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« The new town of Hassi-Messaoud : an alternative between rational choice and paradoxical solution »

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Dedications

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Abstract:

Algeria, like other developing countries, faces the dual challenges of protecting its citizens and property from various risks, while promoting economic development. A comprehensive approach to risk management is critical to balancing these two objectives.

The city of Hassi Massoud offers a living example of these challenges, where industrial risks intersect with environmental, economic and social risks in a complex manner. The oil industry, the main engine of the local economy, is an important source of jobs and prosperity, but it also poses environmental risks to public health and quality of life.

This research highlights the importance of accurate risk assessment and in-depth understanding, taking into account its various aspects, to enable decision makers to make rational choices that balance benefits and risks. It emphasizes the need to adopt adaptive and learning risk management strategies that take into account future changes and contribute to the sustainable development of Hassi Massoud .

Keywords: Risk, Hazard, Vulnerability, Stakes, Disorder, Impact, Assessment, Rational choice, Urban development, new city of Hassi Messaoud, urban cities.

ملخص:

تُواجه الجزائر، كغيرها من الدول النامية، تحديات مزدوجة تتمثل في حماية مواطنيها وممتلكاتها من المخاطر المتنوعة، مع تعزيز التنمية الاقتصادية. ويُعدّ اتباع نهج شامل لإدارة المخاطر أمرًا بالغ الأهمية لتحقيق التوازن بين هذين الهدفين ..

تُقدم مدينة حاسي مسعود نموذجًا حيًا لهذه التحديات، حيث تتقاطع المخاطر الصناعية مع المخاطر البيئية والاقتصادية والاجتماعية بشكل معقد. وتُعدّ صناعة النفط، المحرك الرئيس للاقتصاد المحلي، مصدرًا هامًا للوظائف والرخاء، ولكنها تُشكل أيضًا مخاطر بيئية على الصحة العامة وجودة الحياة.

يُسلط هذا البحث الضوء على أهمية تقييم المخاطر بدقة وفهمها بشكل عميق، مع مراعاة مختلف جوانبها، لتمكين صانعي القرار من اتخاذ خيارات رشيدة تُوازن بين الفوائد والمخاطر. ويُؤكد على ضرورة اعتماد استراتيجيات إدارة مخاطر قابلة للتكيف والتعلّم، تأخذ بعين الاعتبار التغيرات المستقبلية وتُساهم في تحقيق تنمية مستدامة لحاسي مسعود .

الكلمات الرئيسية: مخاطر، خطر، ضعف، مصالح، فوضى، تأثير، تقييم، اختيار عقلاني، تنمية حضرية، مدينة حاسي مسعود الجديدة، مدن حضرية.

Résumé :

L'Algérie, comme d'autres pays en développement, est confrontée au double défi de protéger ses citoyens et ses biens contre divers risques, tout en favorisant le développement économique. Une approche globale de la gestion des risques est essentielle pour parvenir à un équilibre entre ces deux objectifs. La ville de Hassi Messaoud offre un exemple frappant de ces défis, où les risques industriels se croisent de manière complexe avec les risques environnementaux, économiques et sociaux. L'industrie pétrolière, principal moteur de l'économie locale, est une source importante d'emplois et de prospérité, mais elle présente également des risques environnementaux pour la santé publique et la qualité de vie. Cette recherche souligne l'importance d'évaluer avec précision et de comprendre en profondeur les risques, en tenant compte de leurs différents aspects, pour permettre aux décideurs de faire des choix rationnels qui équilibrent les avantages et les risques. Il souligne la nécessité d'adopter des stratégies de gestion des risques qui soient adaptables et apprenables, prenant en compte les changements futurs et contribuant à la réalisation du développement durable de Hassi Messaoud.

Mots-clés : Risque, Danger, Vulnérabilité, Enjeux, Désordre, Impact, Évaluation, Choix rationnel, Développement urbain, nouvelle ville de Hassi Messaoud, villes urbaines.

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General introduction

1. Introduction

Risks are significant factors that affect not only the business environment but also most human activities. Some risks can be predicted, avoided, and transferred and thus reduce their negative impact. The appropriate strategy is chosen by the firm based on the probability and magnitude of the negative impact of the risk. There are many ways and methods to achieve this. However, the core of risk management is the identification of the risks themselves.

While not as immediately alarming as human-caused destruction, industrial disasters are equally feared. Initially, when a catastrophe occurs, the focus is typically on the loss of life and material damage, known as the "negative balance of damage." Following a period of relief, attention shifts to the secondary consequences of the disaster, such as its impact on the urban environment, economic activity, and social life.

Few studies highlight the magnitude and impact of major risks. Some research attempts to establish links between the agents causing disasters and the direct causes of vulnerability, while others analyze the short- and long-term impacts of these phenomena, both materially and physically, as well as socially and humanly.

This study aims to implement a preventive system to collect data on such situations as early as possible **(Margosian, 2006)**, to mitigate the risks of foreseeable disasters caused by petrochemical installations in urban areas in the future.

One fundamental aspect of industrial disasters is their instructive nature. Experience shows that they provide valuable lessons that must be remembered and applied to avoid adverse effects and total misfortune from similar incidents.

The extent of a disaster is closely linked to human actions post-disaster; it greatly depends on how people perceive and manage "risk" **(Leroy & Signoret, 1992)** and their ability to handle it. In

some urban agglomerations, spatial anarchy can present significant risks, particularly in cities like Hassi-Messaoud, which is situated in an area with high land-disturbing activities.

Conversely, as noted by **Dubois-Maury & Chaline (1994)**, addressing risks is crucial for preventing issues during city planning and significantly contributing to the modification of urban areas.

2. Problematic:

It is noted that the risk is a multidisciplinary field of study and therefore quite complex. For a long time, it was estimated, calculated and measured, regarding hazards and dangerous phenomena, however, ignoring all the issues and especially the vulnerability of the elements exposed to risks. Thus, it is important to consider the risk in its overall context, integrating all probabilities of training effects or chain reactions which, at most times, are incalculable.

- How can urban planners reconcile the tension between rational decision-making and embracing paradoxical choices in the development of Hassi Massoud, the new city, to mitigate industrial risks and ensure the safety and well-being of its residents and surrounding environment?
- What strategies can urban planners employ to effectively integrate sustainable development principles while navigating the paradoxical challenges in Hassi Messaoud's urban growth, ensuring resilience against industrial risks and enhancing community safety and environmental quality?
- How can urban planners balance economic development objectives with environmental conservation efforts in the planning and development of Hassi Messaoud, considering the dual imperatives of industrial growth and risk mitigation?

3. Aim of dissertation

To assess the area, buildings and population threatened by industrial accidents related to industrial storage of hazardous material in various scenarios and prepare a database and method that assesses affected areas in an emergency.

4. The objective of the dissertation

- To prepare hazard footprint caused by industrial/technological processes

- To identify possible hazards related to chemical substances used in the industry
- To identify the risk caused by industrial processes
- Identify the elements at risk in surrounding areas to identify
- To determine the spatial vulnerability of the population
- To determine the temporal vulnerability of the population

5. Dissertation assumption

The city of Hassi Massoud faces a dual challenge between rational choice by assessing the possibility of establishing a new city or expanding the current city, taking into account economic, social and environmental factors, and industrial risk, that is, how to deal with the risks of the oil and gas industry to the health and safety of the population.

- Creating a new city could be very expensive, while expanding the current city could be more cost-effective.
- The creation of a new city may be an opportunity to design a more sustainable society.
- It may be possible to create an expansion of the current city in a way that reduces the vulnerability of the population.

6. Methodology of dissertation :

To initiate this topic requires both desk research and fieldwork.

For desk research, the tasks include:

- Gathering documentation.
- Document analysis of collected data.
- Consulting works related to adjacent subjects.

Upon establishing the empirical framework, fieldwork becomes essential to complete the research. At this stage, the focus is on the urbanization of Hassi-Messaoud in relation to technological risks of petrochemical origin, necessitating a thorough analysis that involves various means:

- ✓ Observation.
- ✓ Various statistical data.
- ✓ Photography.
- ✓ Utilization of advanced computing tools, such as a computer, scanner, and GIS software.

7.Study Limitations:

Contextual Specificity: The findings of this dissertation may be limited to the unique socio-economic and environmental context of Hassi Messaoud and may not generalize to other urban development projects in different geographic and cultural settings.

Data Availability: Access to comprehensive and reliable data on urban planning decisions, socio-economic trends, and environmental impacts in Hassi Messaoud may be limited, potentially affecting the depth and breadth of the analysis.

Temporal Scope: The study's focus on current urban planning strategies and challenges in Hassi Messaoud may overlook historical factors that have shaped the city's development trajectory and could impact the interpretation of findings.

Methodological Constraints: The reliance on qualitative research methods, such as case studies and interviews with stakeholders, may introduce subjectivity and bias in data interpretation, despite efforts to maintain rigour and objectivity.

Political and Economic Influences: The influence of political agendas, economic policies, and stakeholder interests on urban planning decisions in Hassi Messaoud may not be fully captured or comprehensively analyzed due to potential complexities and confidentiality constraints.

Environmental Factors: While efforts are made to consider environmental impacts, limitations in environmental data availability and the dynamic nature of ecological systems could constrain the comprehensive assessment of sustainability outcomes.

10.Dissertation outline :

To develop this research, the following approach was chosen:

- **Chapter One: Generalities of Risk**

This chapter will examine the broad concept of risk, categorizing it into natural, technological, and socio-economic types. It will explore the uncertainties impacting urban environments and discuss the implications of these risks for urban planning and development, providing a foundational understanding for further analysis in the dissertation.

- **Chapter Two: Industrial Risks**

This chapter will explore industrial risks, categorizing them into types like chemical spills and pollution. It will analyze their impacts on urban safety and sustainability, using case studies to illustrate challenges and implications for urban planning and risk management.

- **Chapter Three:**

In this chapter, we're going to look at the presentation of the Hassi Messaoud study area and analyse it to determine the dangerous places that threaten its inhabitants.

- **Chapter Four:**

In this chapter, we're going to present possible solutions to the industrial hazard in the Hassi Messaoud area and compare them to the optimal and effective solution.

Chapter One:

Generalities of Risk

1. Introduction

Algeria is actively embracing a new strategy involving comprehensive risk assessments to enhance prevention measures. This initiative places significant emphasis on safeguarding both people and property. However, the multifaceted nature of risks, encompassing human, economic, technical, and environmental dimensions, poses a complex challenge. This study focuses on a case study, which is somewhat paradoxical, as it combines various risk factors within the delicate urban setting of Hassi-Messaoud. Known for its pivotal role in Algeria's economy, Hassi-Messaoud experiences continuous population influx driven primarily by employment opportunities. However, this uneven population distribution exposes the city to potential dangers, particularly as it resides in an oil-rich region prone to inherent risks. The objective of this article is to conduct a risk assessment specifically pertaining to oil-related activities. By employing a structured approach, the study aims to identify different types and levels of exposure and vulnerability within the urban space under scrutiny.

2. Risk definition and its elements:

Risk and uncertainty are an important attribute of most human activities, not only in the business area. The definition of risk is not uniform, as it enters many sectors. Definitions vary according to the need to capture the aspects to which the risk relates. So, the concept differs for economists, theorists, scientists, etc**. (Rejda E. George et al, 2014)** Historically, risk has been associated with some danger with an undesirable outcome which could lead to losses, failure to achieve objectives or negative deviations of the organisation. **(Fotr Jíří et al, 2014)**

Uncertainty is often confused with risk. However, in the economic and financial literature, it is necessary to differentiate between these two concepts. Nevertheless, some authors do not distinguish between these terms. **(Rejda E. George et al, 2014)** Uncertainty refers to a situation where the outcome is unknown or not certain. It arises when the decision maker lacks complete knowledge, information or a full understanding of all factors and their possible consequences. **(Gupta, P.K, 2016)**

For example, this unknown may relate to future trends in material prices, energy prices, exchange rates, future demand, etc.

All of the mentioned aspects could affect the results of future activities. **(Yoe, Charles, 2019)** The uncertainty is not only caused by a lack of information but also by the limited reliability of the determination of future values of the factors. This is due, for example, to the use of unreliable data and inappropriate methods, etc. It follows that uncertainty can be reduced by avoiding the above. However, it is not possible to eliminate it completely. **(Rejda E. George et al, 2014)**

The risk is associated with an activity whose outcome is unknown. In other words, it is the consequence of an uncertain event. That may lead to some negative effect (for example a loss) or something positive. So, risk not only represents a threat but also presents various opportunities that can be used appropriately. **(Fotr Jíří et al, 2014; Gupta, P.K, 2016)**

In geography, risk has been approached by geographers from the perspective of "Hazard," through the study of natural phenomena, their manifestations, triggering mechanisms, and their consequences on both space and society **(Tricart, 1958).**

In environmental science, most definitions of risk converge towards the definition provided by the Environmental Analysis Expertise Center of Quebec, which focuses on the possibility of adverse effects on environmental receptors following exposure to a stressor agent. The environment is defined as the ambient milieu with which living species maintain a relationship, and a stressor agent refers to any contaminant capable of eliciting a harmful response **(Government of Quebec, 2000).**

The concept of risk in human health and safety is defined as the probability of health impairment in individuals attributable to exposure to one or more risk factors. These risk factors can be exogenous (microbial agents, chemical substances) or endogenous (genetic factors, hormones) **(Carrier, 2002).**

In industrial safety, industrial safety can be defined as follows: "the systematic application of policies, procedures, and management practices aimed at analyzing, evaluating consequences,

controlling (through the implementation of prevention, preparation, intervention, recovery, and monitoring measures), and communicating major technological risks, to protect employees, populations,…"

Industrial safety is a multidisciplinary specialization that integrates knowledge from various sciences such as engineering, biology, chemistry, etc. In this specialization, risk is generally defined as follows: "The threat of the probability and severity of an adverse effect on health, material goods, and the environment" **(Jean-Grégoire B, 2002).**

2.1.Hazard:

Australian industry standards define a hazard as “A source or a situation with a potential for harm in terms of human injury or ill-health, damage to property, damage to the environment, or a combination of these". A hazard is an extreme event that poses a risk to human settlements **(Deyle 1998)**. Alexander (1993) defines a hazard as "the exposure to some risk of disaster in the pre-disaster situation, due to the presence of human population in hazard-prone areas.

Hazard refers to the potential occurrence probability, at a specific time and geographical location, of a phenomenon originating from natural, technological, health-related, or anthropogenic sources, capable of causing harm to life, property, or human activities to the extent of triggering an accident or catastrophe. Two parameters are employed to assess a hazard: the hazardous phenomenon (nature, intensity, location, etc.) and its probability (or frequency) of occurrence **(IFRC, 2002).**

2.2.Issues or exposed elements:

Issues or exposed elements correspond to the population, buildings, and other human infrastructures (communication network, transportation network...), human activities (economic, leisure, service...), and cultural and environmental heritage (monuments, landscapes, biodiversity...). There is a triple component of issues: Human, socio-economic, and environmental.

2.3.Vulnerability:

Vulnerability is the varying sensitivity of an issue to a given hazard. It expresses the level of foreseeable consequences of an event on the issues, from human casualties to material damage**(GARNIER C, 2010).** Vulnerability differs depending on the nature of the exposed element (the nature of a building is not the same as that of a communication network axis). Moreover, there is no intrinsic vulnerability, but rather a vulnerability based on the nature of the hazard. Several types of vulnerability have been identified such as physical or technical vulnerability, functional, social, biophysical, or location-based vulnerability **(Beck E, 2004).** The vulnerability of exposed elements is influenced by various factors. J-Thouret and R. D'Ercole propose a synthetic classification of these factors:

2.3.1.Structural Factors

-Socio-demographic and Economic Factors: population structure and mobility (density, growth rate, employment, etc.), population turnover, demographic origin and migrations, etc.;

-Socio-cultural Factors: cognitive, educational, perceptual; acquired knowledge and experiences of past disasters, perception of risk by individuals and groups;

-Physical, Technical, and Functional Factors: extent and quality of buildings and infrastructure, structure, accessibility, and availability of emergency services.

2.3.2.Geographical and Contextual Factors

-Geographical Factors: spatiotemporal parameters of the hazard;

-Contextual Factors: unforeseeable urban and technical malfunctions.

2.4.Risk and disaster differ in their nature and manifestation:

2.4.1.Disaster:

A disaster is the materialization of a major risk, resulting from an intense phenomenon and having dramatic consequences on exposed elements. It is the concrete manifestation of risk on a territory.

2.4.2.Risk:

Risk is the projection towards a potentially dangerous event that has not yet occurred. The Ministry of Ecology and Sustainable Development has established a severity scale of damages to classify natural events into six categories, ranging from an incident to a major catastrophe.

3. The different levels of risk:

The severity of an event alone does not characterize the risk. However, three risk domains can be distinguished by considering both frequency and severity. The simultaneous behaviour of these two components is described by the Farmer curve. The rough shape of this curve highlights the three risk domains mentioned. **(Glatron, 1997).**

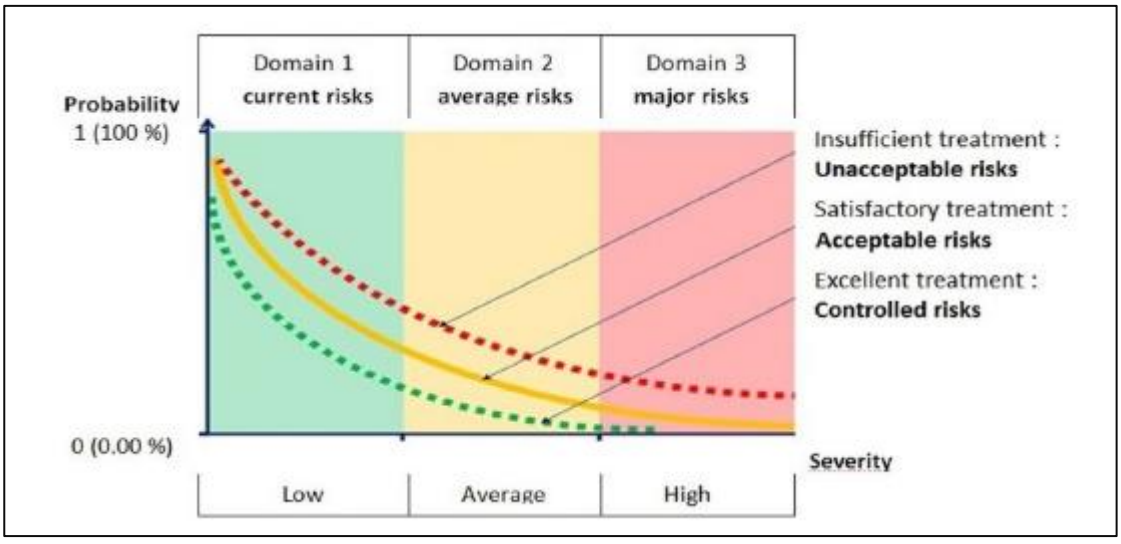


Figure 1: the curve of farmer probability and risk treatment

Source: (Bouzouaid, L., & Benabbas, M. ,2020).

This curve highlights the concept of major risk, which is characterized by:

- Low frequency: People and society may be more inclined to ignore it as disasters are infrequent.
- High severity: Numerous victims, and significant damage to property, activities, and the environment.

4. The different types of risks

The different types of risks to which each of us can be exposed can be classified into 5 main categories:

1- Natural risks: avalanches, wildfires, floods, landslides, cyclones, storms, earthquakes, tsunamis, and volcanic eruptions.

2- Technological risks: of anthropogenic origin, they include industrial, nuclear, and biological risks, as well as dam failures...

3- The risks of collective transport (people, dangerous materials) are technological risks. However, they are considered a particular case because the stakes vary depending on where the accident occurs.

4- Risks of daily life (domestic accidents, road accidents...);

5- Risks related to conflicts. (Wars, insurrections...).

6- Domestic accidents, road accidents, and minor fires are part of everyday life risks. **(Glatron, 1997).**

5. Major or High-Risk:

5.1.What is a Major Risk?

A major or high-risk event is the possibility of a natural or anthropogenic (resulting from human action) event, the effects of which can endanger a large number of people, cause significant damage, and exceed society's response capabilities. In this context, **Haroun Tazieff** stated:

"The definition I give of a major risk is the threat to humans and their immediate environment, to their facilities, the threat whose severity is such that society is overwhelmed by the immensity of the disaster."

For a risk to be major, the hazard must be significant, and the vulnerability must be high.

This implies:

-the presence of numerous human stakes who are potentially victims,

-significant costs of presumed material damage,

-significant and irreversible impacts on the environment.

"Major Risk is characterized by low occurrence and significant severity resulting in a high number of victims and numerous material and environmental damages" **(Beck, 2006).**

According to Beck, two criteria characterize these major risks well:

-low frequency (of the hazard), so low that one might be tempted to forget it and not prepare for its occurrence;

-enormous severity (on the stakes), increasingly poorly accepted (numerous victims, significant damage).

These definitions highlight the disproportionate magnitude of the threat and its consequences on the physical environment and society. In general, major risks can lead to material damage, environmental impacts inducing significant financial burdens, and/or numerous victims.

Violent Hazard + Significant Stakes = Major Risk

5.2.Categories of Major Risk:

Two categories are part of what are called major risks: natural risks and technological risks.

5.2.1.Natural Risk:

Natural risk encompasses the notion of risk of exposure to a natural disaster or the dangers associated with certain natural hazards. There are several definitions of natural risk depending on the country, era, and field of study**.** The commonly accepted recent definition of natural risk generally emphasizes the intersection between a natural phenomenon and human vulnerabilities, according to the following equation:

Natural Risk = Natural phenomenon causing damage x Vulnerability.

The natural or geodynamic phenomenon, whether internal (geophysical) or external (hydrometeorological, etc.), represents the threat and is expressed by a field of action (space) **(Beck, 2006).**

5.2.2.Technological Risk

Technological risk refers to the notion of danger, defined as "a physical and/or chemical situation with the potential for injury to people, property damage, damage to the environment" **(Bernard, 2002).** It encompasses four types of risk:

5.2.2.1.Nuclear Risk:

Nuclear risk is an accidental event related to the use of radioactive materials, and sources of ionizing radiation with risks of irradiation or contamination for personnel, populations, property, and the environment (**www.risquesmajeurs.fr, 2010).**

5.2.2.2.Dam Failure Risk:

The phenomenon of dam failure corresponds to a partial or total destruction of a dam. The causes of failure can be diverse:

Technical: malfunction of gates allowing the evacuation of water, design flaws, ageing of installations, etc.

Natural: earthquakes, exceptional floods, landslides (either of the structure itself or the surrounding terrain).

Human: insufficient preliminary studies and control of execution, operational, surveillance, maintenance errors, and malicious acts **(www.risquesmajeurs.fr, 2010).**

5.2.2.3.Transport of Dangerous Goods Risk:

The risk associated with the transport of dangerous goods (TMD) arises from an accident occurring during the transport of these materials by road, rail, sea, river, or pipelines **(DDRM, 2009).**

5.2.2.4.Industrial Risk

Industrial risk is characterized by an accident occurring on an industrial site that can have serious consequences for personnel, populations, property, the environment, or the natural surroundings (this concept will be addressed later).

6. Estimating vulnerability and risk

The first step in assessing vulnerability is exposure analysis: an inventory of people and tangible and intangible values at risk. The second step is the analysis of resilience: the capacity of institutions,

communities, individuals, infrastructures and ecosystems to deal with the impact of hazards, together with the various factors **(Bruneau, M et al 2003)** (e.g. social, economic, geographical and environmental conditions) that may hamper adaptation and mitigation strategies. **(Smith, K. 2013)** Geographical Information System (GIS) is an important tool to analyze and assess exposure and resilience by mapping information on various exposure and resilience factors at all relevant scales. This information provides an indispensable basis for estimating the potential damage caused by various hazards. **(Mitchell, J. K. 1999)**

Damage can encompass loss of life, loss of means of subsistence and well-being, loss of property, damage to infrastructure, loss of cultural values, and loss of ecosystems and ecosystem services. Estimating damage is far from obvious. Some types of damage can be quantified, for example in money or the number of casualties. Relative figures are often more relevant than absolute figures, for example, the percentage of destroyed habitats or houses**.(Fussel, H. M. 2007)** For some damages that cannot be quantified in this way, indirect valuation methods have been developed, see for example the articles Contingent Valuation Method, Travel Cost Method and Hedonic Evaluation Approach. However, there are also important non-quantifiable values, also called bequest and existence values that have to be considered. **(Weng, Q. 2010)**

The probability of occurrence of disruptive events must generally be inferred from model simulations unless long time series are available from which the mean recurrence intervals can be determined. This is, however, seldom the case as conditions evolve. For example, the likelihood of extremely high waters susceptible to cause flooding increases with sea level rise. The likelihood of pollution accidents susceptible to ruin marine ecosystems increases due to the production of new chemicals or decreases because of safety standards and enforcement. **(Birkmann, J. 2006)** The likelihood of extreme waves susceptible to destroy coastal infrastructures evolves with climate change. Studies for estimating the probability of occurrence of disruptive events usually require process-based simulation models and statistical analyses. Many decision support tools have been developed to facilitate these studies, see for example Decision Support Systems for coastal risk

assessment and management and Decision support tools. Most of these tools are complex and require the involvement of experts. **(IFRC,2002)**

Because risks relate to events that may occur in the future with some probability, assumptions must be made about the evolution of risk factors. Such assumptions are called scenarios. Since we do not know how the future will unfold, different scenarios are usually considered. These scenarios include assumptions on the evolution of exposure, on the evolution of factors related to the resilience of the coastal region under consideration and on the evolution of factors related to the occurrence of potentially disruptive events**. (Kahn, S.,2005)**

The article Flood Risk Analysis Study at the German Bight Coast provides a good example of estimating vulnerability and risks in practice.

7. Summary:

In conclusion, this chapter has illuminated the intricate nature of risk within urban development and management. Defined as the potential for adverse impacts stemming from uncertainties, risk manifests through natural hazards, technological threats, and socio-economic vulnerabilities. Crucially, effective risk management, as outlined by Merna and Yoe, involves systematic steps of identification, assessment, response, and monitoring. Moreover, the chapter emphasized the complexity of estimating damages caused by hazards, underscoring the need for advanced modelling and decision support tools to refine risk assessments and bolster preparedness. Ultimately, understanding and managing risks is essential for fostering sustainable and resilient urban environments, ensuring the safety and prosperity of communities amidst a dynamic and uncertain world. This foundational understanding will guide deeper explorations into specific risk categories in subsequent chapters.

Chapter Two:

Industrial Risks

1. Introduction

At the origin of every accident, even minor ones lies a risk or danger that, under certain conditions, can lead to accidents. Major risks, or high risks, are responsible for major accidents causing serious and immediate consequences for cities. Among these major accidents, a large number originate from industrial activities due to the presence of installations handling substances or processes that can lead to hazardous events.

Generally, two classes of industrial risks are distinguished: occupational risks and major industrial risks, which manifest as major industrial accidents. These will be explored in this chapter.

This chapter addresses the phenomenon of urbanization concerning the risks of industrial accidents. It first introduces the concept of urbanization, then defines the concept of industrial accident risks, their definitions, characteristics, and their various consequences, including thermal, toxic, and mechanical effects, in urban environments. It then discusses the phenomenon of urban-industrial proximity and the industries considered major risk sources, identifying the various repercussions that may arise.

Furthermore, this chapter also delves into the essential aspect of preventing these industrial accidents. Prevention encompasses all measures aimed at avoiding these accidents or reducing their impacts. The prevention policy of these risks adopted globally as well as in France serves as an example studied in this chapter.

2. Definition of the urbanization phenomenon

Urbanization is the movement of urban development, both in number and size, digital and spatial; it concerns everything that is linked to the direct progression of the urban phenomenon and gradually transforms cities or suburbs and often both. **(Garnier J, 1995).** In common language, the word urbanization comes from the Latin (urbs) which refers to the city or city.

Urbanization is the process of organizing the development of cities. According to the World Bank, it is defined as a change in the proportion of the national population residing in urban areas. For Bories, urbanization can be defined as the expansion of population, activities, and urban spaces, and it is the major phenomenon of this century **(Bories V, 2006)**. It is occurring at an average growth rate of 2% globally.

3. Industrial Risks

3.1.Basic Concepts

3.1.1.Hazardous Substances

Substances, mixtures, or preparations present in the form of raw materials, products, by-products, residues, or intermediate products, including those that are reasonably believed to be generated in the event of accidents, whose intrinsic properties are likely to cause harm to human health and/or the environment. **(Garnier J, 1995)**

3.1.2.Industrial Site

An industrial site or industrial zone is a geographical area intended for industrial use, where one or more industrial establishments are located. The term "industrial site" encompasses two main categories of activities:

- Chemical industries that produce or use chemicals in large quantities: manufacturing of basic plastic products, pharmaceuticals, etc.

- Petroleum industries (or petrochemicals) that produce, process, or store all petroleum derivatives: gasoline manufacturing, storage, distribution, etc.

3.1.3.Industrial Establishment

An establishment is a set of installations under the control of an operator where hazardous substances are located in one or more installations, including common or related infrastructures or activities.

3.1.4.Industrial Installation

An installation is a technical unit within an establishment where hazardous substances are produced, used, handled, or stored. It includes all equipment, structures, pipelines, machinery, tools, railway branches, loading and unloading docks, installations serving the facility, jetties, depots, or similar structures, floating or not, necessary for the operation of the installation.

3.1.5.Accident Scenario

A sequence of events leading from an initiating event to a (major) accident. In general, several scenarios can lead to the same hazardous phenomenon that may result in a (major) accident. There are as many scenarios as there are possible combinations of events leading to it. **(Beck,2006)**

4. Industrial Risks: What Risk Model?

Industrial risks can have several classifications. Wybo classifies these risks, according to prevention measures, into two categories: damage risks and crisis risks. Damage risks correspond to situations for which prevention and protection measures have been taken by the organization, whereas crisis risks correspond to situations for which there has been little anticipation. Generally, industrial risks are divided into two groups based on the severity of the accidents they can cause:

- Occupational risks

- Major industrial risks or high risks

4.1.Occupational Risks

These are the causes of workplace accidents and occupational diseases or those of a professional nature. The consequences of these risks are moderate and primarily affect the employees working at the accident site. They mostly involve injuries and sometimes intoxications of varying severity, including fatalities; and material damage, with low ecological impacts, usually limited to the establishment's perimeter. **(Beck,2006)**

4.1.1.The main categories of occupational risks include:

- Mechanical risks: cuts, crushes, impacts, and various injuries during work on machine tools and machines with rapidly moving parts.

- Electrical risks: electrocution or electric shock, often fatal, when coming into contact with bare conductors carrying electric current.

4.1.2.Other Occupational Risks

- Physical Risks: Acoustic (deafness due to exposure to intense noise), vibratory (muscular disorders due to vibrations from vibrating machines), etc.

- Chemical Risks: Similar in nature to major industrial risks.

- Biological Risks: Diseases contracted through the manipulation of pathogenic germs.

- Musculoskeletal Disorders (MSDs) Due to Manual Handling: Risks related to transportation and circulation, risks encountered in various types of work, etc.

4.2.Major Industrial Risks

Major industrial risks, high risks, or major accident risks (to be defined later) encompass three risk models considered in this work as manifestations or effects of major industrial risks: thermal risks, toxic risks, and overpressure risks (see the diagram). These risks differ from the previous ones

in terms of the scale of accidents and damage caused: high number of victims not limited to employees, building destruction, etc.

4.2.1.Generators of Industrial Risk

Industrial risks exist everywhere in factories and industrial workshops, and these risk generators are grouped into two categories:

4.2.1.1.Chemical Industries

The term "chemical industry" encompasses all activities that produce or use chemicals in large quantities. Indeed, some companies extensively use chemicals for manufacturing non-chemical end products, as in the case of PVC production chains.

4.2.1.2.Petrochemical Industries

The petrochemical industry corresponds to all industries working with petroleum products. Refineries are the main element and generally constitute the first link in the chain, while for the consumer, the final link is the gas station where one can refuel their vehicle.

4.2.1.3.Key Feared Phenomena

Various phenomena that can have serious consequences are feared within industrial sites:

BLEVE (Boiling Liquid Expanding Vapor Explosion)

This refers to the explosion of expanding gas from a boiling liquid (as in the Feyzin accident in 1967). An increase in temperature, usually caused by a fire, weakens the metal of the storage sphere. The sphere may burst due to internal pressure. If bursting occurs, it leads to the projection of fragments and/or missiles and the release of the liquid gas, which is instantly vaporized. If the gas is flammable, it results in the formation of a fireball with intense thermal radiation. The effects are primarily thermal. **(Beck,2006)**

5. Causes of Industrial Risks

The potential causes of failure in chemical and petroleum industries that lead to major industrial accidents are diverse and can be classified into three categories:

5.1.Causes related to poor safety management:

Mechanical failures due to poor maintenance of production equipment (such as the rupture of a corroded pipeline due to lack of monitoring and replacement, for example), as well as human failures due to a lack of knowledge of risks or errors in handling.

5.2.External causes:

There are too many to list exhaustively. For example, this category includes all external explosions that could cause a leak or another explosion on the site. Natural disasters can also be a

5.3.Causes related to malicious intent:

This could involve sabotage or deliberate damage to production equipment. It is specifically considered: that it forces industries to implement sophisticated protection measures because it is an unpredictable risk.

6. Effects of Industrial Risks

The main effects of industrial risk that can be generated by industrial installations are grouped into three types of effects:

6.1.Thermal Effects:

These are related to the combustion, more or less rapid, of a flammable or combustible substance. They cause internal or external burns, partial or total, to exposed individuals. They can also ignite nearby structures.

6.2.Mechanical or Overpressure Effects:

Result from a pressure wave (deflagration or explosion depending on the speed of propagation of the pressure wave), caused by an explosion. This explosion can originate from an explosive, a chemical reaction, or violent combustion (combustion of a gas or a cloud of dust), or a sudden decompression of a pressurized gas (such as the bursting of a compressed air bottle, for example). The overpressure effects can be direct and cause injuries to the eardrums and lungs, the projection of people to the ground or against an obstacle. They can also be indirect, such as the collapse of structures or the impact of projectiles on people.

6.3.Toxic Effects:

These result from a leak in an installation or the release of a toxic substance from chemical decomposition during a fire or chemical reaction. Inhalation generally poses the most significant toxic risk to exposed populations. The resulting consequences can include respiratory distress, pulmonary oedema, central nervous system damage, etc**.(M.E.D.D.E., 2007)**

7. Urbanization and Major Industrial Risks

7.1.General Context

This section illustrates the issue of the proximity between hazardous sites (generators of industrial risk) and vulnerable elements exposed in the city. These sites, which were originally located outside of urban areas, are now, due to urbanization, integrated into the city. Many hazardous installations were initially situated outside of built-up areas and far from inhabited zones. However, due to a lack of regulation, government laxity, and increasing demographic pressure, cities have expanded, and urbanized areas have encroached upon factories to the extent of their danger zones

7.2.Proximity of the City and Industrial Sites: What Danger?

Industrial accidents can have four main characteristics or repercussions on the city, which also distinguish them from the numerous usual accidents and incidents known in the industrial environment, both in terms of the number of victims and the extent of damage inflicted on the environment (Pigeon, 2010). The repercussions of industrial sites that can occur in urban areas are combined by:

- A high number of human casualties: Industrial accidents can cause a high number of human casualties, including deaths, intoxications, and injuries (shocks, crushes, fractures, burns) of varying severity. The victims are primarily those present at the workplace. Then some people are occasionally (visitors, passersby) or regularly (residents, merchants, and workers) near the factory within the accident's safety perimeter. In addition to physical injuries, there are also psychological traumas that can deeply affect people. Besides human victims, there are also casualties among pets, not to mention the flora in the event of a release of ecotoxic and biocidal substances. The number of deaths is not the only criterion for a major accident; the Seveso accident did not cause direct deaths but remains the epitome of a major industrial accident due to its consequences in terms of the number of people and animals intoxicated, marked for life and ill, as well as the catastrophic consequences on the ecosystem: wildlife and flora, domestic animals, duration of pollution persistence, etc.

7.3.Material damage:

Material damage is observed inside and all around the site of the major accident, manifested by the destruction of various buildings and structures. Among the material damages that can be caused, we can mention:

- Total or partial destruction of buildings: residential buildings, public buildings, various industrial buildings, etc.;

- Damage to public roads: roads, bridges, tunnels, road signs, railways, overhead or underground pipelines, electric and telephone poles, etc.;

- Damage to vehicles: stationary or moving automobiles.

7.4.Harmful Pollution on the Surrounding Nature

During an industrial accident, harmful and ecotoxic products are released into nature, polluting the air, soil, and aquatic environment (seas, lakes, ponds, rivers, groundwater) with varying degrees of destruction to wildlife and flora. In some cases, the environment becomes uninhabitable for several years.

7.4.Necessity of Organizing Large-Scale Rescue Operations

This task is entrusted to local competent authorities responsible for implementing the planned rescue operations in the event of major accidents and for planning the repair of material damage caused. Post-accident interventions involve several aspects:

- Emergency medical assistance for victims, primarily the responsibility of the civil protection services in the area;

- Possible hospitalization of victims in specialized healthcare centres;

- Organization of traffic and movement near the accident;

- Technical expertise and judicial investigations to determine liability conducted by competent judicial services;

- Compensation by those responsible for the damage caused and implementation of regulatory measures based on the results of technical expertise.

8. Preventing Industrial Risks

The prevention of industrial accidents is defined as the set of administrative, legislative, and technical measures aimed at avoiding these accidents or at least reducing their impact on the population and the environment **(MAUPETIT, 2010)**

Preventing accidents involves intervening before these accidents occur. But it also includes measures taken to mitigate the consequences of these disasters; therefore, post-accident rescue and intervention measures can be considered part of prevention. Police and legal investigations and the search for liability for damage repair after the accident are not considered preventive measures, even if they may have an indirectly favourable effect on safety, if only through their psychological impact on populations.

9. Industrial Risk Management in Algeria

The concept of major risk prevention emerged following various industrial accidents. Since then, the Algerian legislature has developed several laws aimed at preventing major risks, defining, and implementing procedures and rules to limit the exposure of people and property to natural and industrial risks **(J.O.R.D.P.A.):**

- Law No. 03-10 of July 19, 2003: Relating to environmental protection within the framework of sustainable development (Article 21 requires a hazard study for operating authorization).
- Law No. 04-2 of December 25, 2004: Establishes rules for the prevention of major risks and disaster management in Algeria. It is based on the monitoring of major risk installations by both the operator and local public authorities (walis and APC), and the principles of precaution and prevention through the implementation of environmental planning and management tools.
- Executive Decree No. 06-198 of May 31, 2006: Regulation applicable to classified establishments for environmental protection:
    - Article 5: Hazard study required before operation.

- Articles 12 to 15: Purpose and content of the hazard study.
- Article 47: Existing classified establishments.

- Executive Decree No. 07-144 of May 19, 2007: Establishes the nomenclature of installations classified for environmental protection.
- Executive Decree No. 07-145 of May 19, 2007: Determines the scope, content, and approval procedures for environmental impact studies and notices.

These laws, still in force today, aim to protect the environment from nuisances (noise, odour), pollution, and risks that can be generated by industries. Depending on their classification, companies are subject to increasingly stringent safety constraints and periodic inspections by the D.R.I.R.E. (Regional Directorate of Industry, Research, and Environment), with inspection frequency varying according to the **I.C.P.E**. classification **(Hamnet, 2001).**

10. Some experiments

10.1.France

In the 1960s, industrial zones in France began to proliferate on agricultural land near cities. French local authorities aim to develop employment, economic activity, and taxation (property and professional taxes) beyond urban planning objectives. Each city wants to create its own Industrial Zone (ZI). As a result, the industrial zone has largely remained vacant for over 10 years, despite prices being lower than costs. Today, the vast majority of locations are found in business parks. They now cover over 200,000 hectares and have more than 15,000 inhabitants, according to the Ministry of Territorial Planning and the Environment (Ikrame & Mouhcine, 2015). The continued competition between communities has led to increased incentives and lower land prices. Major reorganization and migration to better-designed new areas have resulted in many industrial wastelands. Taxation and strong regulatory constraints have played a significant role in this process.

The involvement of local authorities in the development of local economies in France explains the absence of private industrial parks in France. Business parks in the Île-de-France region have seen significant growth in recent decades. These parks currently occupy a large part of the regional space, not only in urban areas but also in peripheral zones. During this period, the (former) new towns and the urbanized cities surrounding them have greatly contributed to this development. Similarly, some urban centres, such as Mantes, Melun, and Meaux, promote the deployment of activity zones at the regional level. Most importantly, there has been a recent phenomenon of numerous local initiatives focusing on the economic mission of rural municipalities, which were previously reluctant to build event-hosting structures.

The evolution of the Economic Activity Zone (ZAE) in Île-de-France has been under almost constant observation for nearly 30 years and is based on the composition of the database established by the IAU following regular censuses. Through this observation, it is possible to better understand the arrangement of economic activity zones at the regional level and to better understand the evolution and development prospects of the market.

10.1.1.Solution (Global Restructuring)

Among the projects for the reconstruction of former industrial areas, some involve large-scale reconstructions. In most of these sites, studies have been conducted to better define the development conditions of the sector, to reconsider the existence of unauthorized activity installations in de facto industrial zones, and to organize the development of future activity zones. Consequently, there are numerous cases of reorganization, involving not only the industrial zone of the first ring but also the industrial zone of the second ring.

Such land opportunities allow for the planning of development operations and more functional combinations. Thus, the presence of the former industrial zone park constitutes an essential potential in the development of the future activity zone. These should eventually constitute an important land

reserve to support restoration activities. Moreover, these sites, which often benefit from a privileged location, can ultimately enhance the attractiveness of these sites for businesses.

Finally, it should be noted that, if in the 1960s and then in the 1970s/80s, the migration of establishments mainly concerned isolated establishments, relocations were due to urban renewal programs, and then voluntary departures of activities (internal relocations, poorly adapted locations, poor services...).

10.2.Algerian experience

The consequences of the establishment of the industrial zone in the city:

The Skikda industrial zone was established in alignment with the country's industrial policy. Initially, it had significant economic and social repercussions, such as reducing unemployment rates and improving living standards. However, it also generated some rather negative problems and consequences:

- ✓ Rural exodus and demographic explosion: The industrial zone in Skikda has led to significant rural exodus and a rapid increase in population.
- ✓ Unplanned urban sprawl and excessive consumption of urban land: There has been anarchic development of built-up areas and an abusive use of urban land.
- ✓ Encroachment on agricultural lands: The industrial zone has encroached upon agricultural lands.
- ✓ The proliferation of slums and individual housing on the outskirts of the industrial zone: There has been a proliferation of slums and individual housing developments on the outskirts of the industrial zone.
- ✓ Industrial risks and pollution: The establishment of the industrial zone has brought about industrial risks and pollution issues.

10.2.1.Identification of major industrial risks:

Industrial risk is considered as the probability of an accidental event occurring at an industrial site, leading to severe immediate consequences for personnel, neighbouring populations, property, and the environment.

Thus, major industrial risks in the petrochemical sector manifest in the following forms: (6)

- Fires and/or explosions in industrial and/or urban environments,

- Discharge of wastewater (polluting groundwater and hence drinking water and water used for irrigation of crops), release of toxic and hazardous gases,

- Accidental or deliberate spills in aquatic environments,

- Emission of ionizing radiation.

Regarding the Skikda industrial zone, risk assessments have highlighted the following risks:

- Fire risk

- Explosion risk

- Poisoning risk

10.2.3.Solutions :

Certainly! Based on the identified major industrial risks in the petrochemical sector, particularly in the context of the Skikda industrial zone, here are some solutions that can be implemented:

- **Fire Risk Management:**

- Implement strict fire prevention measures such as regular inspection of electrical systems, equipment maintenance, and installation of fire detection and suppression systems.

- Conduct regular fire drills and train personnel on emergency response procedures.

- Establish designated fire zones with adequate firefighting equipment and resources.

- **Explosion Risk Mitigation:**

- Ensure compliance with safety standards and regulations related to handling and storage of hazardous materials.

- Conduct thorough risk assessments to identify potential explosion hazards and implement appropriate mitigation measures.

- Use explosion-proof equipment and facilities where applicable.

- Provide training to personnel on handling volatile materials and emergency response protocols in case of explosions.

- **Chemical Exposure Prevention:**

- Implement engineering controls such as ventilation systems and barriers to minimize exposure to toxic and hazardous gases.

- Provide personal protective equipment (PPE) to workers and enforce its use.

- Monitor air quality regularly and conduct health surveillance for workers exposed to chemicals.

- Develop and enforce strict protocols for handling, storage, and disposal of chemical wastes to prevent accidental releases.

- **Environmental Protection:**

Implement wastewater treatment systems to effectively treat and manage industrial effluents before discharge.

Monitor groundwater quality regularly to detect any contamination from industrial activities.

Implement spill prevention and response plans to minimize the impact of accidental releases into aquatic environments.

Promote sustainable practices such as recycling and resource conservation to reduce environmental footprint.

11. Summary:

At the conclusion of this chapter, it is clear that industrial risks present serious challenges that require effective and diverse responses. Proper handling of these risks requires rapid interaction and comprehensive planning, protecting individuals and communities and ensuring the sustainability of industrial processes without adversely affecting the environment and natural resources.

Chapter Three:

Analyzing the Study Area

1. Introduction

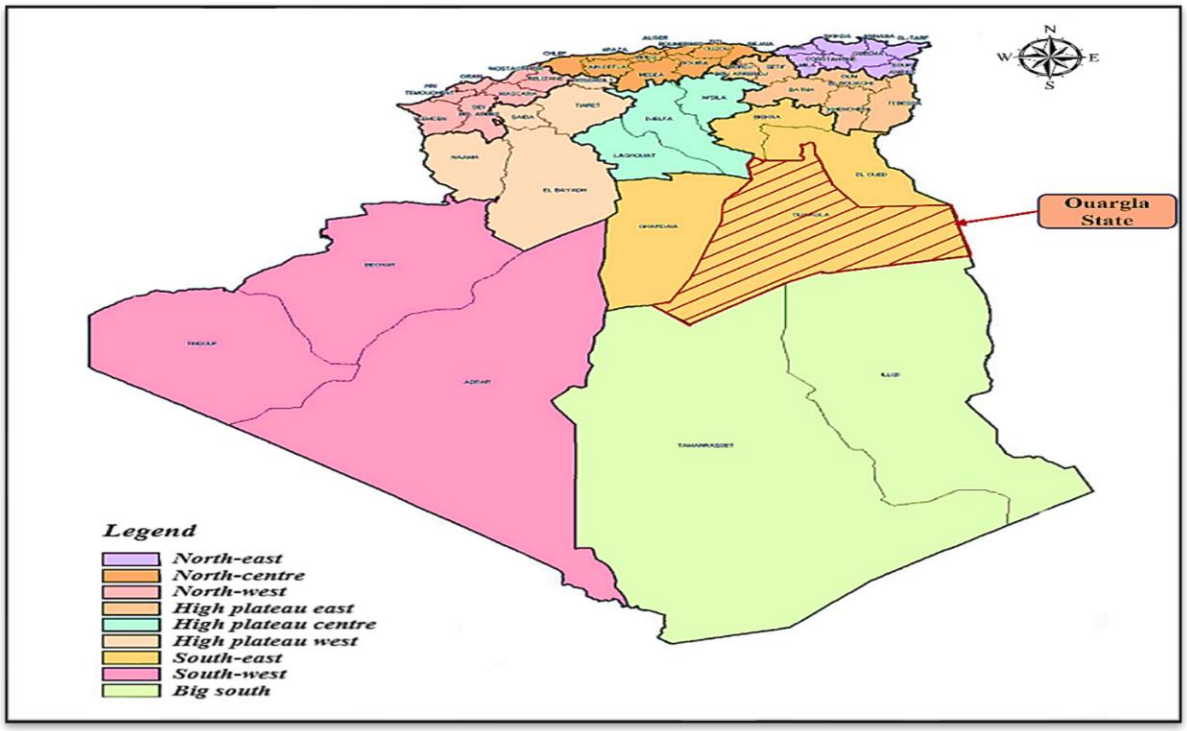
Hassi Messaoud is considered the economic hub of the country and is the No. 1 centre in Algeria. It is home to large oil and gas fields, which have attracted numerous national and international companies involved in hydrocarbon activities.

This overlap between the population and industrial fabric of the oil region (in Hassi Messaoud) classifies it as a high-risk area according to Algerian law. In this chapter, we will gather the necessary data and information about the city of Hassi Messaoud and assess its industrial risks.

2. Presentation of the urban territory of the city of Hassi Messaoud

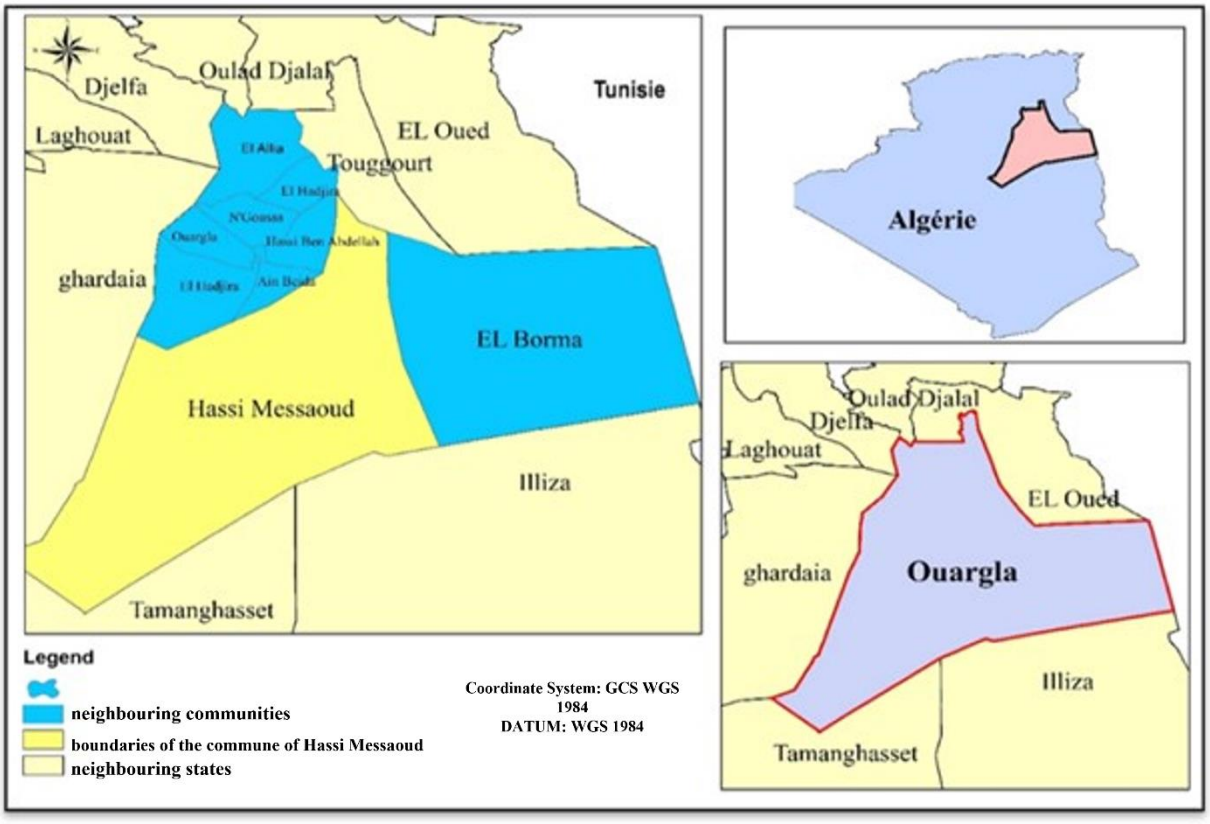
The city of Hassi Messaoud is situated in the southeast of Algeria, right in the middle of the state of Ouargla. It is located 830 km away from the country's capital and 83 km from the state capital. The city covers an area of 71,237 km², making it the largest municipality in the state of Ouargla. It is bordered by:

- From the northwest: the municipalities of Al-Manaqour, Al-Ruissa, Ain Al-Bayda, and Hassi Ben Abdullah.
- From the northeast: Taiba Municipality.
- From the east: Al-Barma Circle. From the south: Illizi province.
- From the southwest: Tamanrasset Province.
- From the west: Ghardaia Province.



Map 1: Ouargla State Location

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



Map 2: Study area location " Hassi Massaoud "- Ouargla state

Source: Author, 2024.

A group of national roads marks the location of Hassi Messaoud, including:

- National Road No. 53 connects Hassi Messaoud to the municipality of Berma in the east.
- National Road No.03 links Hassi Messaoud to In Amenas in the south and Touggourt in the north.
- National Road No. 49 connects Hassi Messaoud to the headquarters of Ouargla Province.

All of these national roads play a role in facilitating connections and communication with other regions, as well as contributing to social and economic progress. **(APC, Hassi Mesoud mentioned by Z Ben Brahim,2015)**

In 2019, the industrial zone of Hassi Messaoud contained a significant oil reserve, with over 350 wells being drilled. This made the city of Hassi Messaoud economically and strategically important. The spatial structure of the municipality's territory is centred around the city's agglomeration due to the existence of oil wells, leading to an economy exclusively dependent on oil-related activities. **(Souirat,2019.p 34)**

3. The physical and natural environment

3.1.Geomorphology

The municipality of Hassi Messaoud is characterized by the diversity of its terrain, as it can be generally divided into three main units:

Tadmait Plateau: situated in the southwestern part of the municipality, characterized by a flat surface and rocky soil.

Great Eastern Sand Dunes: These extensive dunes cover about half of the municipality's area and are situated in the southern and eastern regions.

Hamadas: is a vast desert plain covered with gravel located in the western part of the municipality.**(Bouzouaid, L., & Benabbas, M. ,2020)**

Hassi Messaoud's diverse terrain, which includes plateaus, sand dunes and desert plains, reflects the complex geological history of the region.

3.2.Geological

The Hassi Messaoud region is an ancient metamorphic land, covered with sedimentary formations that, according to geologists, date back to the fourth era (Neolithic period).

Among the deposits that make up the area are: alluvial deposits, sandstones, limestone, and sedimentary salts.

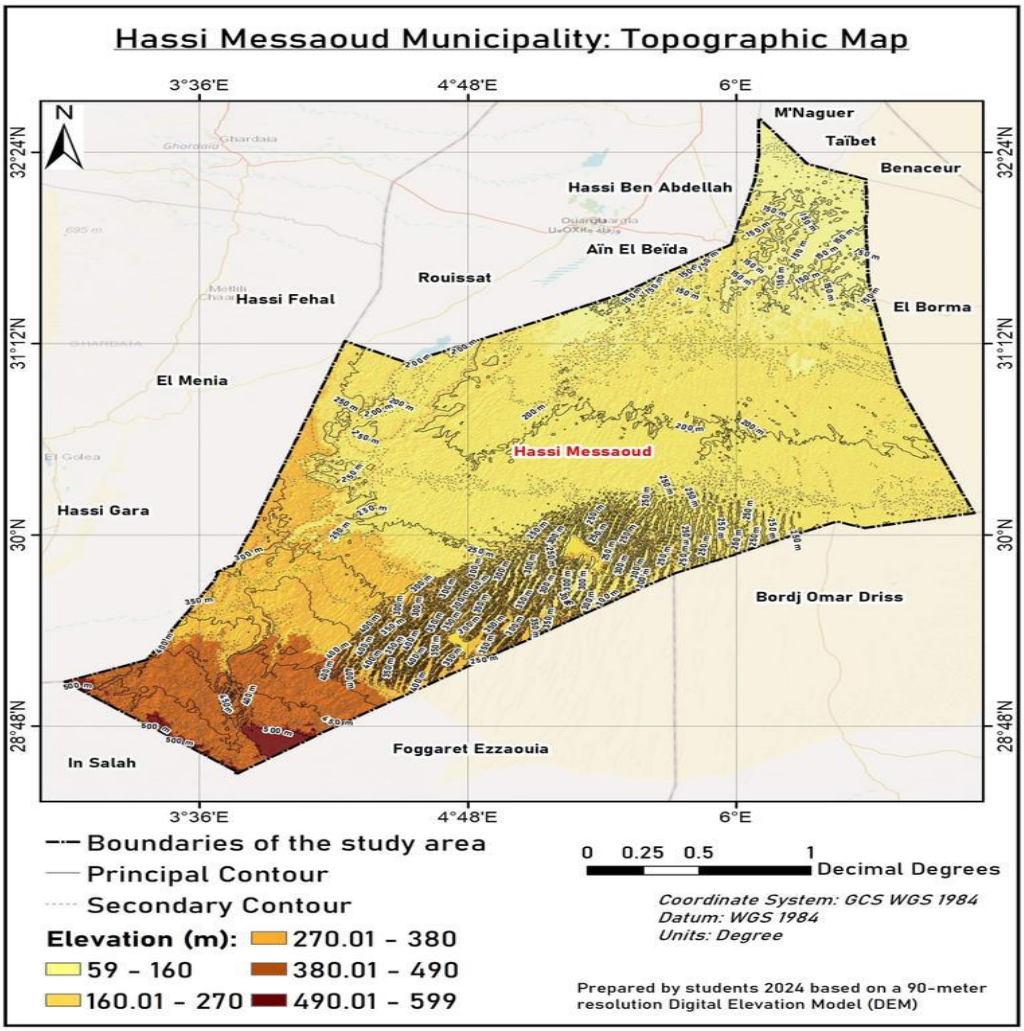
Hassi Massoud has the largest oil stockpile in the country, with reserves estimated at 900 million tons that can be extracted at depths of 3,000 to 3,500 meters. The pelvic area covers approximately 1500 km². **(Yahia Cherif, 2017)**

3.3. Topography

" The position of the issues in relation to the source of the risk can also play a role. If the building is located at a height, there is overall a stronger heat flow. If it is located at a lower altitude than the source of danger, the heat flux received will be lower " **(Souirat ,2019).**

From the topographic map of the municipality of Hassi Messaoud, we notice that it is characterized by its low elevation, with its maximum height reaching 599 meters, and the lowest point reaching 59 meters.

Hence, the municipality of Hassi Messaoud does not benefit from sufficient natural obstacles to prevent the occurrence of risks such as floods or sand storms.



Map 3: Hassi Messaoud Municipality : Topographic.

Source: Author,2024.

Table 1: Details of digital elevation model data

Data	Entity ID	Acquisition Date	Resolution (m)
DEM 1	Srtm_37_06	2007	90
DEM 2	Srtm_38_06	2007	90
DEM 3	Srtm_37_07	2007	90
DEM 4	Srtm_38_07	2007	90

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

3.4.The climate

Hassi Masoud has a dry and hot desert climate with low rainfall, as in some years it may not fall at all, as well as common sandstorms and rising temperatures and evaporation rates. As for moisture, it's very low, these previous data have led to a weakening of the biological life of the ecosystem.

Table 2: Temperature table, Hassi-Messaoud 2021

	Average temperature (°C)	Average minimum temperature (°C)	Maximum temperature (°C)	Precipitation (mm)
January	10.3	4.5	16.2	7
February	12.7	6.3	18.8	3
March	17.8	10.7	24.1	5
April	22.8	15.3	29.1	3
May	27.7	20.1	34	2
June	32.2	24.2	38.8	0
July	35.2	27	41.8	0
August	34.3	26.6	40.7	0
September	30.3	23.3	36.3	2
October	24.1	17.5	30.1	3
November	16.1	10.1	21.8	5
December	11.1	5.7	16.7	4

Source **:** (clima.data.2024)

High temperatures with combustible materials may lead to explosive fires. According to Sonelgaz statistics, the municipality of Hasi Massoud experienced this type of incident in 2018.

4. Historical Overview

The name "Hassi" means "well." The city of Hassi Messaoud, also known as the City of Black Gold, originated from the journey of the farmer (Sheikh Rawaba Masoud bin Ammar) from the village of Ain El Bayda in 1917.

During Masoud's journey, he dug a well whose springs exploded at a depth of 20 metres. His memory was immortalized by naming the well and then the city that grew around it **.**

Hassi Messaoud's development went through three main stages:

- **The first stage:** It was in the year 1956 when oil flowed for the first time from the well, which led to the French colonial attempt to separate the desert.
- **The second stage:** It was in the year 1971 when decisions were issued to nationalize fuels, and Algeria began managing oil facilities, thus the rapid development of Hassi Messaoud and the increase in the number of oil wells to 900 wells.
- **The third stage:** It was in the year 1984 when Hassi Messaoud became a developed municipal region according to the administrative division, that is, it was transformed from an industrial area into an urban area (with a population of more than 35,000 people) containing various social, cultural and economic facilities, residential areas, and production and storage centres.

Figure 2: The town of Hassi-Messaoud in 2001

Source: SEGHIRI, A.,Hassi-Messaoud est-elle une ville, article, (2002)

The region is characterized by a mix of residents, combining peasants and urban residents, who came from different parts of the country in search of a better life. **(APC, Hassi Mesoud Z Ben Brahim,2024)**

5. The urban study of the Hassi Messaoud region :

5.1. The different phases of urban growth:

We mentioned previously that Hassi Messaoud went through three main phases which are shown in Table 5:

Table 3: the evolution of industrial zone and urban environment, fabric (1956-2007)

Phases	**First phase 1956-1971**	**Second phase 1971-1984**	**Third phase 1984-2007**
Urban fabric	/	23 hectares	880 hectares
Industrial zone	200 hectares	512 hectares	552 hectares
Urban environment	**200 hectares**	**535 hectares**	**1432 hectares**

Source : Hassi Messaoud Census Bureau , from (APC ,Hassi Mesoud Z Ben Brahim,2024).

After the discovery of oil in the Hassi Messaoud region, the large influx of people into the region led to numerous problems of inability to provide adequate housing, leading to the emergence of informal settlements in tin houses near the industrial zone, which posed a great danger to the safety of its inhabitants.

The situation worsened as these settlements expanded to encroach upon the boundaries of the industrial zone, disregarding safety standards.

That's what made the inhabitants of this area live on a dormant volcano that might explode at any moment.

5.2.Demographic study

The purpose of this study is to identify the characteristics of society in the municipality of Hassi Massoud and the factors controlling it.

5.2.1.Population growth

Our aim of this study is not to highlight the population but to emphasize that the population of the municipality of Hassi Massoud is growing, which is after the stage of nationalizing the burns and Algeria's interest in industrial and petrochemical installations in the region, so we have taken different periods of study.

Table 4: population growth between 1977-2007

Years	Number of inhabitants	HMD Growth Rate	The Country Growth Rate
1977	6500	/	/
1987	11428	4.92	3.17
1998	40368	10.15	3.06
2007	60196	5.45	3.06

Source: APC urban planning office Hassi Massoud, from (APC, Hassi Mesoud Z Ben Brahim,2024).

The table represents population growth during the period (1977-2007) in the municipality of Hassi Massoud, where we note that from 1977 to 2007 the development was rapid, having doubled by 9 times, with an average growth of 10.15 between 1987 and 1998, which is very high compared to the national average of 3.06. This indicates the attractiveness of the region as a result of immigration.

This growth has resulted in several economic and social transformations as well as a housing crisis and increased risk of industrial hazard.

5.2.2..Factors controlling population growth

We have noted that the population growth in Hassi Massoud is on the rise, which is due to two types of factors:

- Natural factors: Births and deaths are one of the most important factors affecting demographic changes, as mortality has declined since 1998 and this is by compensating births for the shortfall caused by deaths (see annexe A).
- Unnatural factors: It is represented by immigration, as Hassi Messaoud is an attractive area for residents from different states, according to the data provided by ONS (see annexe B).

5.3.Land exploitation in the area

The urban fabric of the municipality of Hassi Masoud consists of:

Residential use: It includes houses, apartments and other residential buildings, which are the most common type of land use in Hassi Massoud and constitute about 50% of the total area of the area.

Equipment: It includes schools, hospitals, public parks, and other public facilities, most of which are located in the city centre to meet the needs of the population .

Agricultural use: It includes lands designated for agriculture and livestock rearing and is located around water wells, but these agricultural areas suffer from difficulties.

Tourist use: Includes hotels, restaurants, and other tourist resorts, but the municipal authorities of Hassi Messaoud do not give much attention to this area.

Industrial use: includes factories, warehouses and other manufacturing facilities. The region has a huge oil field of great importance to the country in terms of development, and the national company Sonatrach has dominated this area, which opens the way for foreign companies to research and develop the petrochemical industries, making the region an important centre of the industry.

6.Hassi-Messaoud City is at risk

The significant population growth in Hassi Messaoud has led to an increased need for housing. This caused the chaotic expansion without proper planning, resulting in the overlap of residential and industrial areas. Consequently, the city's vulnerability has increased. In response, Algerian authorities have designated Hassi Messaoud as a high-risk zone, posing a threat to the safety of its residents, under Executive Order No. 05-127 dated April 24, 2005.

This executive order included regulations for the transportation of hazardous plants, the determination of the territorial boundaries of the oil zone, and measures to address potential harm.

7. Location of risks in Hassi-Messaoud

The complex and formative nature of the Hassi Masood region made it difficult to predict its vulnerability to disasters and hazards. Table 7 and Figure 9 show that certain risks overlap with other hazards, indicating that this urban area is encroaching on industrial and petrochemical facilities.

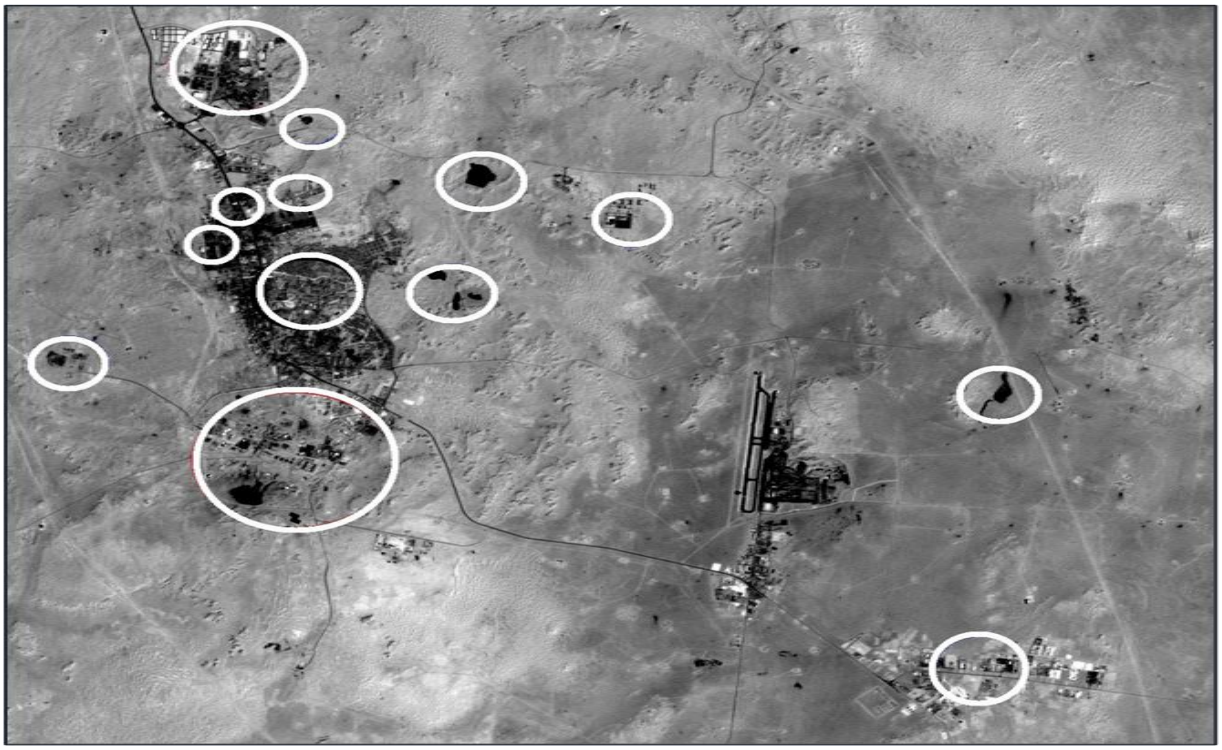


Figure 3: Agglomeration of Hassi-Messaoud, Location of oil exploitation sites.

Source: (Bouzouaid, L., & Benabbas, M. ,2020)

The picture of LandSat shows the areas at risk where we conclude that the vulnerability of space lies in overlapping urban areas or the vicinity of industrial zones. In other words, the area is surrounded by oil wells, gas pumping stations and water systems. The presence of oil wells that are not far enough from housing complexes can be identified, which puts them at risk.

Table 5: Distribution of types of risk according to the area and type of land use

AREAS	POS	OCCUPATION	TYPE OF RISK
ZONE/A SERVITUDE 3000m	Pos:(1, 2, 3, 4, 5, 8, 10, 12, 13, 14)	-Main Networks Electricity HT & MT -Gas-Oil-HP-Water Pipes -ZEA-ZET-AEP-Equipment	-Explosion - Fire – Pollution - Explosion - Electrification - Explosion - Fire - Pollution -Electrification - Flood
ZONE/B SERVITUDE 1000m	Pos:(3, 13, 14)	-Distribution networks Sewerage networks	-Pollution -Contamination
ZONE/C SERVITUDE 500m	Pos:(1, 2, 12)	-Lines Tanks Lines	-Explosion - Fire - Pollution from Railway accident
ZONE/D SERVITUDE 500m	Pos: (4,10)	-Center Wells Station Line	-Explosion - Fire -Pollution from Railway accident
ZONE/E SERVITUDE 500m	Pos: (4, 5, 10)	- Facilities Tanks Pipes	- Explosion - Fire - Pollution from Flood
ZONE/F SERVITUDE 500m	Pos:(7, 8)	-Networks Wells Lines	-Fire - Pollution - Flood
ZONE/G SERVITUDE 500m	Pos:(--)	-Line	-Fire - Pollution - Flood
ZONE/H SERVITUDE 500m	Pos:(11)	-Fuel storage	-Explosion - Fire - Flood
ZONE/I SERVITUDE 500m	Pos:(11)	-Lines industry	-Explosion - Electrification - Fire and Railway accidents
ZONE/J SERVITUDE 500m	Pos:(O)	AGIP Sonatrach	-Fire Explosion

Source: (Bouzouaid, L., & Benabbas, M. ,2020).

Through the above table, the vulnerable areas can be divided into three categories:

- High-risk areas, which require a safety distance of 3,000 meters, include the following areas 1, 2, 3, 4, 5, 8, 10, 12, 13 and 14.

- The second category, which is less dangerous, requires a safe distance of 1,000 meters and includes areas 3, 13, and 14.

- The last category consists of low-risk areas requiring a safe distance of 500 meters, including areas 1, 2, 4, 5, 7, 8, 10, 11, and 12.

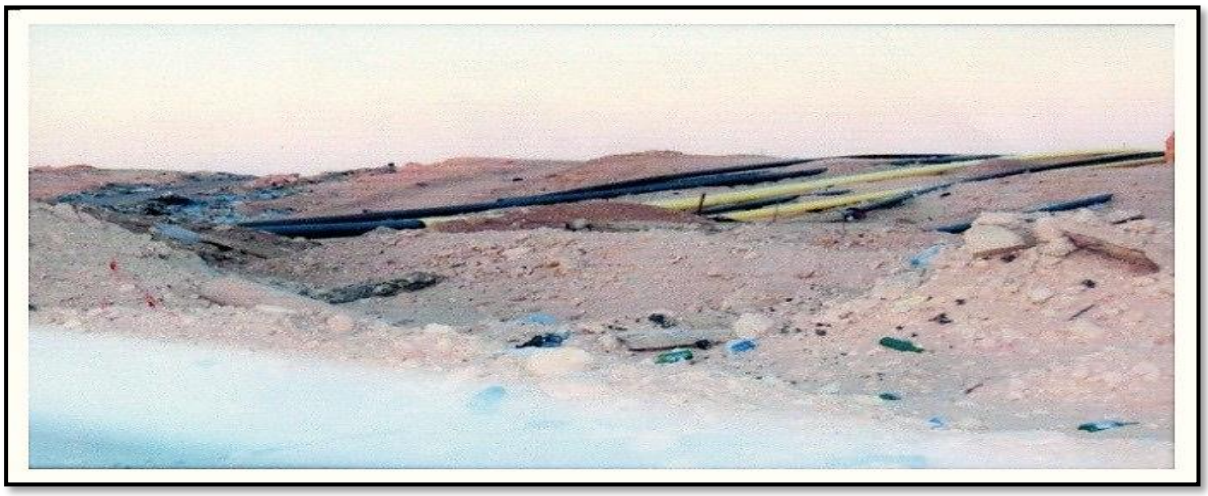


Figure 4: Pipelines of Oil and Gas

Source: (Z.ben brahim,2015).

Figure 5: Pollution caused by the refinery

Source: (Z.ben brahim,2015).

Figure 6: Wells near an area of human habitats

Source: (Z.ben brahim,2015).

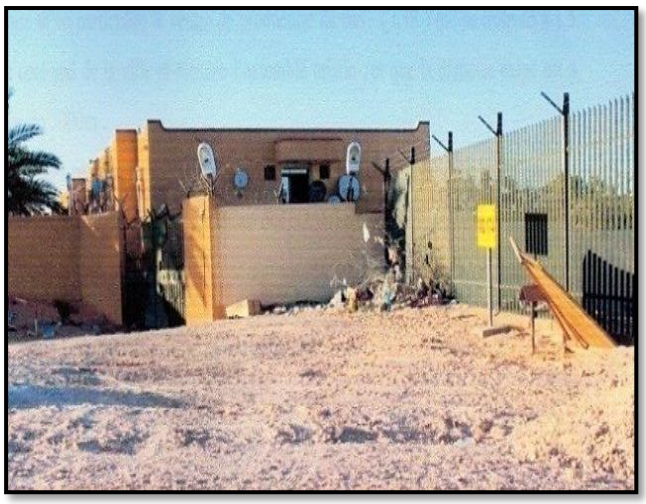


Figure 7: Well near human activity

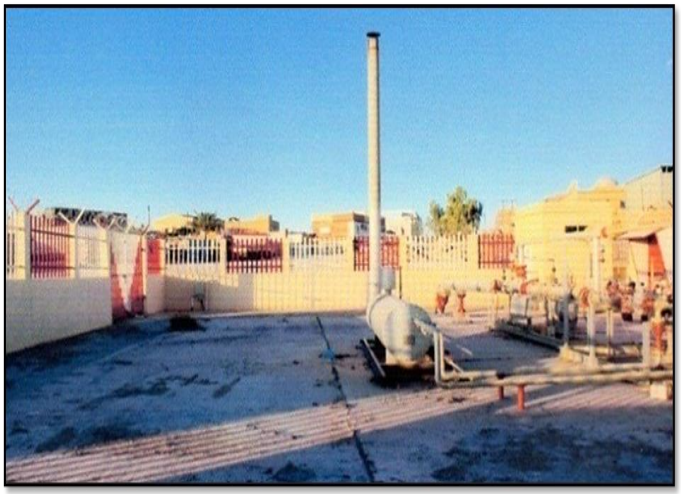


Figure 8: Gas pumping in the middle of an area of human habitats

Source: (Z.ben brahim,2015).

Figure 9: fuel storage Sonatrach, Hassi-Messaoud

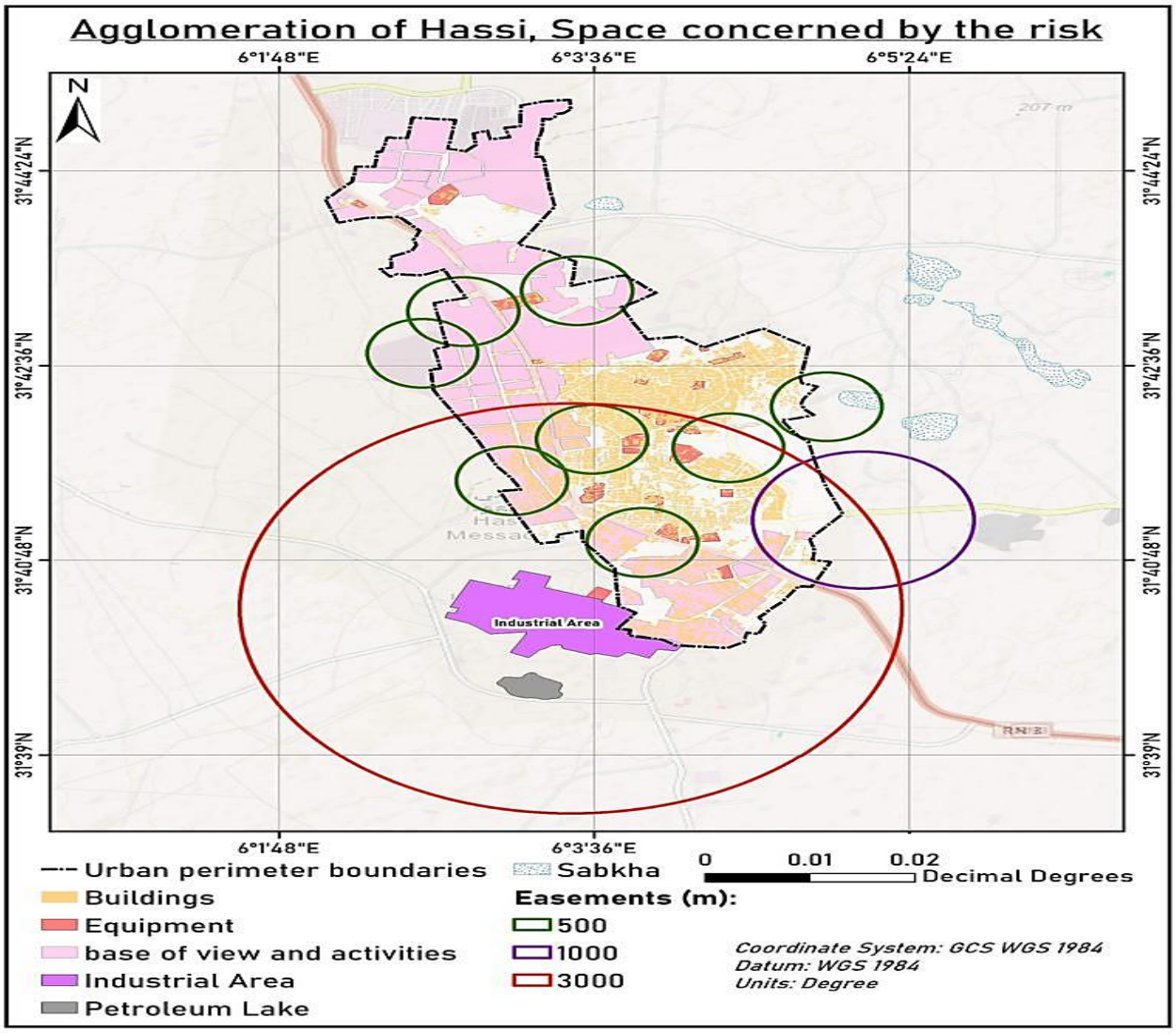
Source: (Z.ben brahim,2015).

Through the above, we mentioned that the danger areas in the city of Hassi Messaoud lie in urban areas where industrial areas overlap with residential areas. The previous Figures (4,5,6,7,8,9) show us some industrial areas close to housing and the threats they contain. For the population.

And we can mention some of the different risks that Hassi Massoud could be exposed to:

- Explosions and fires are due to the presence of flammable and explosive substances.
- Pollution is due to the presence of toxic or contaminated substances.
- The electrocution is due to the presence of high-stressed, exposed power lines.

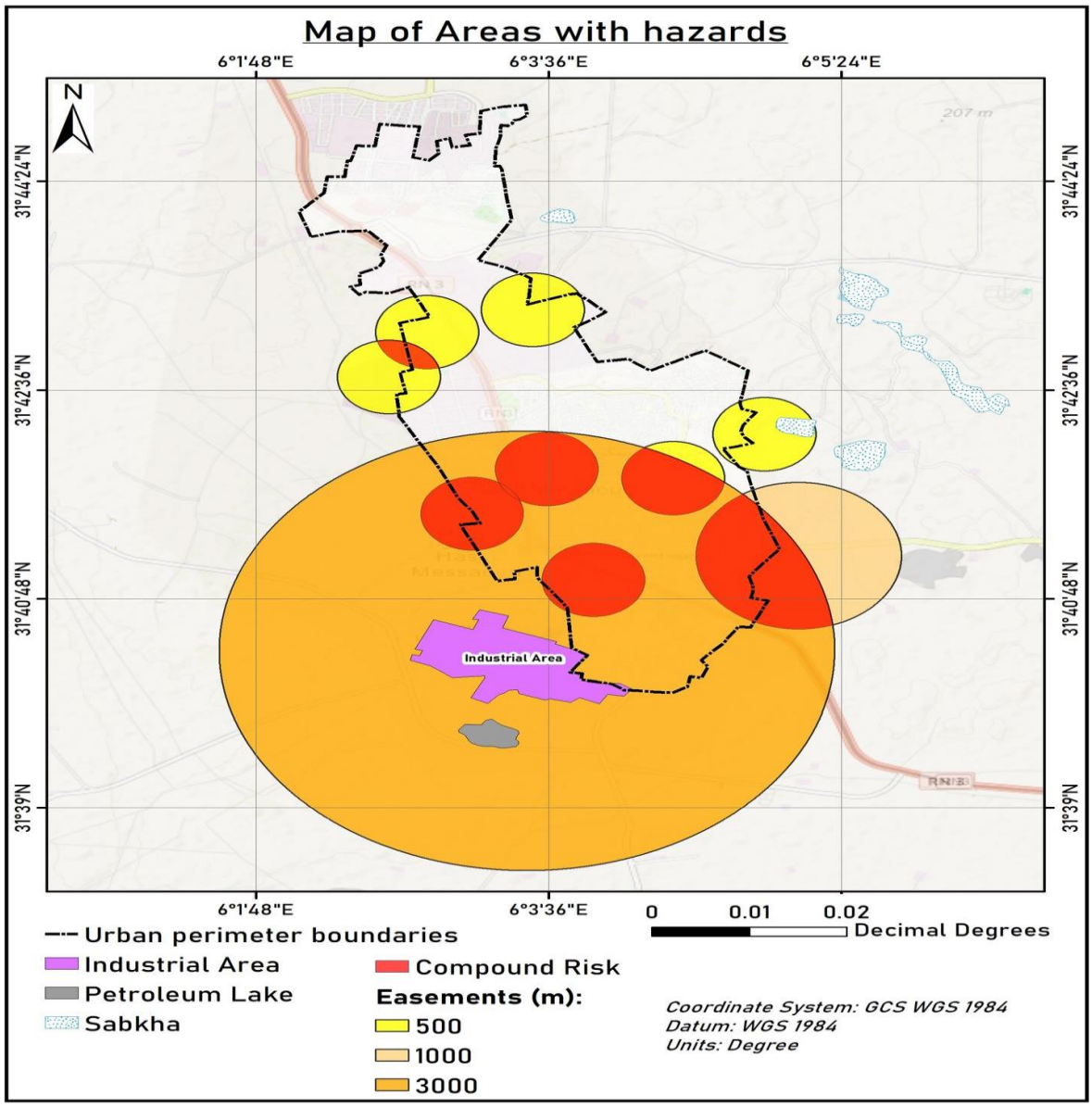
To analyse potential disaster situations in urban areas, we provide the following maps:



Map 4: Agglomeration of Hassi, Space concerned by the risk.

Source: Editor based on map from (Bouzouaid, L., & Benabbas, M. ,2020).

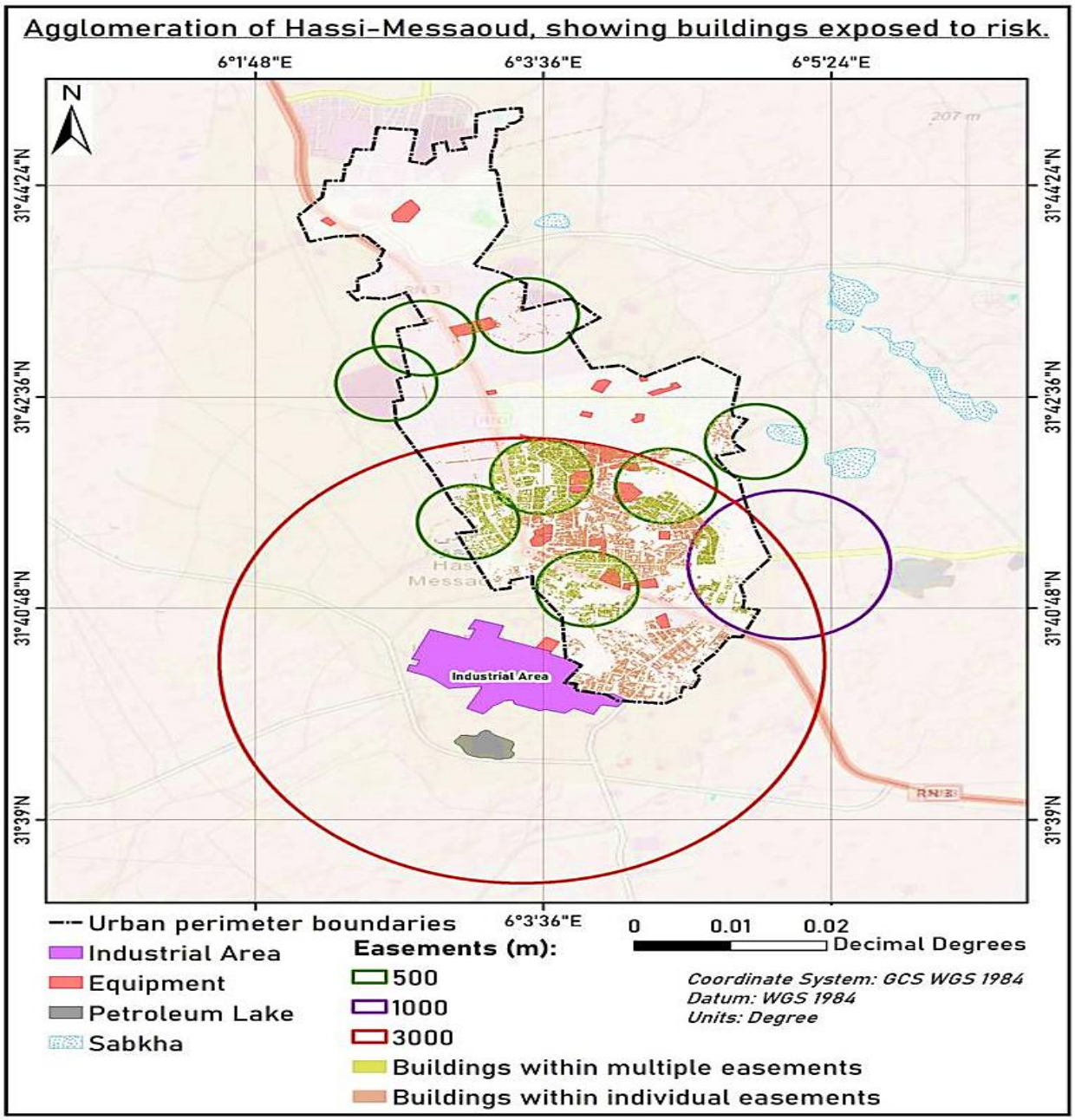
The above map 4 shows us the blueprint of Urban areas at risk where there are 10 overlapping areas coded to (A, B, C, D, E, F, J, H, I, and G) We find every area with the necessary safety distance, and you can distinguish 3 different distances by degree of hazard (3000 m, 1,000 m, 500 m).



Map 5: Map of areas with hazards

Source: Editor based on a map from (Souirat ,2019).

As previously mentioned, the 10 hazard zones have different levels of gravity. Some dangerous areas overlap across zones, making those shared spaces particularly hazardous. This is illustrated in map 5, which shows four areas with varying levels of risk. The most severe risks are indicated in red and represent a compounded risk resulting from the overlapping of two different risk areas.



Map 6: Agglomeration of Hassi-Messaoud, showing buildings exposed to risk.

Source: Editor based on map from (Bouzouaid, L., & Benabbas, M. ,2020).

The possibility of an accident within the giant power rotation area raises serious concerns about the safety and safety of the population of the adjacent area. This area is located in the vicinity of two residential areas, one with 1,600 houses and the other 120 houses, as well as 20 villas and two other houses for collective housing **(Saadan Fadhala and Aysat Idir)(Bouzouaid, L., & Benabbas, M.,2020)**.

The possibility of an accident within the giant power rotation area raises serious concerns about the safety and safety of the surrounding population. Strict preventive measures must be taken to prevent such incidents and reduce their risks.

8. Summary:

After an in-depth analysis and detailed study of the Hassi Massoud area and a risk assessment, it has been found that these threats are the result of the expansion of the urban area within the industrial and petrochemical areas, which urgently requires solutions to address the situation before the disaster occurs in this region. This is what we will address in the next chapter.

Chapter 4:

Rational Choice and Paradoxical Solution

1. Introduction :

After an analytical study of the city of Hasi Massoud and an assessment of the impact of the overlap of the industrial and residential areas (due to random planning) and the identification of the risks they pose, we have to find an effective solution to this problem to mitigate the risks involved in ensuring the safety and security of the population.

2. The first solution: the establishment of a new city

The establishment of a new city as a solution to the industrial hazards in the Hassi Messaoud region was proposed by the Algerian authorities to create a sustainable, intelligent city, completely free of industrial activities and petrochemicals, to ensure the safety and security of its inhabitants by transferring them to the new city, which is about 70 Km from the original city, thus separating the residential areas from the industrial areas.

3. Presentation of the new town of Hassi Messaoud:

The new city, Hassi Messoud, is located in the state of Ouargla -Algeria, with an area of 4483 hectares and a planned population of 8,000, with a population density of 17.84 inhabitants/ha, 450 verified facilities, and 40,000 positions, for more information look to Table 8.

Figure 10: The new city of Hasssi Messaoud.

Source : (Algerie presse service).

Table 6: Technical sheet of the new city of Hassi Messaoud.

Technical sheet		
Situation		Hassi Messaoud-Ouargla-Algeria
Total area		4483 hectares
Urbanization		2053 ha
Future extension area		1152 ha
The surface of the Logistics Activity Zone "ZAL"		965 ha
Population		80000 inhabitants
Density		17.84 inhabitant/hectare
Project owner		Public power at the Ministry of Energy and Mining
Project manager		DONGMYEONG Group
Decree of establishment		nº 06-321 of 01/09/2006 under the supervision of the Ministry of Energy; Placed under the supervision of the Ministry of Habitat and Urban Planning and the City, following executive decree nº20-298 of 12 October 2020
Decree approving of the layout plan		No. 16/150 of 23 May 2016
Projected Programs	**Collective housing**	10299
	Semi-collective housing	3658
	Individual housing	3854
	Mixed housing	2773
	Public facilities	450 facilities

Source: (M ,Othmani , 2023).

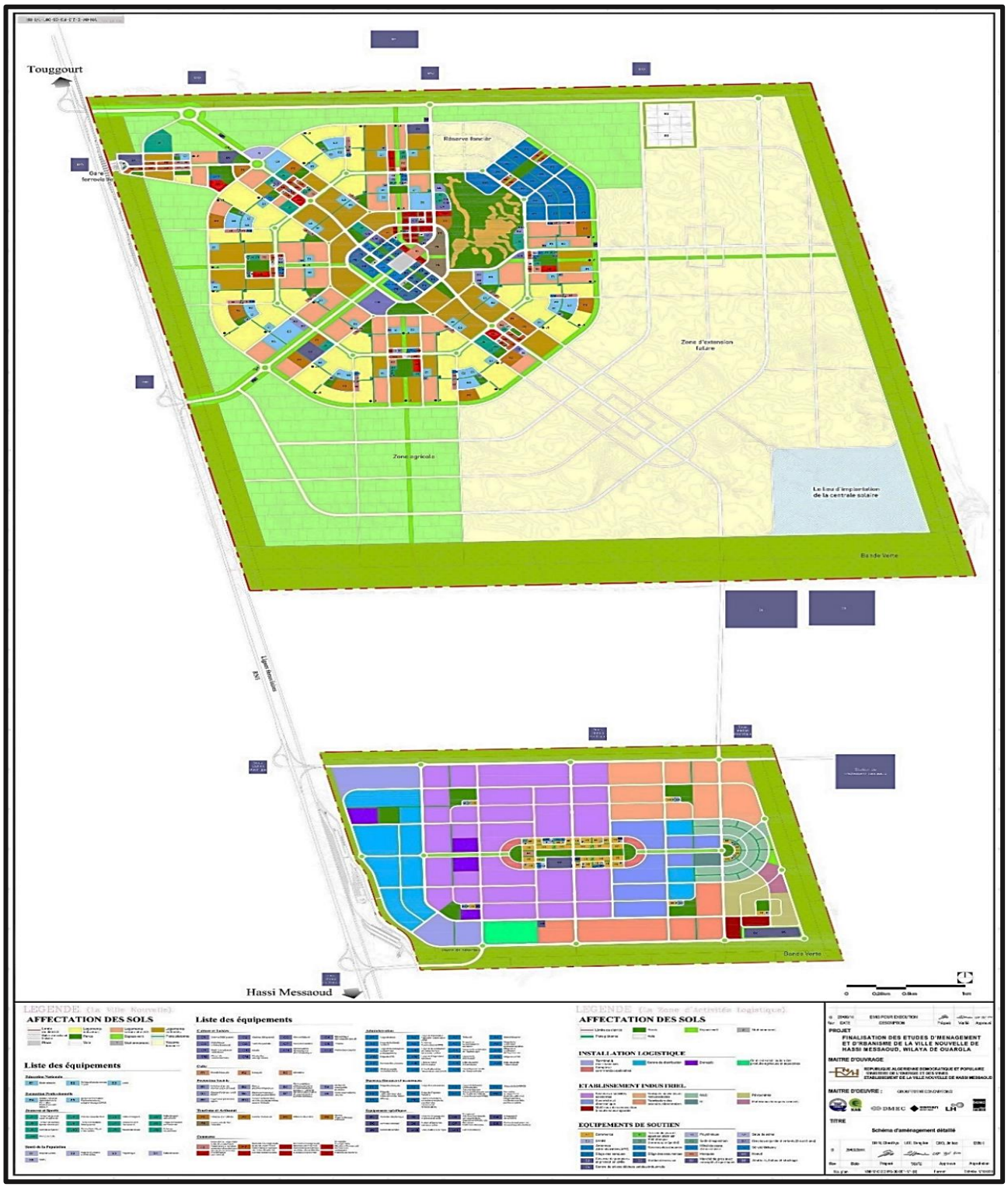


Figure 11: Plan The new city of Hassi-Messaoud -Ouargla-Algeria

Source: (GROUPEMENT DONGMYEONG , EVNH,2012).

4. The situation of the new city of Hassi Messaoud

The new city of Hassi-Messaoud is strategically situated within Ouargla province, one of Algeria's largest. While located 90 km southeast of Ouargla, the provincial capital, and roughly 850 km southeast of Algiers, the national capital, it boasts excellent regional connectivity. Notably, the new town sits within the Oued El Maraa region, roughly 80 km from each of the surrounding cities: Ouargla, Touggourt, and the existing Hassi Messaoud town. Additionally, its location on the RN3 highway provides a convenient link between the RN49 and RN56 national roads.

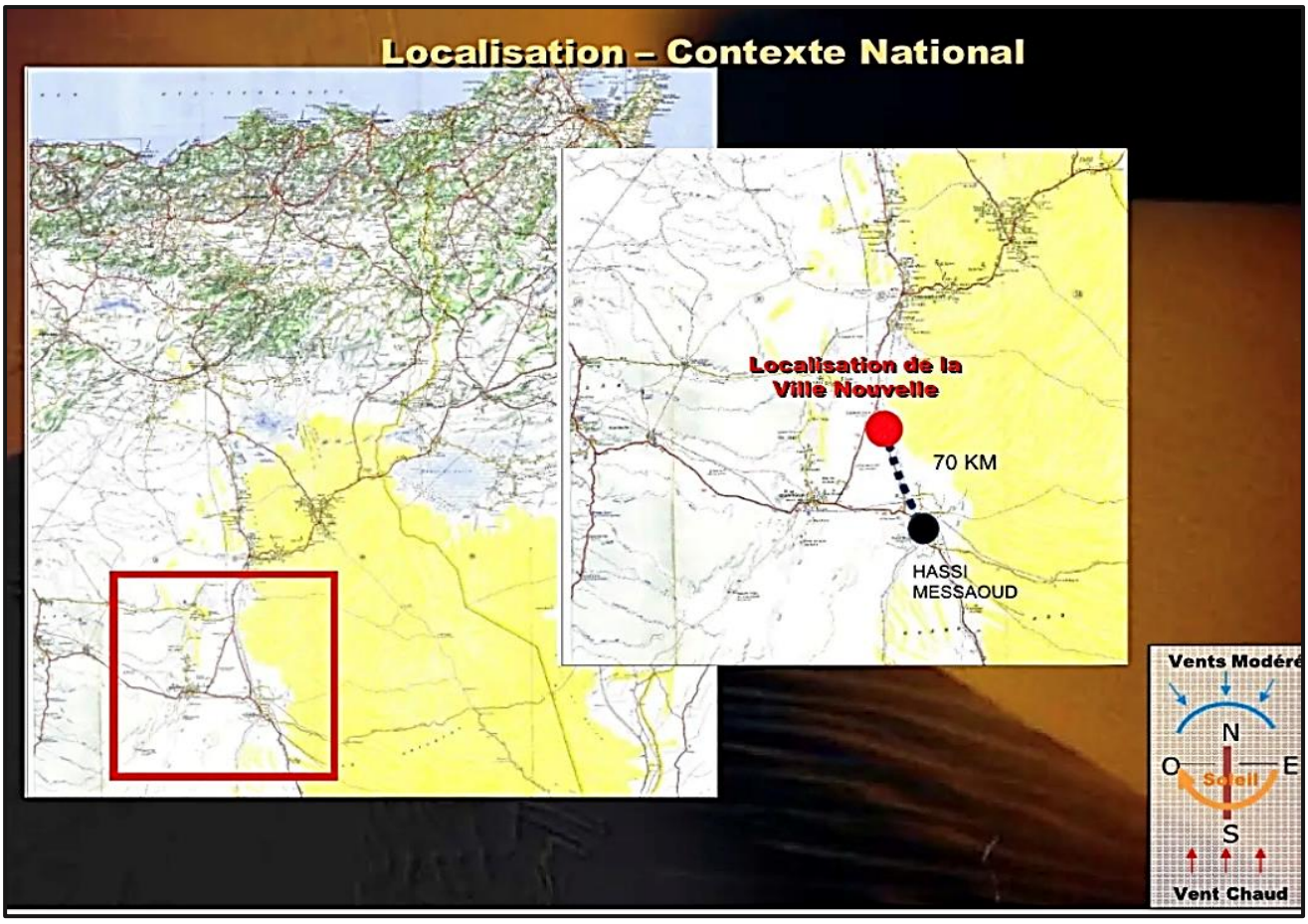


Figure 12: The location of the new city -Hqssi Messaoud-

Source: (https://fr.scribd.com/).

5. The reason for choosing the location of the new city:

- The strategic location is through its positioning between three major southern cities.
- The possibility of benefiting from solar energy due to its environment, to develop it and achieve sustainability.
- Achieving security and safety by staying away from the industrial areas in the old city.

6. Objectives of the new city "Hassi Messaoud":

The primary goal of the new city is to establish a safe environment for the population, free from technological hazards, to solve this issue. This will be achieved by creating a sustainable environment focusing on four main objectives: economic efficiency, social progress, environmental comfort, and improved quality of life. Additionally, efforts will be made to generate new employment opportunities, with plans in place for about 40,000 jobs across different sectors. The new city also seeks to promote economic development in the southern regions.

7. The perimeter of the new city of Hassi Messaoud:

The new city spans an area of 4.483 hectares, which is divided into four distinct areas**:**

- **The first area**, covering 2.044 hectares, is designated for the urbanization and development of the new city**.**
- **The second area**, spanning 1.161 hectares, is earmarked for future urban expansion**.**
- **The third area**, encompasses 313 hectares of protection zone for the new city.
- **The fourth area**, is located in the area of logistics activities, with an estimated area of 965 hectares.

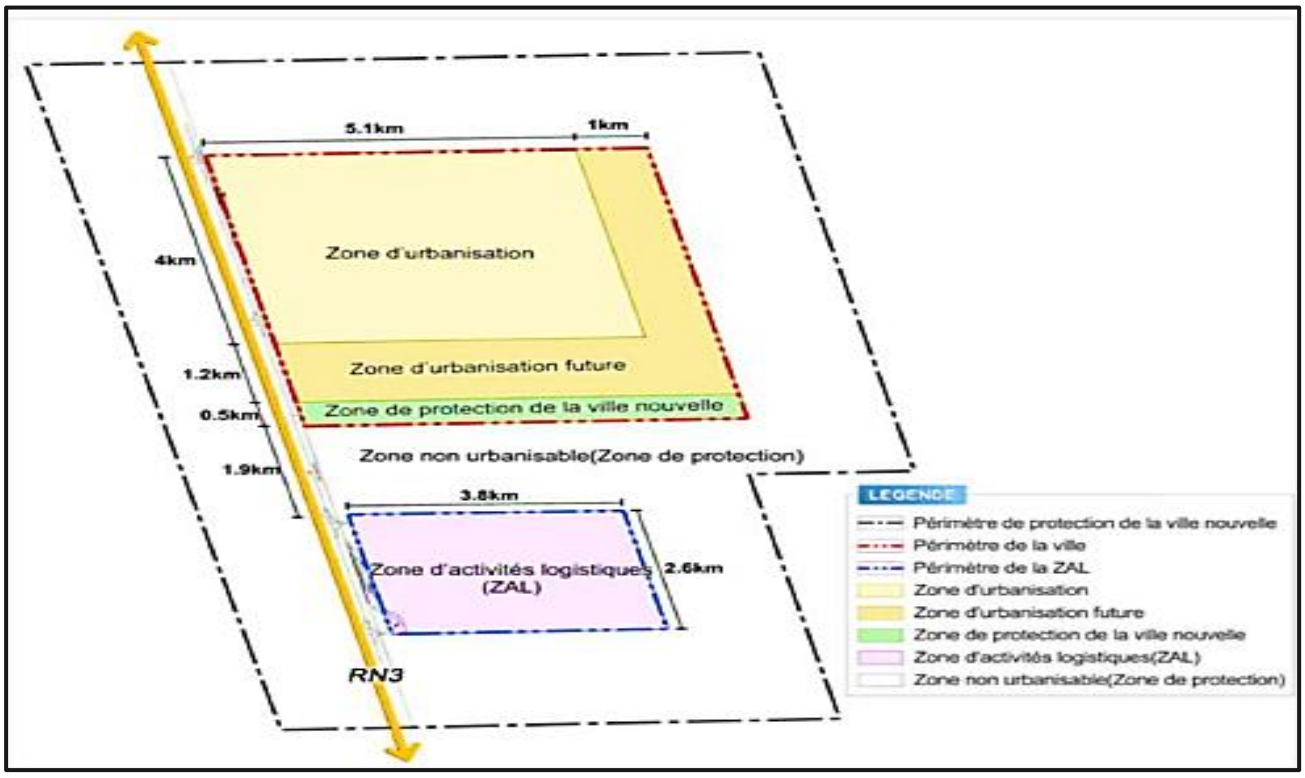


Figure 13: Perimeter of the new City.

Source: (Ministère d'habitat,Algérienne).

8. The principles of urban composition:

The new city, Hassi Massoud, was designed based on the concept of an urban oasis. It merges modernity with tradition while considering the desert environment. The city is divided into four residential areas, separated by the city centre.

City centre: Urban Pulse Convergence: The city centre is cut off by key hubs that meet the various needs of the population and include economic and commercial activities, administrative services and various cultural events.

Green Recreational Spaces: The centre is surrounded by a green belt that provides recreational spaces suitable for all family members. These spaces include gardens, playgrounds, sports facilities, and walking paths.

Balanced Urban Model: The city's design follows a traditional urban model, with the business centre concentrated at the city's core. It is encircled by densely populated residential areas, while low-density housing is distributed towards the outer edges.

Figure 14: the city Hassi Massoud.

Source: (GROUPEMENT DONGMYEONG, EVNH, 2012).

Based on initial studies from the city's research offices, the residential area covers 35% of the city's total area, estimated at 40 to 45 hectares. The commercial zone covers 5%, the equipment area 10%, the network 30%, and green spaces and gardens 20%.

9. The Second Solution: Proposing a new urban expansion with some recommendations :

Because of the industrial danger that threatens the residents of the municipality of Hassi Messaoud as a result of the random and unplanned expansion of residential areas at the expense of industrial areas, the establishment of a new expansion that is only a few kilometres away from the mother city, taking into account some recommendations, maybe a solution to this crisis.

9.1.Possibility of the urban expansion of Hassi Masood

9.1.1.Internal expansion

Through the analytical study of the Hassi Messaoud region, we find that it is impossible to accept internal expansion, that is, in the middle of its urban fabric. This is due to the complex danger network in that region, since the majority of its lands are oil wells and gas fields, in addition to other obstacles previously mentioned.

9.1.2.External expansion

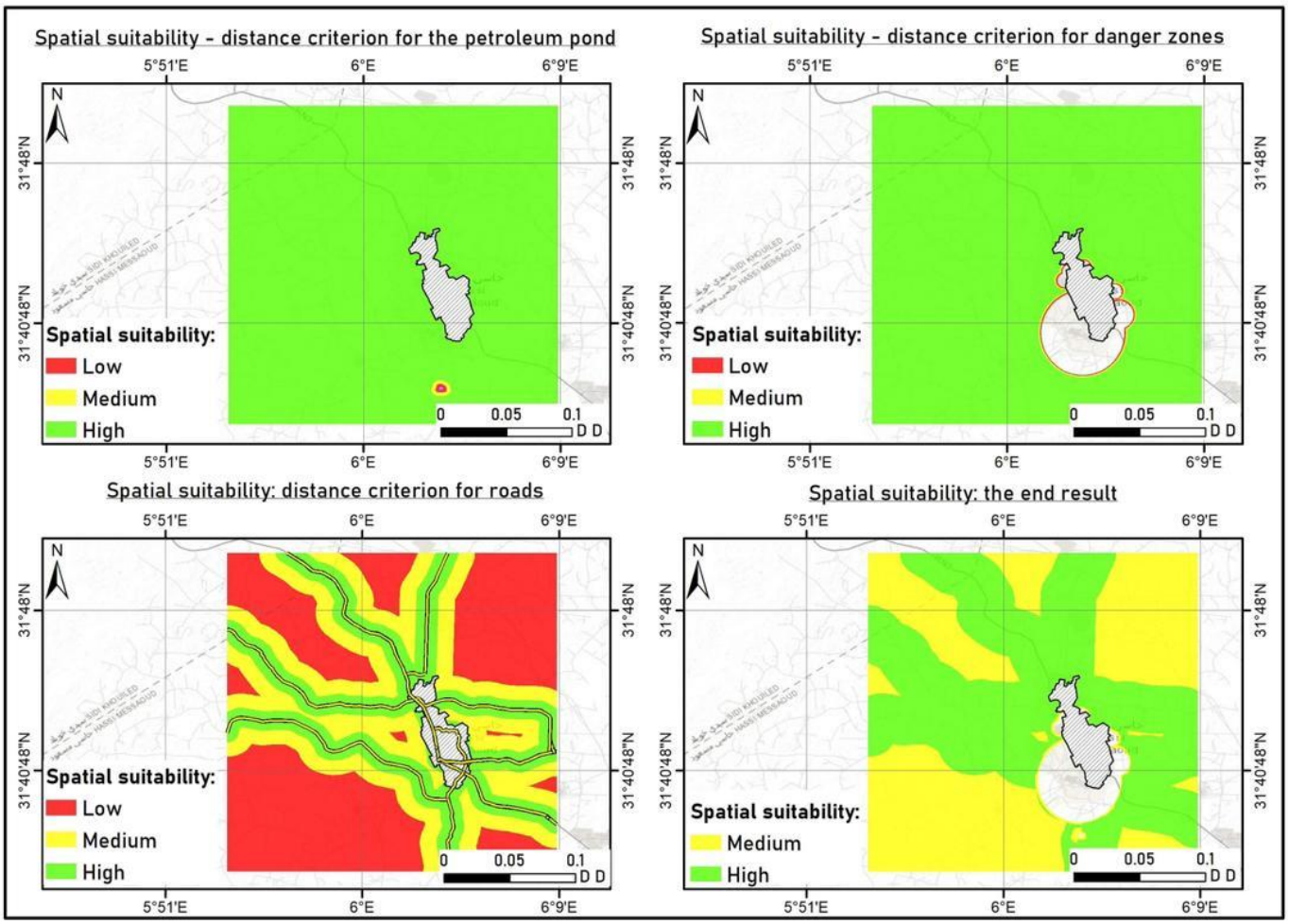
What characterizes this kind of expansion is that it's known as the horizontal stretch or the cities of the city of origin.

From the map (06) showing hazard areas concerning residential areas within this space, we can identify 10 areas (A, B, C, D, E, F, G, H, I, J).

Residentials within the danger zone (A.B.C.D.E.F.) They form a housing block together, and therefore a common expansion area must be set up with sufficient distance to get away from danger.

Residential areas within the space (G, H, I) also have to have a common expansion zone, but not the same as the first expansion zone.

Moving areas close to each other is the same extension for the unit of the neighbourhood.



MAP 7: Spatial suitability in the city of hassi mesaoud

Source: Author,2024.

The four maps show different spatial suitability criteria for expansion in the Hassi Massoud area.

Benchmark 01: The distance standard between the oil ponds

The first map divides the Hassi Masoud area into three spatially appropriate zones based on the distance between the oil pools.

Low spatially appropriate areas (in red) are those less than 1 km from the oil pond.

Medium spatially appropriate areas (in yellow) are those that are more than 1 km from the oil pond.

High-spatially appropriate areas (green) are those that are more than 2 km from the oil pond.

Therefore, the most suitable areas for expansion are those located far from the oil pond.

Benchmark 02: The criterion of distance between hazardous areas

The second map divides the Hassi Masoud area into three spatially appropriate zones based on the distance between the hazardous areas.

Low spatially appropriate areas (in red) are those located within or near hazardous areas.

Medium spatially appropriate areas (in yellow) are those located 0.5 km from hazardous areas.

High spatially appropriate areas (green) are those more than 0.5 km from hazardous areas.

This map indicates that the most suitable areas for expansion are those located far from the hazardous areas. That is because these areas will be safer for the population and infrastructure.

Benchmark 3: The criterion of distance between roads

The third map divides the Hassi Masoud area into three spatially appropriate areas based on distance to the roads.

Low spatially appropriate areas (in red) are those that are more than 2 km off the roads.

Intermediate spatially appropriate areas (in yellow) are those that are between 1 and 2 kilometres from the roads.

High spatially appropriate areas (green) are those less than 1 km from the roads.

This map indicates that the most suitable areas for expansion are those located near the roads. These areas will have easy access to transport, which will reduce transport costs and improve communication.

Map 04 shows the final result of the integration of the three spatial suitability criteria.

Low spatially appropriate areas (Red) are those that do not meet any of the three spatially appropriate criteria.

Intermediate spatially appropriate areas (in yellow) are those that meet one of the three spatially appropriate criteria.

High spatially appropriate areas (green) are those that meet the three spatially appropriate criteria.

9.2.Characteristics of the areas proposed for expansion:

- Taking into account the terrain, and given the topographic map of the city of Hassi Massoud, most of them are flat.
- Geological study of the area to find out where the dyes are and where the oil and gas are.
- Studying the feasibility of creating electricity, gas, water and sewage systems
- The site must have the potential to expand in the future.
- Stay away from the oil pools above the surface of the Earth.
- The new area must contain all social, economic and cultural facilities except industry, and therefore separate the residential area from the industry.
- The selected expansion zone is close to the original city, but with a guarantee of safety and this is to maintain the same pattern of living environment.
- Social participation by involving the population in the process of selecting expansion to ensure that their needs are met
- To be close to national roads: 03 National Road and 49 National Road .

Figure 15: Aerial photo of an oil pond

Source: (Google Earth Pro Edited by the Author,2024).

10. Proposed expansion programmes:

For housing: individual residences, semi-collective and collective.

As for the facilities: they include all educational, commercial, and recreational services, except industrial ones. This is to eliminate the danger resulting from them and ensure the safety of individuals. Thus, the expansion areas are primarily residential, achieving their purpose.

11. Recommendations for urban expansion:

We have had to attach the solution to the creation of a new urban expansion to several recommendations:

- ✓ The afforestation of the endangered area of the original city is a green belt problem, with the consideration of the type of trees used, to fit into the difficult environment.
- ✓ Planting trees in the area surrounding the residential areas (in the place of the converted areas) to form a green belt separating the fixed residential areas from the industrial areas.
- ✓ Using filters to filter gases in industrial areas to reduce environmental pollution.

table 7: Some suitable trees in the desert area

Type of Tree	Picture of the Tree
The acacia tree	
The oak tree	
Olive tree	
The maple tree	
Willow tree	

source: by Author,2024.

12. Summary:

One of the proposed solutions to the problem of industrial hazards in the Hasy Masoud region is the creation of a new city outside the affected area, to minimize the negative effects of major industries on the population. However, by analysing and comparing the first with the second solution of establishing a nearby urban expansion of the area by transferring threatened dwellings and facilities, the best option is for several reasons.

The economic cost of building a new city requires massive investments in infrastructure and basic services, while those funds can be used to improve air, water and other infrastructure within the current region, taking into account the recommendations we mentioned earlier.

As for sustainability, expansion within the current region could be more sustainable, including the use of clean technology and emission control to reduce negative environmental impacts.

Let us not forget the social impact factor: the creation of a new city may lead to the loss of social and cultural ties that bring together the people of Hasi Massoud, while the expansion near the region maintains the continuity of these ties.

Thus, it can be said that expansion near the borders of the Hasi Masood region is the best solution to address the problem of industrial risks, thanks to the combination of economic development while preserving the environment and the community.

General Conclusion

General Conclusion:

We have thoroughly analyzed the industrial risks in the Hassi Masoud region and carefully considered potential solutions. After careful evaluation, we have concluded that expanding near the current region is the most suitable option. While the idea of establishing a new city outside the region might initially seem attractive, it entails high economic and environmental costs and poses a risk of undermining the cultural identity and social connections in Hassi Mesoud.

Therefore, it is crucial for the selected solution to address the basic needs of the population, including housing, education, and healthcare, while also fostering economic development and job opportunities. Additionally, it should prioritize environmental sustainability by safeguarding the environment and natural resources, thereby contributing to sustainable development for future generations.

Expanding near the region presents itself as a harmonious and sustainable solution that can enhance the quality of life for the local population without compromising the rich cultural heritage of the society. Consequently, the relevant authorities and the community must collaborate effectively in implementing this solution, thus ensuring a prosperous and sustainable future for the Hasi Masood region while striking a balance between economic development, environmental preservation, and the region's cultural heritage.

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Annexe Liste

List of Annexe

Annexe A: The migrants of Hassi Messaoud by district (2007)

District	Migrants	Pourcentage	District	Migrants	Percentage
Adrar	88	1.24	Constantine	157	2.22
Chleff	42	0.59	Medea	66	0.93
Laghhouat	148	2.09	Mostaganem	36	0.50
Oum bouaghi	65	0.92	Msila	74	1.04
Batna	307	4.34	Mascara	19	0.26
Bejaia	170	2.40	Oran	142	2.01
Biskra	275	3.89	El-Bayad	33	0.46
Bechar	38	0.53	Illizi	57	0.80
Blida	137	1.93	B.Bou Arreridj	43	0.60
Bouira	81	1.14	Boumerdes	74	1.04
Tamanrasset	44	0.62	El-Taref	14	0.19
Tebessa	85	1.20	Tindouf	08	0.11
Tlemcen	27	0.38	Tissemssilt	04	0.04
Tiaret	31	0.43	El-Oued	1773	25.10
TiziOuzou	310	4.38	Khenchla	103	1.45
Alger	1289	18.25	Souk Ahras	52	0.73
Djelfa	330	4.67	Tipaza	53	0.75
Jijel	115	1.62	Mila	79	1.11
Setif	142	2.01	Ain Defla	37	0.52
Saida	21	0.29	Naama	05	0.07
Skikda	55	0.77	Ain Tmouchent	26	0.36
Sidi bel Abbes	21	0.29	Ghardaia	139	1.96
Annaba	72	1.01	Ghilizane	48	0.67
Guelma	40	0.56	Total	7036	100

Source:(ONS,2015).

Annexe B: Spatial characteristics of risk-prone areas according to the type of occupation

AREAS	SURFACE (Ha)		NUMBER		EQUIPMENT		
	Total	Built	Housing	Inhabitant			
ZONE/A	2826	367.38	3670	18350	• Activity Area • Complex • Base ZELACI • ECO • Nursery • CTC Sud	• Annex ADM • Defence Area • REBO • APC Center • Technicom • School	• Hotel • SNTV • Daira SEAT • Area Games • Station • SONELGAZ
ZONE/B	340	1.5	42	366	• Arab Bahir • Activity Area	- • CFPA	- • SONELGAZ
ZONE/C	78.5	21.98	732	3663	• • High School	• • Customs	• Barrack • SubHydrau
ZONE/D	78.5	14.13	235	1413	• SNTV • Technicom	- • NAFTAL	- • School
ZONE/E	78.5	40.82	833	4166	• • NPHS • Sport Room	• • KANALGAZ • ENAFOR	• HESP • CEAU • Private Base
ZONE/F	78.5	29.83	586	4102	• Hotel •	• Camp •	• Station • Center
ZONE/G	78.5	5.79	115	805	• ENECO • SONELEC • Center	• NAFTAL • Center • Fezz Souad	• GTP • Ouarlissi • SAERB
ZONE/H	78.5	39.59	266	1333	• Ouarlissi • ENAGEO	• NAFTAL • Center	• SONELEC • GTP
ZONE/I	78.5	40.79	375	1875	• Military • NAFTOGAZ	• ENTP • Society	• Center • Industrial
ZONE/J	78.5	10.03	166	833	• AGIP	• SONATRACH	• ENTP • Society

Source: (Bouzouaid, L., & Benabbas, M. ,2020).