 & RGPH of 2008.

Consequently, there has been significant horizontal expansion "urban sprawl", in the region, indicating a disregard for the urban plan. Notably, the population of the city of Chlef alone (without Chattia) reached approximately 250,575 in 2023, leading to further expansion and covering 26.36 km², or 20.75% of the total area (refer to Map 10). This expansion came with Consequences that we will discuss in the next section.

3. Consequences of urban expansion:

The development of the city of Chlef has been marked by fragmented decisions, particularly in the aftermath of earthquakes. These decisions were made in response to the immediate crisis, without adequate consideration of the long-term implications of urbanization. These outcomes can be categorized into two levels:

3.1. At the urban level:

The city's repeated reconstruction has led to the development of three different types of dwellings:

3.1.1. Prefabricated dwellings: the dwellings that came during the period of temporary reconstruction and were eventually converted into permanent dwellings due to the migration process. That is because the construction process for permanent dwellings took longer than expected, and there were delays in the compensation program for the affected population, which was first observed in January 2009. However, these dwellings distorted the city's urban landscape (see Figure 22). According to Mr. M. Arkoub in 2023, 95% of these dwellings have been replaced. Over 16,500 people have received assistance from the National Housing Fund, while around 2,000 units have not received compensation due to various reasons, such as their inclusion in other housing programs or conflicts between landlords, etc (APS, 2023).

Figure 22: Prefabricated Dwellings of Chlef City

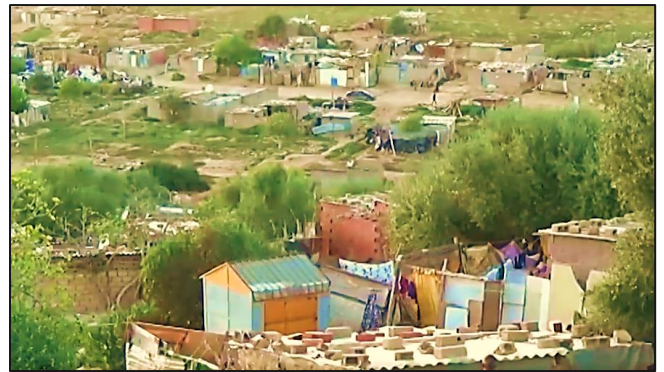


Source: (Boukhtache, 2021).

3.1.2. Current dwellings: are both anti-earthquake and non-earthquake-resistant which lack appropriate safety measures. This is a result of the population forgetting the psychological effects of the 44-year-old AL-ASNAM earthquake and the lack of control by the authorities over building code violations. Additionally, many people cannot afford earthquake-resistant construction, even with government assistance, which is estimated at 2.000.000 Algerian dinars (Decree n° 09-01, 2009).

3.1.3. Slum dwellings: Unplanned housing that does not adhere to the regulations of the Reconstruction Act reflects the ongoing processes, growth, and urban sprawl in Chlef City due to population growth, migration, and rural displacement. This distorts the city's urban landscape and spreads low standards of living in the city (see Figure 23), which hinders its sustainability.

Figure 23: Slum Dwellings in "The Neighbourhood of Abbas Brother " in Chlef City



Source: (Belkacemi, 2019).

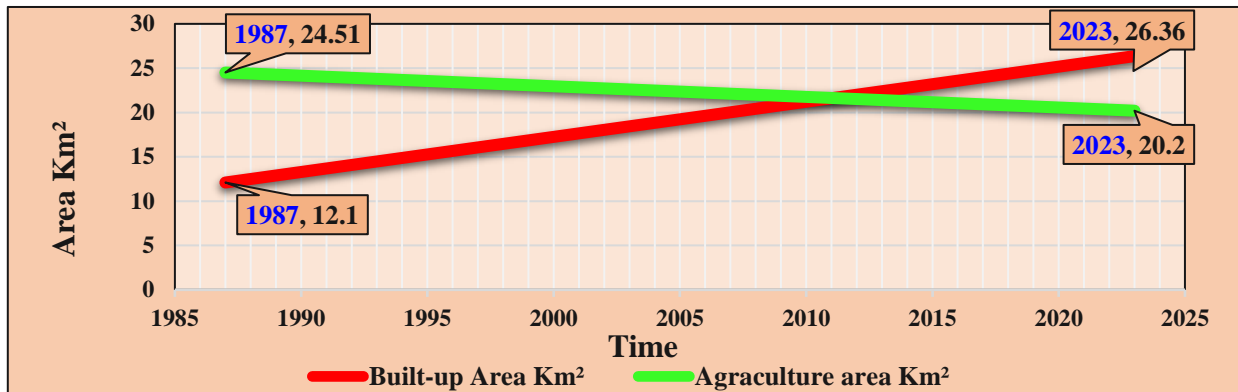
3.2. At the environmental level:

In the previous LULC maps (return to Map 9 & map 10), we observed a decrease in agricultural land areas from 24.51 km² in 1987 to 20.2 km² in 2023, which indicates a decrease of 4.31 km² over 36 years. This decline was accompanied by urban sprawl and an increase in the size of built-up areas (refer to Figure 24), showing that as construction increases, agricultural land decreases - an "urban sprawl phenomenon at the expense of agricultural land" (see Figure 25). This

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poses a problem due to the reduction of fertile land for agriculture and the instability of such land, which is particularly vulnerable due to its alluvial soil ¹⁴ nature, especially during strong earthquakes.

Figure 24: Scatterplot of Built-up area vs Agriculture area over time



Source: Author based on table No.10& table No.11,2024.

Figure 25: Aerial Images Show the Urban Sprawl at the expense of Agricultural land in Chlef City



Source: Author based on Google Earth & Google Maps Aerial images,2024.

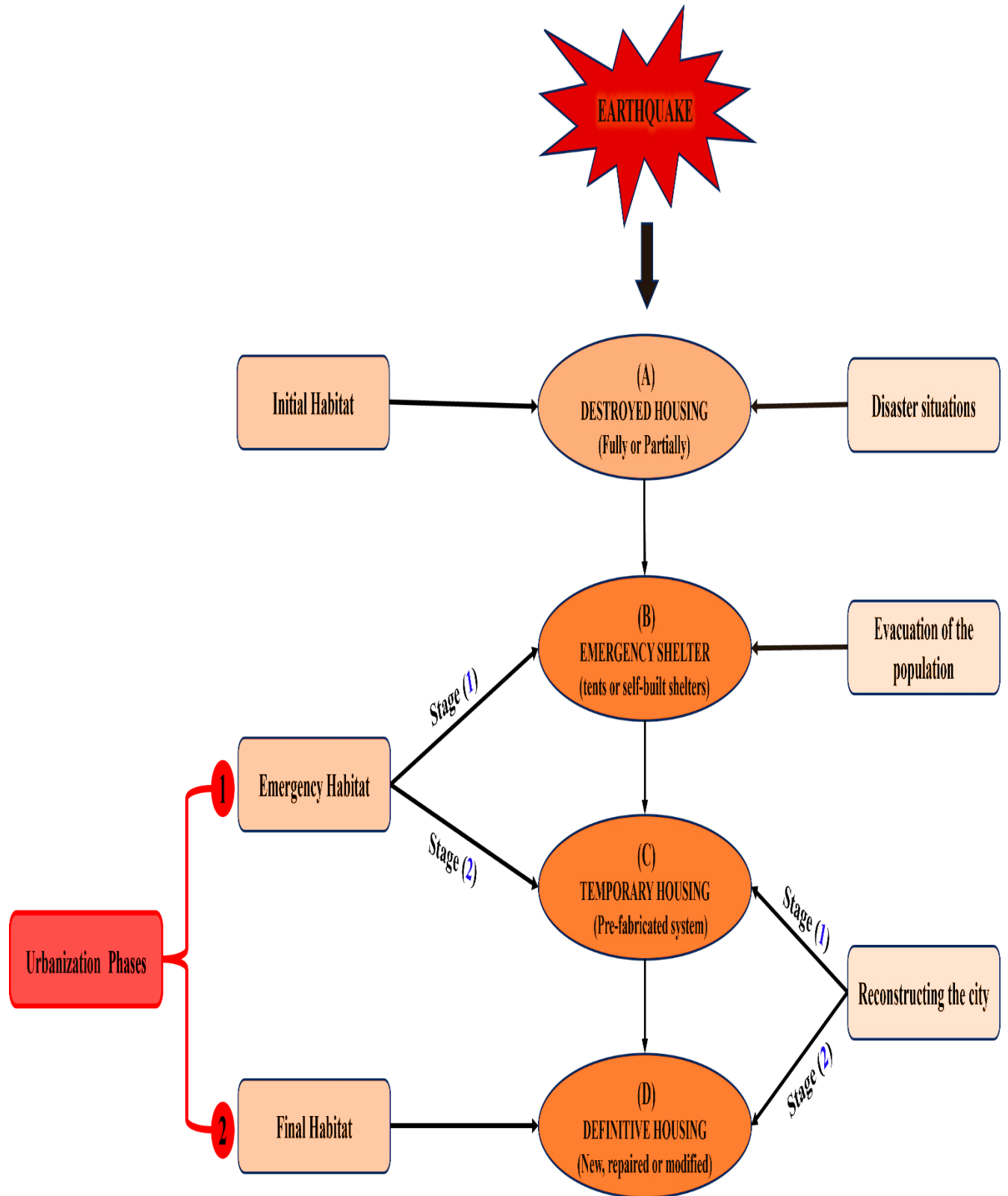
¹⁴ *alluvial soil* is defined by *USDA (U.S. DEPARTMENT OF AGRICULTURE)* as: “Soils that have developed over time as sediments are deposited by the periodic flooding of streams or rivers”(USDA, 2017).

4. Summary:

Based on the provisions outlined in this chapter and our analysis of the urban expansion of Chlef City, along with our assessment of the impact of earthquakes on physical reconstruction and economic aspects, as well as demographic growth and migration, we have concluded that post-earthquake urbanization and housing occurs in multiple stages, which can be summarized in Figure No.26.

However, in our view, we believe that in the period of temporary reconstruction, the decision to import prefabricated housing after the AL-ASNAM earthquake is deemed impractical from technical, economic, and social standpoints. This is particularly relevant as Algeria is a developing country rather than a developed country, and although it has the means to afford these imports, it has placed a significant strain on the country's finances, in addition to the costs associated with permanent reconstruction, which took a long time. This has resulted in the shift from temporary housing to a term of permanent housing, the effects of which continue to manifest in the city as a form of reconstruction, resulting in urban distortion in the region, as well as the emergence of urban sprawling, and continuing urbanization at the expense of agricultural land and the construction of dwellings that do not take into account the criteria of seismic safety norms.

Figure 26: Diagram Showing the Evolution of Urbanization & Housing Stages Post-Earthquake



Source: (Bouzouaid, 1991) it was modified by Author, 2024.

Chapter 4

Conclusion

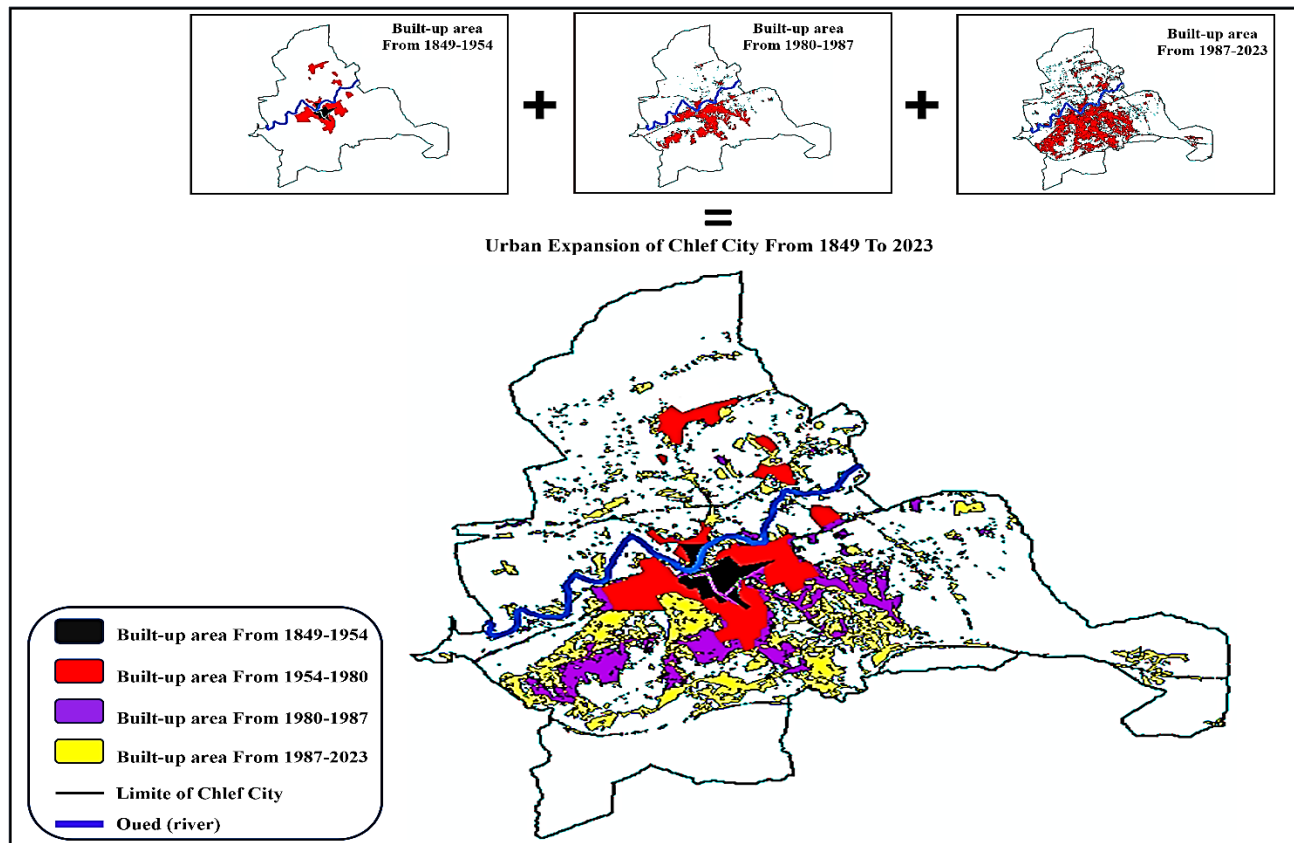
1. Introduction:

This chapter will provide a summary of the main research findings, address the research aims, answer the research questions, confirm the validity of the assumptions presented earlier in this thesis and give general Recommendations. Additionally, it will the study will suggest and propose opportunities for future research.

2. Answer the thesis questions and verify the assumptions :

From what has already been discussed in Chapter 4, we have concluded that the extraordinary expansion of Chlef City during its various periods took place rapidly and fundamentally between 1954-1980 and 1980-1987 we can see this clearly in Map No.11, which means that the spatial development of Chlef was impacted by both the 1954 Orléansville earthquake and the 1980 EL-ASNAM earthquake, respectively.

Map 11: Chlef City Urban Expansion Map Synthesis From 1849 To 2023



Source: Author, 2024.

therefore, we answer the questions of the thesis that we put in Earlier :

Question 1, Section 1: Why is the Chlef City experiencing continuous urban expansion, despite its presence in a seismic geographical area?

The answer is: Although Chlef City is located in a seismic zone, it suffers from continuous urban expansion for several causes, since the causes for This expansion has one major cause:

The cause of the political decision: We have noted that during both disasters, whether the 1954 disaster or the 1980 disaster, urgent political decisions were taken to deal with the impact of these devastating disasters on the city at various levels, whether social, economic or urbanization. This decision thus showed other subsidiary causes:

- 1) **the physical reconstruction cause:** During every period of the urban expansion of the city, which we discussed in the previous chapter, it became clear that whenever a powerful earthquake destroyed its buildings, the city would experience rapid, Exceptional spatial development. This was due to the political decision to rebuild it quickly to provide all the population's needs, especially in terms of housing and restoring normal life to the region.
- 2) **economic aspect cause:** We refer here to the decisions of decision makers in both disasters to focus primarily on the urban centre area and to the considerable amount of money it has spent to revive urbanization, whether temporary or permanent, especially in the construction of economic sectors in its various administrative, social and cultural activities at the urban centre. As a result, the region has maintained its centrality and attractiveness in comparison with the parts of the urban environment that the temporary reconstruction process has created, especially when compared to rural areas.

- 3) The social cause: represents the unexpected population increases in the region, which is not taken into account in the urban plan and is subtracted into two branches: Natural population increase and Migration.
- ✓ Therefore, the First assumption is **valid**, proven by studying the Chlef earthquakes before, during and after the disaster and its impact on the urban, economic, social and demographic aspects.

Question 1, Section 2: What are the consequences of this phenomenon?

The answer is: The Exceptional spatial expansion of the Chlef has resulted in two consequences:

Urban level: Three types of dwellings have emerged: Prefabricated dwellings, Current dwellings, and Slum dwellings.

The environmental level: The area of agricultural land has decreased depending on the increase in the built-up area and the emergence of urban sprawl.

- ✓ Therefore, the Second assumption is **valid**, confirmed by the fact that the impact of the earthquake was the urbanization of the Chlef agglomerations, which in turn led to the appearance of unplanned urban sprawl and the decline in living standards, as well as the expansion at the expense of agricultural land, which increases the vulnerability of the city in these particular areas to the threat of earthquakes in the future.

Question 2: How do seismic hazards impact Chlef City?

The answer is: Seismic hazards impact Chlef City on several levels during and after the disaster is summarized in the following Table 17:

Table 18: Levels of Impacts of Seismic Hazards on Chlef City

| Impact Levels | Impacts of Seismic Hazards on Chlef City | |
|----------------|---|--|
| | During the disaster | After the disaster |
| Urban level | The city's buildings have been destroyed, damaged, or lost their shape and urban landscape | Rebuilding the city, restoring, and renovating the buildings caused it to expand even further than before |
| Economic level | The economic sector has declined due to the destruction of various economic activities such as administrative, cultural, social, and commercial | Construction of various economic sectors and substantial financial expenditures on temporary and permanent housing, infrastructure, and services |
| Social level | Human losses, injuries, homeless people, reduced living standards of the population due to loss of housing and jobs | The emergence of the phenomenon of migration to the city of Shelf and its urban centre in particular, in search of work and a better life |

Source: Author, 2024.

- ✓ Therefore, the Third assumption is **valid**, but it didn't include the impacts after the disaster.

Question 3: How can the challenge of Exceptional urban expansion in seismic Chlef be radically resolved or made an acceptable risk?

The answer is: The challenge of managing urban expansion in earthquake-prone areas such as Chlef cannot be easily addressed. Even the concept of building a new city ¹⁵ is not a radical or unacceptable solution, as any alternative must avoid causing social, economic, and urban unrest, or at least the resulting losses must be manageable. This is due to the vulnerability of the entire northern part of Algeria to earthquake hazards, making the creation of a new city elsewhere an impractical option because it will lead to the same consequences as the Chlef disasters do. Additionally, the high cost of construction in economic terms and the difficulty of relocating

¹⁵ A *New City* is defined as: “*purposefully designed tracts or centres of urban development located beyond the periphery of an existing area. They are typically planned and constructed to accommodate population and urban growth*”(Kolankiewicz et al., 2022).

communities from their familiar surroundings in social terms, make this proposal challenging. Therefore, it is recommended to maintain the city's original location, and following the recommendations we will propose to mitigate the problem and make the risk more acceptable.

- ✓ Therefore, we **withdraw** the fourth assumption for the reasons mentioned above.

3. General Recommendations:

- ❖ To promote vertical construction over horizontal construction to minimize the use of land, particularly urban sprawl in agricultural land, while ensuring that construction adheres to earthquake-resistant standards and considers the seismic microzonation of the area.
- ❖ Ensuring strict adherence to earthquake-resistant construction regulations and providing state support to residents in these areas to construct buildings that meet the required standards. This includes supplying necessary building materials at reasonable prices, with a focus on sourcing local materials that are sensitive to seismic specifications, as well as offering expertise in seismic design and construction.
- ❖ Strict penalties are imposed for any breach of the building rules or urban sprawl at the expense of agricultural land because the basic wealth of the Chlef lies mainly in agriculture.
- ❖ In the event of a disaster, it is crucial for city administrators and planners to ensure that attention and resources are distributed equally across urban, suburban, and rural areas. By avoiding a focus solely on the urban centre, we can prevent issues such as mass migration, slum development, and urban sprawl.
- ❖ Incorporating modern technology such as remote sensing through the ArcGIS program can help integrate spatial and demographic data into urban planning. This will enable authorities to respond early in emergencies by accurately assessing the

sizes and locations of existing properties and their owners. By doing so, the government can avoid previous mistakes in the event of a disaster, accurately determine material losses, and ensure fair compensation for the original property owners. This approach also guards against exploitation by opportunistic individuals seeking to take advantage of post-disaster social and economic opportunities and financial compensation.

- ❖ It is essential to consider the economic implications when making decisions and to avoid rushing through the process. As we have observed this issue occurring repeatedly, it is important to develop future supervisory plans to prevent the repetition of past mistakes. For example, we should avoid concentrating large expenditures solely on prefabricated dwellings (stage C) as this has led to social, urban, and economic challenges (refer to figure 26).
- ❖ The process of definitive housing (stage D) must be accelerated as soon as possible and with local materials that are protective against earthquakes since Algeria is a developing country and not a developed one that can afford these costs without harming its economy. Therefore, we suggest that we make a resilient urban plan for Chlef City so that it can live with natural disasters such as in Japan.
- ❖ To take into account in the resilience planning of the city the views of all the actors involved in the management of a city, beginning with including urban planners, economic planners, sociologists, urban policy decision-makers, etc, to make a comprehensive contribution to ensure an integrated vision of the city's urbanization and to allow human achievements to withstand this disaster or at least not cause it to fall. Additionally, efforts should be made to cultivate a resilient cultural mindset among citizens.

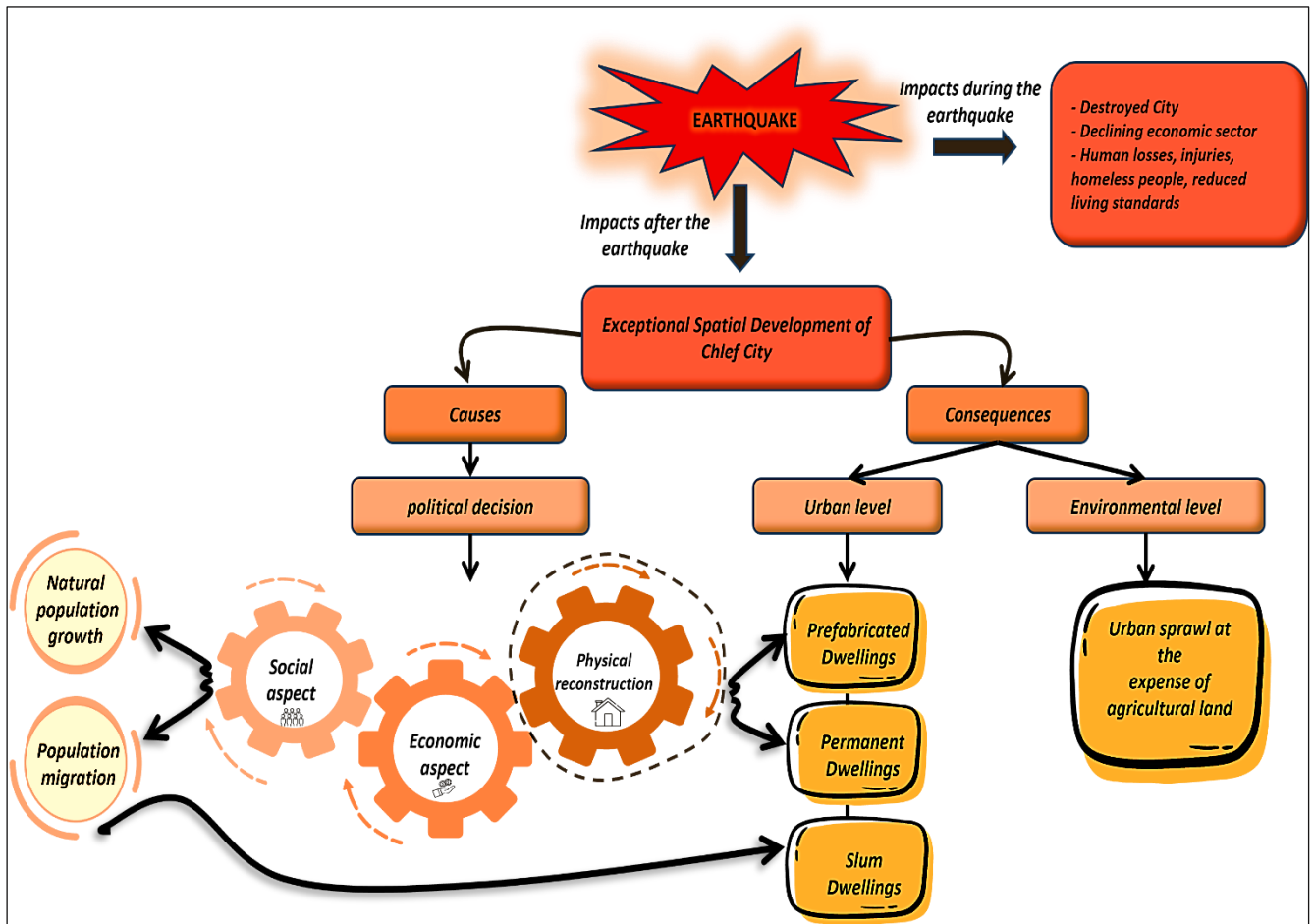
4. Suggestions for future studies:

Based on the research presented in this thesis and our observation of the impact of the city of Chlef's reconstruction on urban, social, and economic aspects, we recommend that future studies focus on "The development and construction of seismic-resilient cities, taking into account economic, social, and urban considerations", or a study on "Locally sourced materials that enable the proactive construction of earthquake-resistant structures".

5. General Conclusion:

The phenomenon of urbanization in Chlef City is reflected in its continuous spatial expansion over time. This exceptional spatial process is characterized by rapid and periodic development, linked to the impact of the "earthquake" motive. The city's dynamic environment is influenced by the combination of the disaster's impact, rapid **political decisions**, **urbanization** manifestations, **economic aspects**, and **social factors** such as natural population growth and migration. These elements interact dynamically, leading to continued urban sprawl and expansion at the expense of agricultural land, shaping Chlef into the agglomeration we see today (see Figure 27).

Figure 27: Diagram showing the whole Impacts of the Earthquakes in Chlef City



Source: Author, 2024.

It is important to acknowledge the potential for a repeat of the same disaster in the future, and in the same location. If the same process that occurred in 1954 and 1980 is repeated, it will yield similar outcomes. This implies that the cycle of demolition, reconstruction, and rapid urban expansion will persist indefinitely unless the root causes are addressed. However, with today's technological and cognitive advancements, the process can be executed more efficiently and rapidly so that these outcomes can be mitigated by following the earlier recommendations we have outlined. We urge decision-makers to consider these recommendations for the creation of a resilient city, a sustainable future, and an acceptable level of risk.

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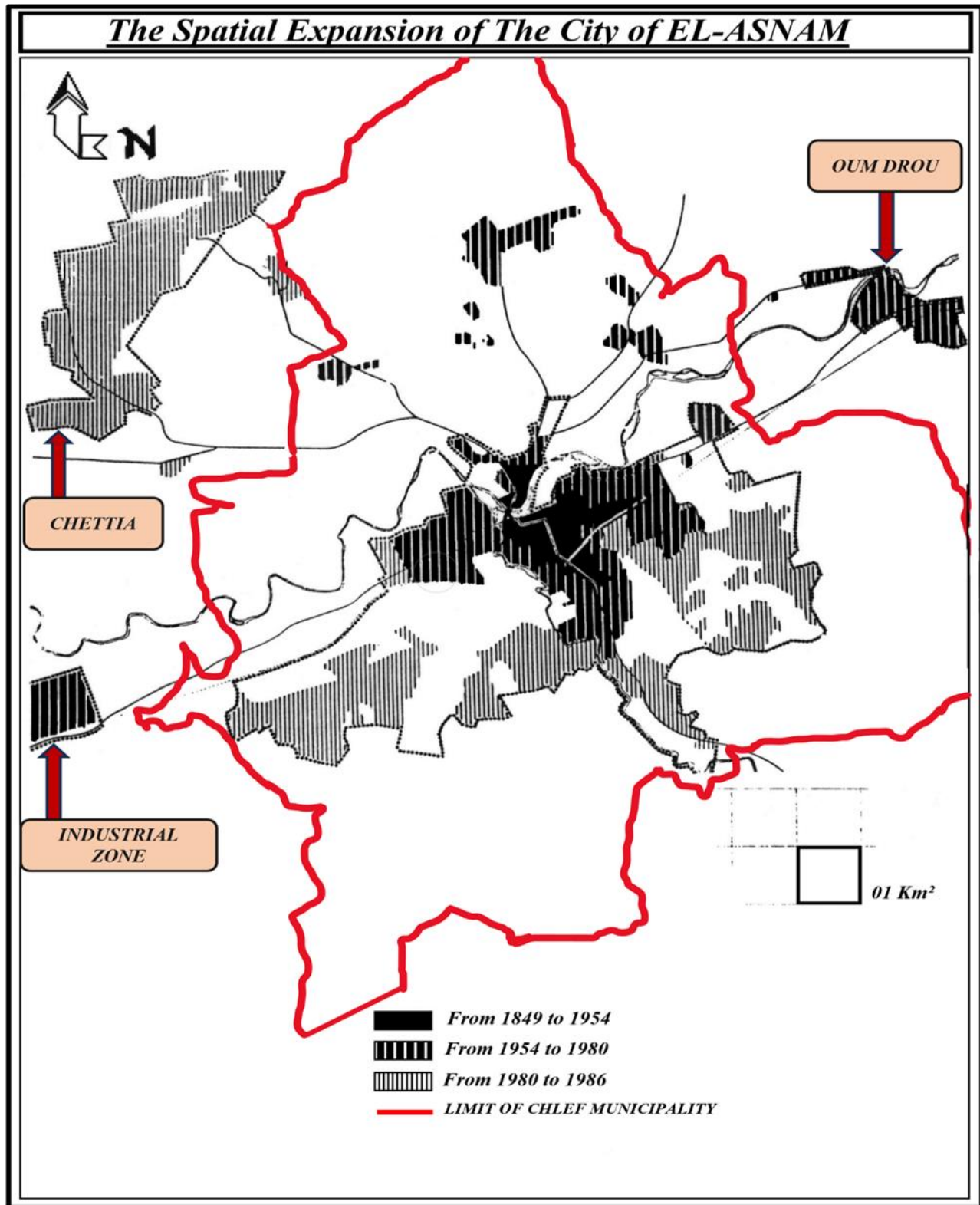
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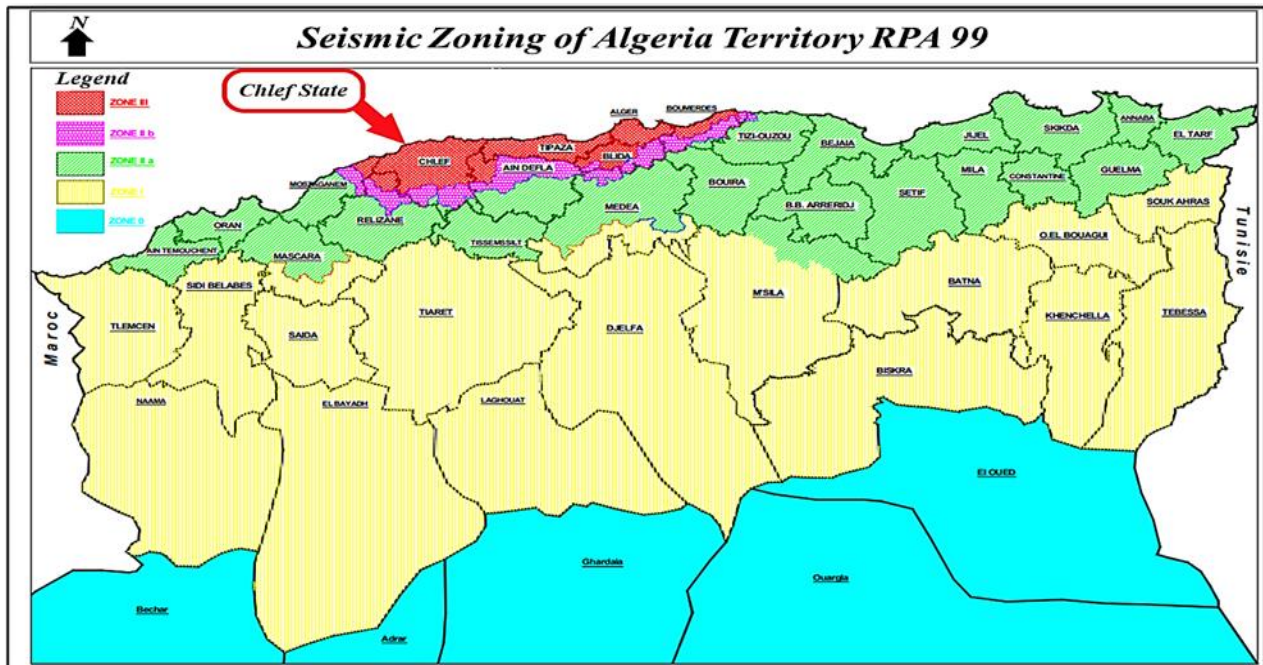
Appendix

Appendix A: The Spatial Expansion of the City of EL-ASNAM



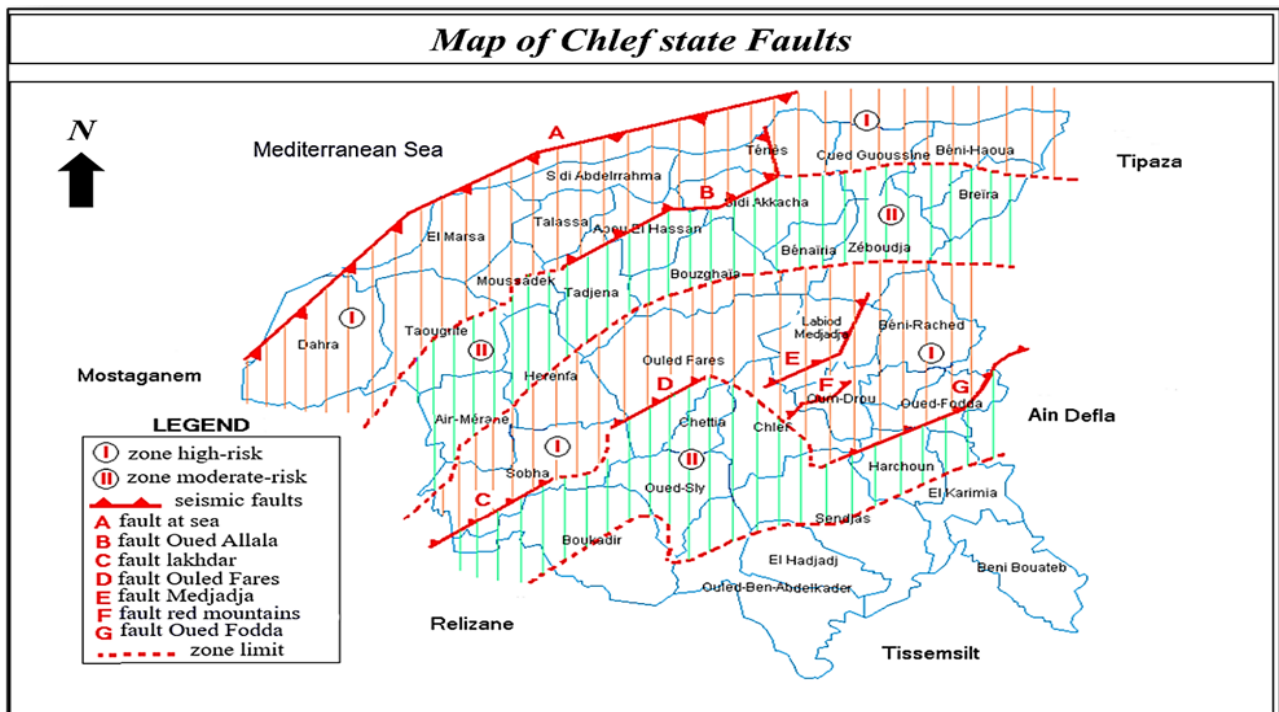
Source: D.U.C.H cited in (Bouzouaid, 1984), Modified by Author, 2024.

Appendix B: Map of Seismic Zoning of Algeria Territory RPA 99



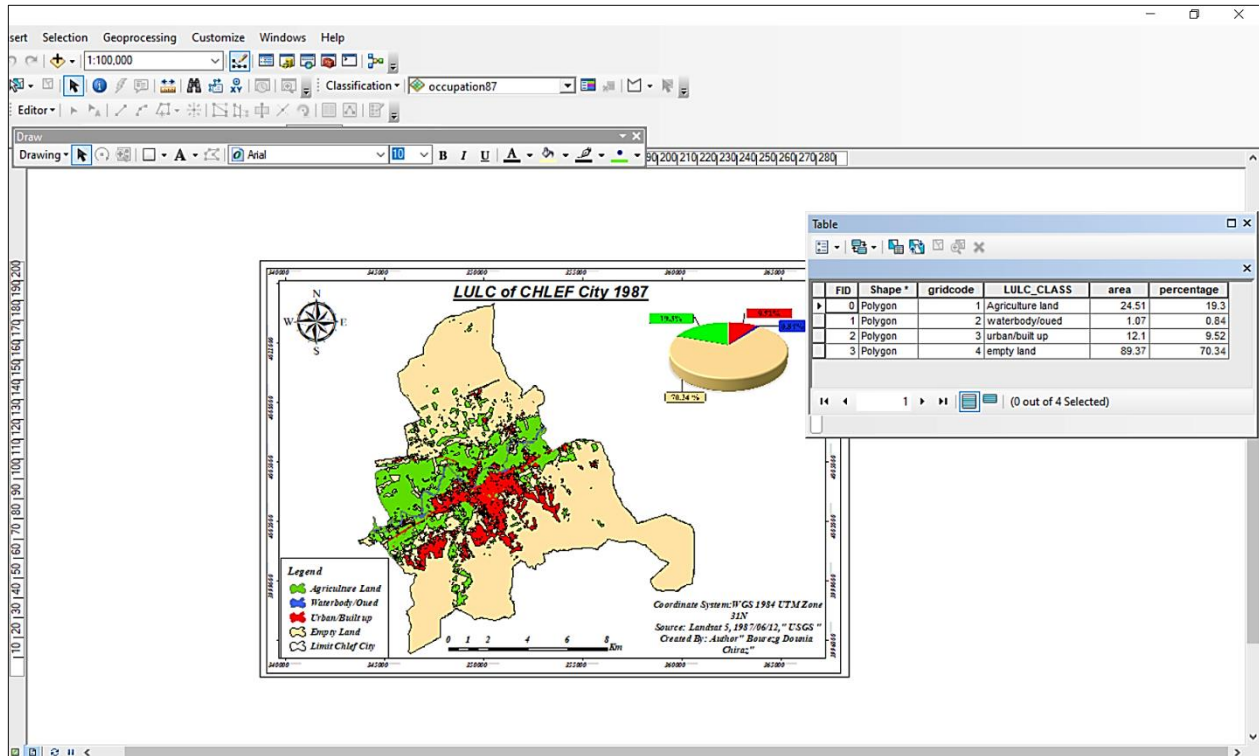
Source: RPA99 Version2003 (BELAZOUGUI et al., 2003), Modified by Author, 2024.

Appendix C: Map of Chlef State Faults



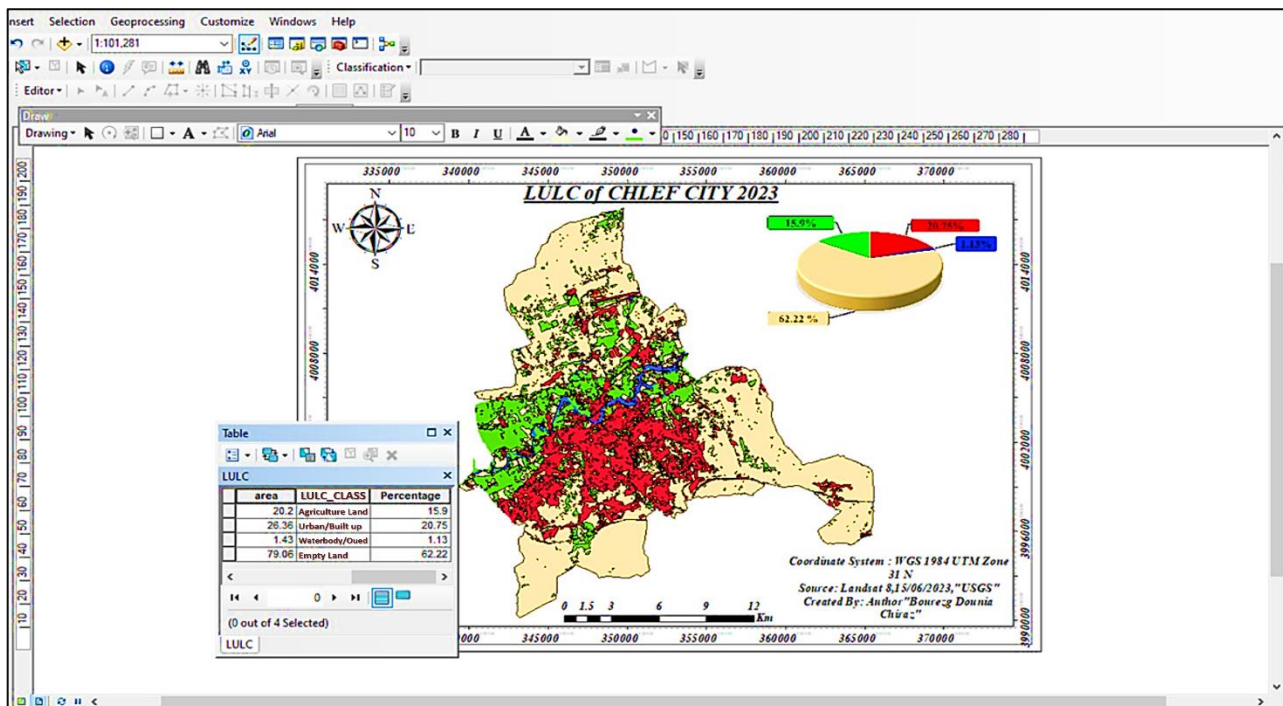
Source : (Boutaraa, 2013a), Modified by Author, 2024.

Appendix D: GIS automatic calculation for LULC Classification of Chlef City 1987



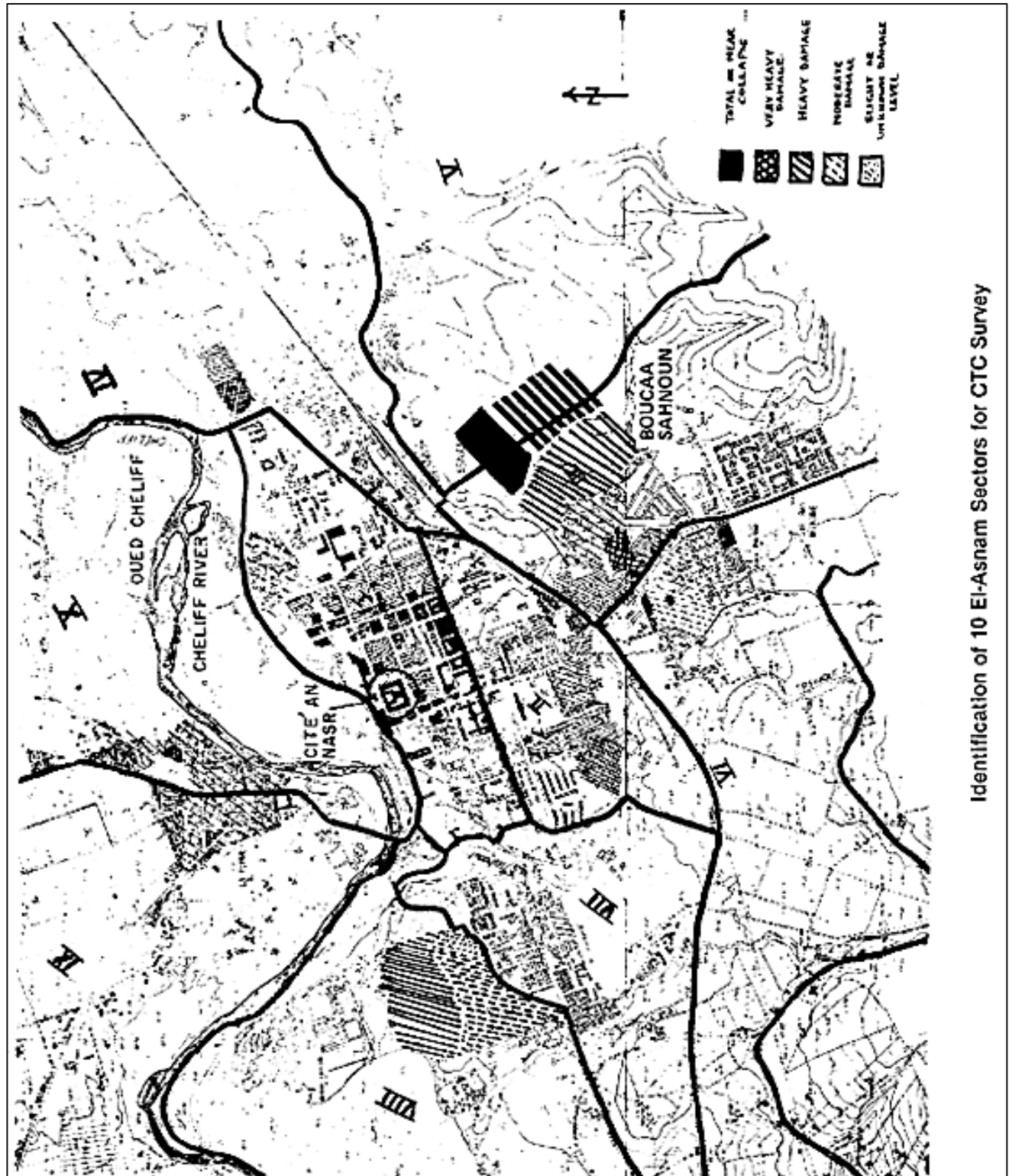
Source: Author, 2024.

Appendix E: GIS automatic calculation for LULC Classification of Chlef City 2023



Source: Author, 2024.

Appendix F: Map of the 10 sectors of El-Asnam City after the 1980 Earthquake -CTC-



Identification of 10 El-Asnam Sectors for CTC Survey

Source: (Bertero & Shah, 1983).

