People's Democratic Republic of Algeria

Ministry of Higher Education and Scientific Research
Salah Boubnider University – Constantine 3
Faculty of Architecture and Urbanism
Department of Urbanism

2024-2025

COURSE PACK OF :
RISK MANAGEMENT 2

Level: Bachelor's Degree – Year 3, Semester 6 (S6)

Field: Urbanism

Specialization: Urbanism

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GLOSSARY OF ABBREVIATIONS

International & UN Organizations

UNISDR –United Nations International Strategy for Disaster Reduction (former name).

UNDRR – United Nations Office for Disaster Risk Reduction.

UNDP – United Nations Development Programme.

IPCC – Intergovernmental Panel on Climate Change.

EM-DAT – Emergency Events Database (CRED international disaster database).

WHO – World Health Organization.

SDGs – Sustainable Development Goals (UN 2030 Agenda).

Risk Management Terms

DRM – Disaster Risk Management.

DRR – Disaster Risk Reduction.

French/European Planning Tools

PPR – Risk Prevention Plan (generic term).

PPRN – Natural Risk Prevention Plan (for floods, landslides, earthquakes, etc.).

PPRT – Technological Risk Prevention Plan (for industrial hazards).

PPRNP – Natural Risk Prevention Plan Name (1982 French law).

PLU – Local Urban Plan (municipal land-use document).

SCOT – Territorial Coherence Scheme (inter-municipal planning).

DICRIM – Communal Information Document on Major Risks (municipal risk information).

SNAT – National Spatial Planning Scheme (Algeria).

Emergency & Civil Security

ORSEC – Civil Security Emergency Response Organisation Plan (multi-hazard emergency plan).

PPI – Specific Intervention Plan (off-site emergency plan near hazardous sites).

SMS – Short Message Service alerts (mass text warnings to population).

Technologies & Tools

AI – Artificial Intelligence (for predictive modeling and early warning).

GIS – Geographic Information System (spatial analysis and mapping).

QGIS – Open-source GIS software.

ArcGIS – Commercial GIS software.

IoT – Internet of Things (network of connected sensors).

GPS – Global Positioning System.

Legal & Financial Instruments

Barnier Fund – Major Natural Risk Prevention Fund (French financing mechanism).

SEVESO site – Industrial site covered by EU Seveso directive on major-accident hazards.

ICPE – Classified Installation for Environmental Protection (regulated industrial facility).

Environmental & Monitoring

Natura 2000 – European ecological network of protected areas.

GMOs – Genetically Modified Organisms.

Institutional & Research

IFHV – Institute for International Law of Peace and Armed Conflict (IFHV / Ruhr University Bochum).

CRED – Centre for Research on the Epidemiology of Disasters (manages EM-DAT).

DNRM – National Delegation for Major Risks (Algeria).

COSPAR – Committee on Space Research (space risk management).

CNPG – National Council for Civil Protection (if mentioned).

SYLLABUS

IDENTIFICATION TEACHING SUBJECT

Title: **Risk Management 2**

Teaching unit: **Methodological Teaching Unit 6**

Number of credits: **5** Coefficient : **3**

Total weekly hours:

- Courses (number of hours per week) : 1h30
- Tutorial work (number of hours per week): 3h00

DESCRIPTION OF TEACHING

Prerequisites

To undertake this course dedicated to the integrated management of major risks in urban environments, students must possess several essential foundational competencies. They should have a solid understanding of fundamental concepts related to natural and technological hazards in order to grasp the interactions between risks and urban dynamics. Prior familiarity with public policies and territorial regulatory instruments is necessary, as the course relies on tools such as Natural Hazard Risk Prevention Plans (PPRN) and Technological Risk Prevention Plans (PPRT). Students must also be capable of following analytical discussions concerning the role of institutional actors in risk planning and management. General knowledge of prevention issues, urbanization processes, and crisis management will facilitate the comprehension of case studies and intervention frameworks. Finally, an awareness of the challenges of resilience, adaptation, and capacity-building within urban systems constitutes a significant asset for understanding the strategic dimension of the course.

Learning objectives to be assessed

The learning objectives of this course focus on the in-depth understanding of integrated major risk management in urban environments, combining both natural and technological dimensions. Students must demonstrate their ability to analyze and interpret prevention policies, particularly the regulatory instruments represented by the Natural Hazard Risk Prevention Plans (PPRN) and Technological Risk Prevention Plans (PPRT). A central objective is to assess their capacity to propose strategies aimed at reducing the vulnerability of existing urban assets, notably through historical and technical diagnostics, the selection of appropriate rehabilitation strategies, and the implementation of suitable intervention techniques. Learners must also show that they understand crisis management mechanisms, both in the preparatory phase and in the development of a structured feedback process. Furthermore, they should be able to integrate the

concept of urban resilience and its related approaches to adaptation and capacity-building, thereby contributing to the development of cities better equipped to face major hazards.

Course Titles And Timetable

Course Titles	Scheduled Date
Chapter 01: The Management of Major Urban Risks	
Chapter 02: The Policy of Major Risk Prevention	
Chapter 03: Development of Natural Risk Prevention Plans (PPRN): From Initial Assessment to the Definition of Regulatory Zoning *(Mapping of PPRNs)*	
Chapter 04: The Policy for Technological Risk Management (PPRT)	
Chapter 05: The Algerian National Policy for Disaster Risk Prevention and Reduction	
Chapter 06: Urban Resilience in the Face of Major Risks	
Chapter 07: Risk Management and Urban Governance	
END OF SEMESTER EXAM	

Assessment Method

(Type of Assessment and Weighting) Continuous Assessment and Examination (67%, 33%)

GENERAL INTRODUCTION TO THE COURSE CONTENT

Urban areas around the world are increasingly exposed to major risks, both natural and technological, due to factors such as climate change, rapid urbanization, and industrial development (UNISDR, 2015). Managing these risks is crucial to safeguarding communities, infrastructure, and the environment (Cutter, Burton, & Emrich, 2008). In response, the field of disaster risk management has evolved to include a broad range of strategies aimed at reducing vulnerability, improving resilience, and ensuring the sustainability of urban areas in the face of both anticipated and unforeseen threats (Blaikie, Cannon, Davis, & Wisner, 2014).

This course offers a comprehensive exploration of the management of major urban risks, focusing on preventive strategies, regulatory frameworks, and the roles of various stakeholders in mitigating the impacts of disasters. Through the course content, we will delve into the complexities of risk management policies, planning tools, and intervention strategies at the urban level (Beck, 2013).

The first chapter, *The Management of Major Urban Risks*, introduces the concept of urban risk management, emphasizing the multi-dimensional nature of risks in cities. It discusses the various types of risks that cities face, including natural hazards such as earthquakes, floods, and storms, as well as technological risks like industrial accidents and hazardous materials spills (Vale & Campanella, 2005).

In the second chapter, *The Policy of Major Risk Prevention*, we will examine the policies and frameworks designed to prevent major risks, focusing on the importance of integrating risk management into urban planning and governance (Blaikie et al., 2014). This chapter addresses the role of government agencies, municipalities, and other actors in formulating and implementing risk prevention policies (Cutter et al., 2008).

Chapter three, *Development of Natural Hazard Risk Prevention Plans (PPRN)*, explores the process of creating and implementing Natural Hazard Risk Prevention Plans (PPRN). The chapter covers the steps from initial hazard assessment to the definition of regulatory zoning, including the critical role of mapping and spatial planning in risk management (UNISDR, 2005).

In chapter four, *The Policy of Technological Risk Management (PPRT)*, the course shifts focus to technological risks, providing an in-depth analysis of the policies and regulations associated with the prevention of industrial and technological hazards. This chapter highlights the importance of creating Technological Risk Prevention Plans (PPRT) to mitigate the impacts of accidents related to industrial activities (Cutter et al., 2008).

Chapter five, *The Algerian National Policy for Disaster Risk Prevention and Reduction*, takes a specific look at the national context, focusing on Algeria's legal and institutional frameworks for disaster risk prevention. This chapter highlights the country's approaches to reducing risk exposure, improving disaster preparedness, and enhancing response mechanisms, particularly in light of recent legislative developments (Benbrahim, 2014).

Finally, in chapter six, *Urban Resilience in the Face of Major Risks*, we explore the concept of resilience in urban settings. The chapter examines how cities can prepare for and recover from major risks, discussing strategies for strengthening urban infrastructure, governance, and communities to enhance their capacity to withstand and recover from disasters (Vale & Campanella, 2005).

To conclude the course, chapter seven, *Risk Management and Urban Governance*, provides a comprehensive synthesis of institutional and governance-based approaches to urban risk management. This chapter emphasizes the importance of coherence between public policies, forward-looking planning, and the coordination of stakeholders at all levels of governance. It introduces key principles such as policy consistency, anticipation, flexibility, and equity in managing urban risks. The chapter also outlines strategic elements including integrated territorial planning, multi-stakeholder collaboration, and continuous evaluation and learning, all of which are essential to building resilient urban systems (Pahl-Wostl, 2009; Ansell & Gash, 2008; Djalante et al., 2011).

Throughout the course, students will engage with case studies, best practices, and current research to gain a comprehensive understanding of how urban areas can be made more resilient to major risks. By the end of the course, students will have a solid grasp of the key principles, strategies, and tools used in urban risk management and will be prepared to contribute to disaster prevention and resilience-building efforts in their own professional contexts (Beck, 2013; UNISDR, 2015).

Chapter 01: The Management of Major Urban Risks

Targeted Competencies

At the end of this chapter, the student will be able to:

- Define the fundamental concepts related to major urban risks (hazard, exposure, vulnerability, risk, mangement);
- Distinguish between the different types of natural and technological risks in urban environments;
- Explain the historical evolution of risk management and its current foundations;
- Identify and discuss the pillars of risk management (information, prevention, protection, crisis management, forecasting);
- Analyze the human, economic, environmental, and social stakes associated with major risks.

Introduction: Major Risks and Their Management on a Global Scale

Major risks, whether of natural or anthropogenic origin, constitute significant threats to contemporary societies, affecting populations, infrastructures, and ecosystems. According to the World Risk Report (Birkmann et al., 2022), approximately 3.6 billion people live in areas exposed to hazards such as floods, earthquakes, hurricanes, or industrial accidents. This growing vulnerability is aggravated by global dynamics, notably rapid urbanization, climate change, and socio-economic inequalities, which exacerbate exposure and reduce the resilience of communities.

In the face of these challenges, the management of major risks defined as the set of approaches and strategies aimed at reducing the impacts of hazards while strengthening the resilience of populations has become an international priority. The Sendai Framework for Disaster Risk Reduction (2015–2030), promoted by the United Nations, identifies four fundamental strategic priorities: understanding risks, strengthening institutional capacities, investing in resilience, and preparing for an effective response (UNDRR, 2015). These priorities demonstrate the necessity of a coordinated and systemic approach to anticipating and mitigating crises.

Recent catastrophic events, such as the 2004 Indian Ocean tsunami and Hurricane Katrina in 2005, have revealed the limits of prevention and crisis management systems, particularly in countries with low institutional capacities. Conversely, successful examples, such as those in Japan, show that proactive policies, supported by advanced warning systems and a culture of resilience, can significantly reduce the impacts of disasters (Hosseini et al., 2016).

Finally, the management of major risks increasingly relies on enhanced international cooperation. Multilateral initiatives, such as the Paris Agreement on Climate, highlight the interconnection between environmental and socio-economic risks. Moreover, the integration of

modern technologies, notably Geographic Information Systems (GIS) and Artificial Intelligence, provides innovative tools to model hazards, assess vulnerabilities, and plan adapted responses (Mysiak et al., 2018). These developments underline the necessity of global collaboration and optimal use of scientific and technological knowledge to address major risks.

1. Definition of Major Risk Management

1-**Major risk management** is defined as a structured set of processes, strategies, and policies aimed at identifying, analyzing, mitigating, and managing natural or anthropogenic hazards likely to generate significant impacts on populations, infrastructures, and ecosystems. These risks include natural disasters (for example, floods, earthquakes, and hurricanes), industrial accidents (such as explosions and chemical pollution), health crises (like pandemics), as well as social and political conflicts (Birkmann et al., 2022).

"*We cannot reduce the intensity of a hurricane or a volcanic eruption. But we can better prepare to reduce the vulnerability of a population or a territory.*"Alvaro González

2-**Risk management** has emerged as a solution for methodically addressing risks and the potential consequences associated with them. Its rapid development in recent years has made it a discipline now recognized at the international level.

3-Thus, **risk management** is defined as a preferred method adopted by a community or an entity, whose objective is to minimize risks by systematically and continuously integrating them into its administrative decisions, the management of its resources, and the way it fulfills its obligations. Today, it is considered an essential component of best practices within local authorities or organizations.

2. History of Major Risk Management

2.1.Antiquity and the Middle Ages: First Risk Management Strategies

In ancient societies, risk management relied on the observation of natural phenomena and engineering solutions such as dikes, irrigation systems, and aqueducts to reduce flooding. During the Middle Ages, approaches remained empirical, notably through the use of stone buildings to limit urban fires.

2.2. (16th–18th) Centuries: First Systematic Approaches

The Renaissance and the Enlightenment introduced a more scientific approach to risk management. The Lisbon earthquake of 1755 encouraged the study of seismic hazards, while sanitary measures such as quarantines and the establishment of lazarettos were implemented to control epidemics.

2.3. 19th Century: Industrialization and New Anthropogenic Risks

Industrialization generated new risks, including industrial accidents and pollution. Major disasters led to the development of safety regulations and the emergence of insurance systems to manage economic losses.

2.4. 20th Century: Institutionalization and Globalization of Risk Management

Risk management became institutionalized through the development of early warning systems and emergency planning. Large-scale disasters strengthened international cooperation, particularly through initiatives led by the United Nations.

2.5. 21st Century: Towards an Integrated and Resilient Approach

Risk management has adopted an integrated approach focused on resilience and sustainability. Frameworks such as the Sendai Framework, combined with advanced technologies (GIS and artificial intelligence), enhance risk anticipation and modelling, especially in relation to climate change.

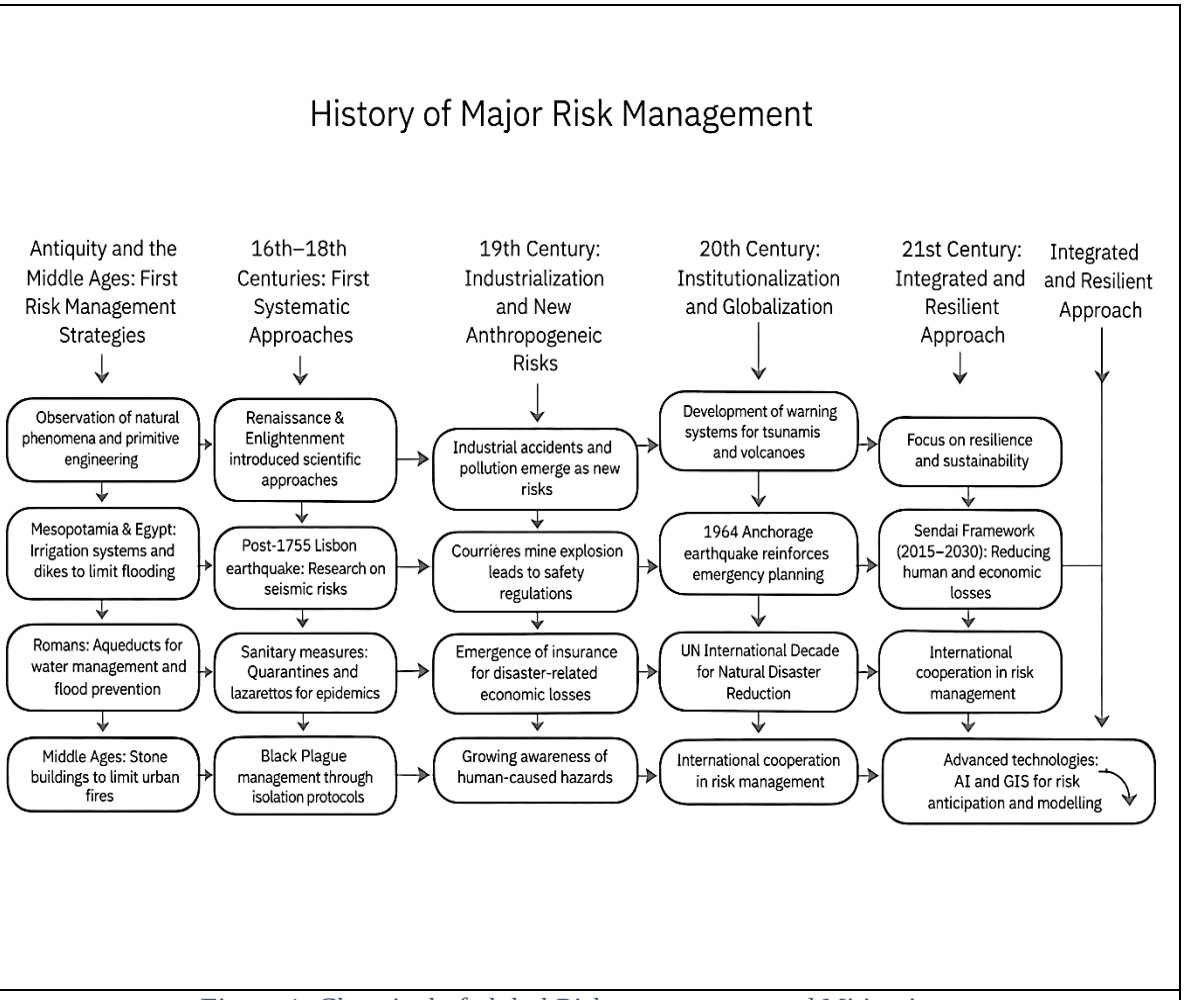


Figure 1: *Chronical of global Risk management and Mitigation.*
Source: Author,2026

3. Stages of Risk Management

Risk management aims to reduce vulnerability and enhance resilience. It operates across the different phases of risk, upstream, during, and downstream of hazardous events. These phases vary according to approaches and scholars (Vatn, 2004; Zihri, 2004). Risk management is defined as "coordinated activities aimed at directing and controlling an organization with regard to risk" (Zihri, 2004).

According to Vatn, risk management takes place in three main stages (Vatn, 2004):

1-Risk analysis: understanding risks in terms of their intensity, frequency, and probability, and identifying the exposed stakes.

2-Risk assessment: evaluating vulnerability in all its dimensions (social, economic, and environmental).

3-Risk reduction: adopting strategies and making decisions to prevent and mitigate hazards.

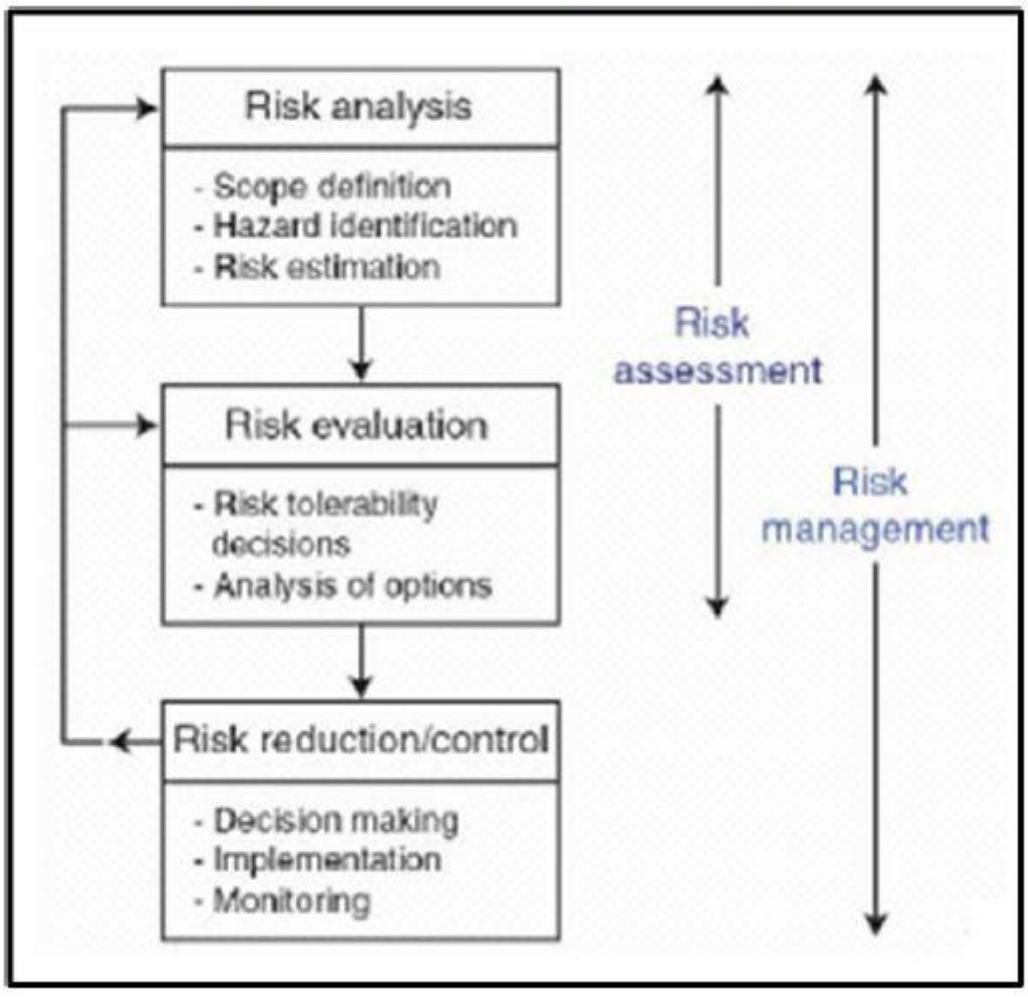


Figure 2: Stages of Risk Management

Source: Vatn, 2004 in Bendjemila, 2018

4. The Pillars of Major Risk Management

This management is based on four fundamental pillars:

4.1.Information

Information is the fundamental pillar for understanding and raising awareness among populations in the face of risks. This pillar is structured around three key elements:

- **Developing risk knowledge**: This includes an in-depth analysis of hazards and stakes in order to understand the concept of risk (risk = hazard × stakes). Risk mapping tools, disaster databases, and scientific studies play a crucial role in this process (Lhomme, Serre, & Diab, 2010).
- **Empowering citizens**: Information must be disseminated to populations to encourage responsible behavior and reduce their exposure to risks. For example, awareness campaigns about floods or earthquakes.
- **Promoting a risk culture**: Building a risk culture requires the integration of educational programs and training within local communities to strengthen their resilience (Kuhlicke et al., 2011).

4.2.Prevention: Reducing vulnerabilities upstream

All the measures to be applied to minimize the impact of a foreseeable natural or human event on individuals and objects are grouped under the term major risk prevention.
It adheres to a sustainable development approach, because unlike post-crisis repair, prevention aims to minimize the economic, social, and ecological impacts of our society's imprudent progress.

The goal of prevention is to minimize the likelihood that a harmful event will occur or to mitigate its consequences. It relies on the following measures:

- **Reducing vulnerability**: By integrating risks into territorial planning, it is possible to minimize the exposure of populations and infrastructure (Burby et al., 2000). For example, avoiding construction in flood-prone or seismic zones.
- **Taking risks into account in land-use planning**: Preventive urban planning and strengthened building standards (for example, earthquake-resistant construction) are essential tools for effective prevention (Godschalk, 2003).
- **Feedback from experience**: Lessons learned from past crises are valuable for adjusting risk management policies and strategies (Birkland, 1997).

4.3.Protection: Minimizing the impacts of disasters

Protection aims to reduce the direct impacts of events on populations and their property.

- **Protecting infrastructures and people**: Protection systems include physical infrastructure (dikes, dams, shelters) and organizational devices such as early warning systems (Alexander, 2002).
- **Strengthening resilience capacities**: Communities must be prepared to respond to events. This may include the distribution of emergency equipment or the improvement of critical infrastructure (Cutter et al., 2008).

4.4.Crisis Management

This pillar intervenes during and after the occurrence of a catastrophic event.

- **Monitoring and tracking phenomena**: The use of monitoring technologies (satellites, seismic sensors) makes it possible to anticipate extreme events (UNISDR, 2009).
- **Rescue planning**: Effective coordination between the various actors (rescue services, NGOs, local authorities) is essential to reduce human and material losses (Comfort et al., 2010).
- **Return to normal**: After a crisis, it is essential to organize reconstruction and provide support to victims while drawing lessons to improve future crisis management (Vale & Campanella, 2005).

This approach requires multidimensional integration, mobilizing knowledge from various disciplines such as urban planning, engineering, sociology, economics, and ecology. It also highlights the importance of planning based on scientific data, the use of modern technologies, and interdisciplinary collaboration to maximize the effectiveness of interventions (Mysiak et al., 2018).

In addition to the four previously mentioned pillars, a fifth pillar, forecasting, proves to be complementary and essential in major risk management. This pillar makes it possible to anticipate catastrophic events by facilitating the implementation of appropriate preventive measures. These different pillars, both interdependent and complementary, are fundamental for building resilient societies. They contribute to reducing the vulnerability of communities to natural or anthropogenic risks. Each concept fits into a proactive or reactive approach, depending on the phases of the risk management cycle, and is deployed dynamically throughout this process.

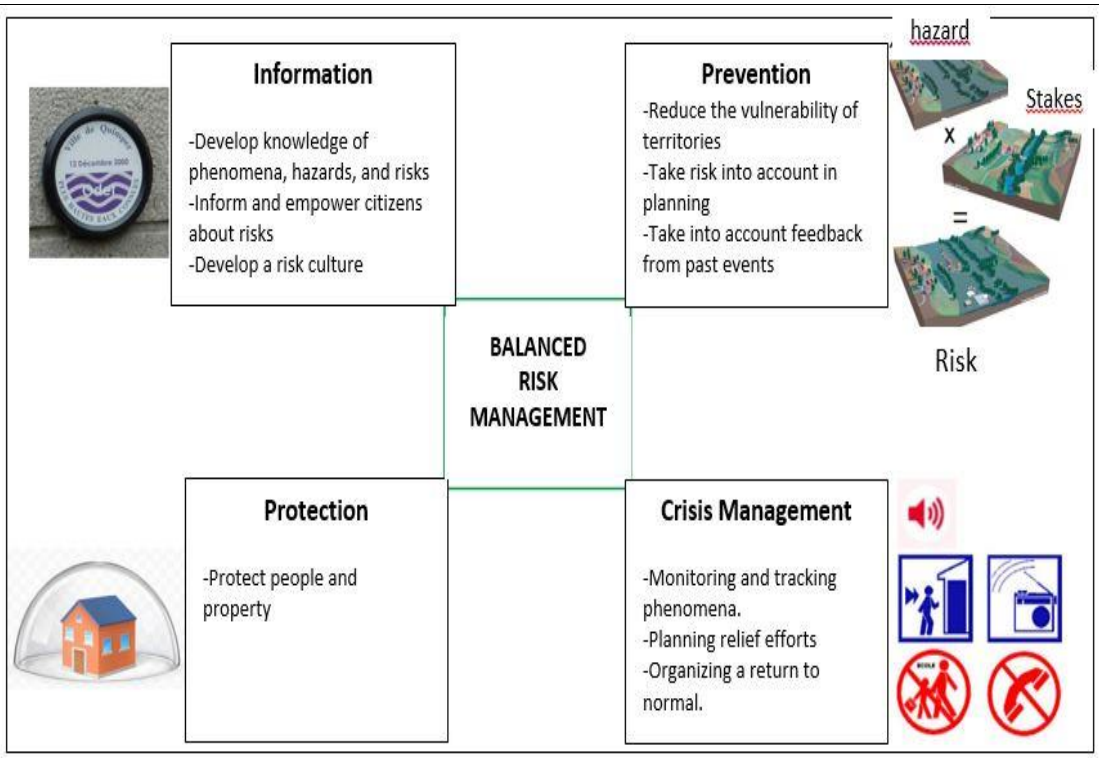


Figure 3: The Four Pillars of Balanced Risk Management

Source:https://www.finistere.gouv.fr/Actions-de-l-Etat/Risques-naturels-et-technologiques/Generalites/La-politique-de-prevention-des-risques-majeurs

Case Study:

1-The Cascading Effects of the Great East Japan Earthquake (2011)

On March 11, 2011, a magnitude 9.0 earthquake struck Japan, triggering a massive tsunami (waves up to 40m).

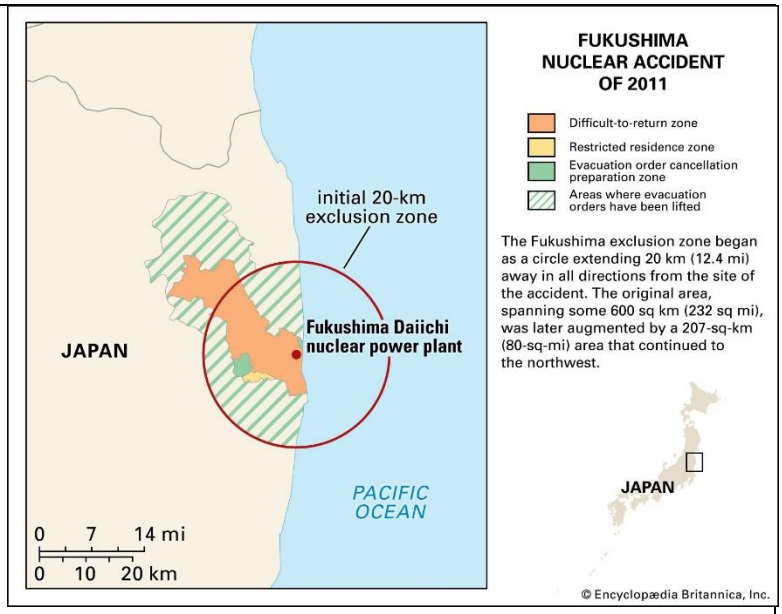
The Cascade:

Natural Disaster: Earthquake + Tsunami caused massive destruction of coastal infrastructure.

Technological Disaster (Natech): The tsunami flooded the cooling systems of the Fukushima Daiichi Nuclear Power Plant, leading to a nuclear meltdown.

Social & Economic Crisis: Mass evacuation (160,000 people), energy shortages (shut down of nuclear plants), and long-term stigma of the region.

Lesson: Modern risk management must move beyond single-hazard planning to Multi-Hazard Early Warning Systems (MHEWS) and consider "black swan" events (unpredictable, high-impact events).



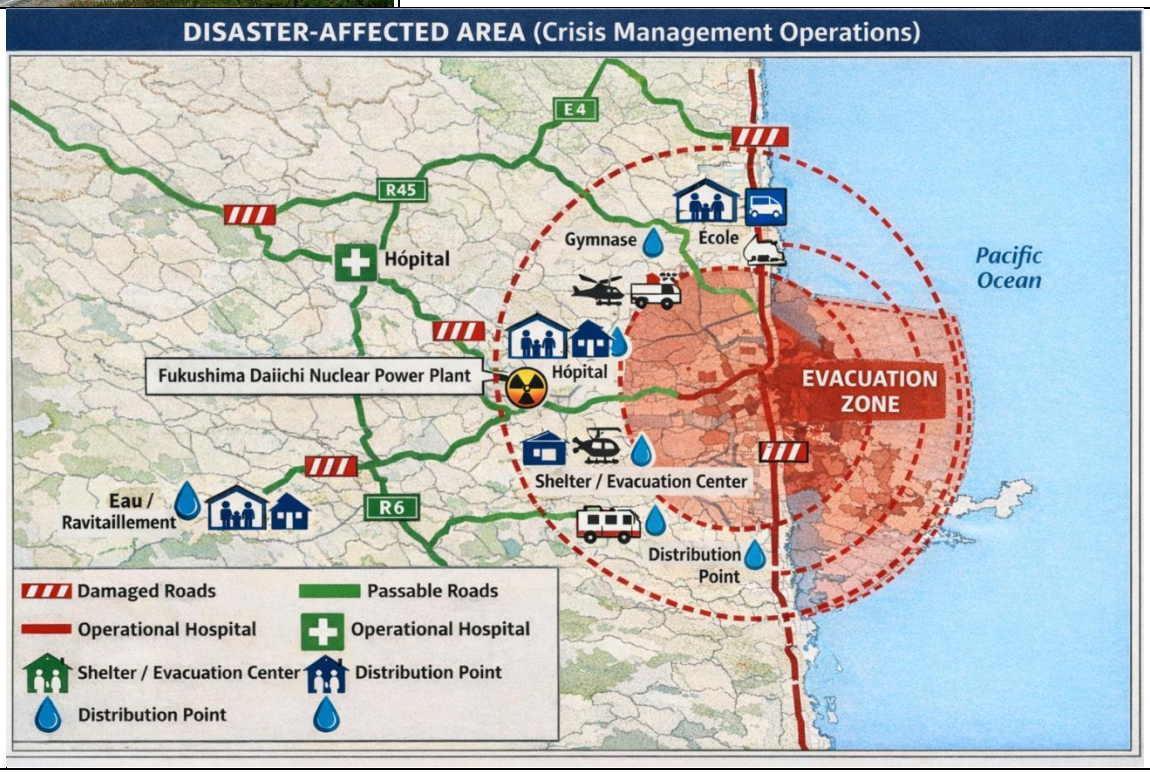


Figure 4: The Cascading Effects of the Great East Japan Earthquake (2011)

Source: https://www.gsi.go.jp/common/000065837.pdf?utm_source=chatgpt.com

5. The Stakes of Major Risk Management

The management of major risks involves several crucial stakes, which affect human, economic, environmental, and socio-political dimensions, in order to minimize the effects of disasters.

5.1.Human Stakes: Protection of Human Lives

Disasters primarily affect the most vulnerable populations, often located in high-density areas or in contexts of poverty. Between 2000 and 2020, more than 1.2 million people lost their lives

due to natural disasters, with human losses particularly concentrated in low-resource countries (UNDRR, 2020). The main objectives are to protect populations from common risks, to reduce inequalities in the face of hazards, and to promote a culture of prevention.

5.2.Economic Stakes: Preservation of Assets and Reduction of Losses

The economic impacts of disasters are considerable, ranging from the destruction of essential infrastructures to the loss of economic activities. According to the World Bank, the annual economic losses due to natural disasters amount to approximately 300 billion dollars globally (World Bank, 2018). Economic priorities include reducing post-disaster intervention costs, protecting key economic sectors, and strengthening the resilience of infrastructures.

5.3.Environmental Stakes: Preservation of Ecosystems

Disasters, whether natural or human-induced, have devastating effects on the environment, causing the destruction of habitats and pollution. Risk management aims to limit these degradations, to preserve essential natural resources, and to encourage ecological solutions, such as reforestation and the restoration of marine ecosystems, in order to strengthen the resilience of human societies.

5.4.Social and Political Stakes: Strengthening of Cohesion and Governance

Disasters exacerbate social inequalities and can generate political tensions or forced migrations. Effective management relies on strengthening local institutional capacities, involving communities in decision-making processes, and reducing the risks of conflict linked to access to resources after a crisis. These stakes highlight the necessity of an integrated and coordinated approach to effectively manage major risks and to reinforce societal resilience.

6. The Importance of a Proactive Management of Major Risks

Major risk management must shift from a reactive approach, focused on post-disaster responses, to a proactive approach emphasizing prevention and the resilience of societies (UNDRR, 2015). This proactive approach relies on several essential elements:

1. **Education and Awareness of Populations**: It is crucial to inform and train communities about the risks they are exposed to, as well as the actions to take in order to limit the impacts of disasters (Paton & Johnston, 2001).
2. **Investment in Resilient Infrastructures**: Building infrastructures capable of withstanding disasters contributes to the protection of populations and the preservation of essential societal functions after a major event (Hallegatte et al., 2017).

3. **Strengthening Institutional and Legislative Frameworks**: Strong institutions and well-adapted legislative frameworks facilitate effective risk management and ensure optimal coordination of prevention and response efforts (Mysiak et al., 2018).
4. **International Cooperation**: Effective management of major risks requires cooperation between countries, thus enabling the sharing of resources, technologies, and good practices (Birkmann et al., 2022).

7. Tools for the Prevention of Major Urban Risks

7.1.Better Understanding These Risks

For several years, efforts have been made to collect and analyze data on natural and technological risks, stored in specialized databases. This information, used by public bodies such as Météo-France, helps authorities develop prevention strategies and prepare responses to potential disasters. Experts produce post-event assessment reports on phenomena, their impact, and their financial consequences. This data collection on hazards and vulnerability is essential to identify the risks to which a community is exposed. Risk knowledge is based on several fundamental components:

• **A. Environmental Characterization**: This step consists in establishing a general overview of the situation in order to identify the main issues and problems related to risks and disasters. It involves providing a detailed description of the physical, social, economic, and environmental characteristics of the area (Lavell, 2015).

• **B. Identification and Characterization of Hazards**: This consists in compiling an inventory of historical data related to past disasters, while taking into account physical factors such as industrial facilities, hazardous substances used, and natural phenomena like prevailing winds and waterways (Bourgouin et al., 2019).

• **C. Analysis of Hazard Characteristics**: This allows for a better understanding of their nature, assessment of their likelihood of occurrence, and definition of their patterns of spread and evolution. This analysis is essential to anticipate possible effects and to implement appropriate preparedness and prevention measures (Fuchs et al., 2012).

• **D. Identification of Stakes**: This consists in identifying people, the environment, essential assets and services present in areas exposed to risks. Public authorities must identify sensitive infrastructures (schools, hospitals, nuclear power plants) and critical equipment (fire stations, airports), and take specific measures to protect these resources (Dombroski et al., 2013).

7.2.Controlling Urbanization

The control of urbanization is a central element in risk management, expressed through the Risk Prevention Plans (Plans de Prévention des Risques – PPR) developed by the State. These plans provide urban managers with the tools needed to act in accordance with local data and the geological specificities of the concerned zones. They include constructive measures (e.g., adapting building foundations) and urban planning provisions, such as stormwater and wastewater management, in order to limit the impacts of natural and technological risks (Gagnon et al., 2017). These PPRs allow for estimating the magnitude of danger and limiting potential consequences based on local geographic and environmental characteristics (Douguet & Van der Laan, 2014).

7.3.Integrating These Risks into Spatial Planning

Territorial planning must avoid establishing new districts in high-risk areas while reducing the vulnerability of already urbanized zones. The PPRs, established by the "Barnier" Law of February 2, 1995, constitute a fundamental tool to control urbanization in sensitive zones and to ensure sustainable development. Once validated, these plans become public utility easements and are annexed to the Local Urban Plan (Plan Local d'Urbanisme – PLU), thereby requiring any new construction to comply with safety regulations (Leclerc et al., 2015). The Technological Risk Prevention Plans (Plans de Prévention des Risques Technologiques – PPRT) complement this approach by regulating urbanization around classified high-risk facilities (Fay et al., 2016).

7.4.Mitigation

Mitigation aims to reduce the damage caused by hazards either by lowering their intensity (e.g., floods or avalanches) or by reducing the vulnerability of critical infrastructure (industrial buildings, communication networks, etc.). Mitigation is based on the training of building and engineering professionals (architects, engineers, contractors) to integrate climatic and geological risks into the design of structures. Moreover, rigorous enforcement of building standards is essential to ensure the effectiveness of prevention measures (Flouris et al., 2017). Collaboration among various stakeholders, such as insurers and project managers, is crucial to enhance the effectiveness of mitigation efforts (Parsons et al., 2018).

7.5.Preventive Information for the Population

The right to information about major risks is a fundamental right inscribed in the Environmental Code (Article L. 125-2). It is essential for every citizen to be aware of the risks to which they are exposed and to assess their own vulnerability in order to implement appropriate preventive actions. This implies continuous information on potential risks and safety instructions in the

event of an incident (Perron et al., 2016). This approach enables better responsiveness and resilience of populations facing disasters.

7.6.Planning Emergency Response

Once the risks have been identified and assessed, it is imperative that public authorities organize the necessary emergency response resources to cope with possible crises. This organization must rely on a balanced distribution of responsibilities between the State and local governments to ensure a rapid, coordinated, and effective response in the event of a disaster (Broc et al., 2015).

8. Protection Against Major Urban Risks

Protection against urban risks is a crucial component of crisis management, focused on alert, immediate response, and post-crisis reconstruction. Alert systems, using technologies such as sensors and GIS, detect risks and facilitate rapid intervention (Khan & Malik, 2018). An effective organization of monitoring and intervention chains, as exemplified by Japan, relies on close coordination between local and international actors (Fay et al., 2020). Crisis management mobilizes logistical relief, coordinates efforts, and prioritizes evacuation, emergency care, and the securing of infrastructure (Shaw et al., 2018).

In the post-crisis period, infrastructure reconstruction, resilience strengthening, and social support are essential, as illustrated by the initiatives following the 2004 tsunami (Alexander, 2018).

Finally, post-crisis analysis and feedback make it possible to improve risk management strategies and to increase the effectiveness of future interventions (Birkland, 2016).

9. General Instructions for Populations

General instructions for populations exposed to major urban risks emphasize preparedness, awareness, and coordination. Evacuation plans, defining safe routes and gathering points, are essential to limit human losses (Lindell & Perry, 2019). Emergency kits, including water, food, medicine, and communication tools, constitute a key element of individual preparedness (Fay et al., 2020). Moreover, citizens must be trained in specific reactions according to the types of risks, such as taking shelter during an earthquake or evacuating in case of flooding (Shaw et al., 2018). Communication, via social media and visual supports, must be rapid and adapted to ensure that instructions are understood by all (UNISDR, 2019). Finally, citizen participation in

simulations and awareness programs reinforces community resilience and social cohesion in the face of crises (Shaw et al., 2018).

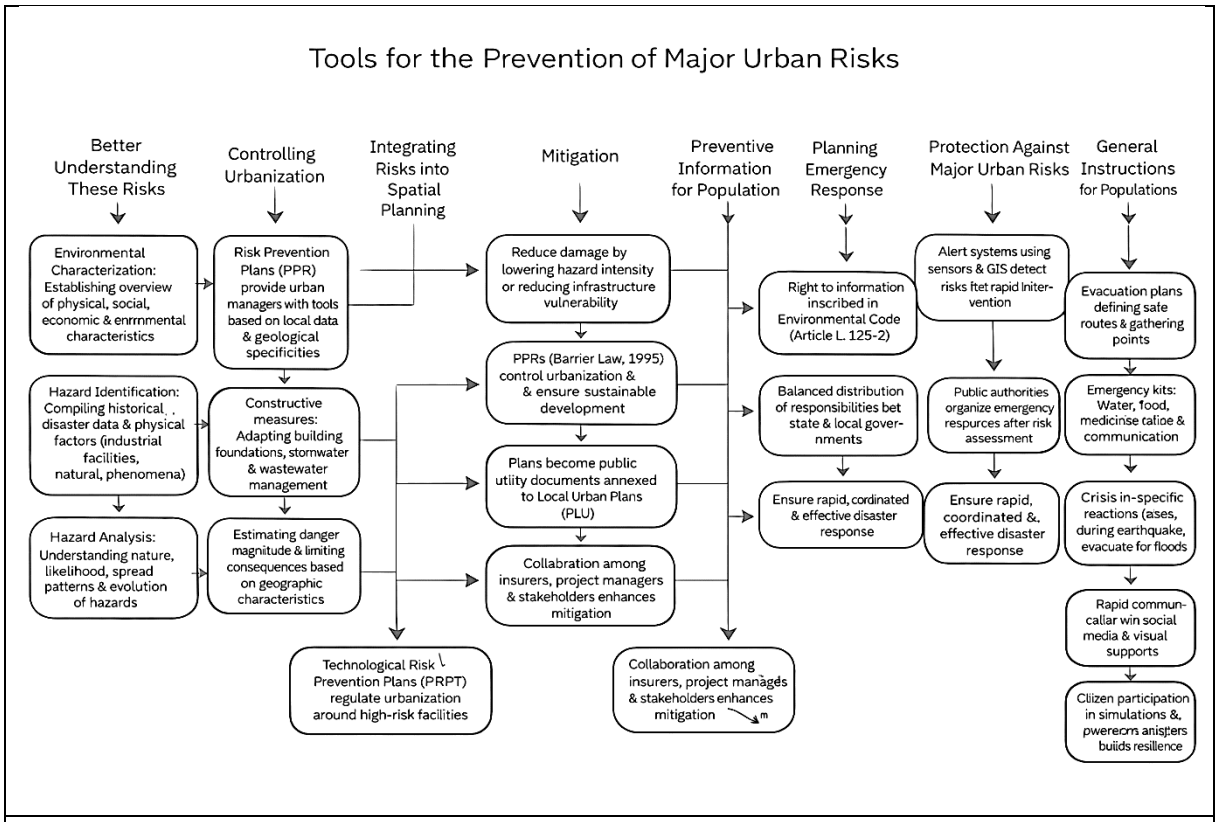


Figure 5: Tools for the Prevention of Major Urban Risks.
Source: Author,2026

Conclusion of Chapter 1

The management of major urban risks is essential to ensure the safety, resilience, and sustainable development of cities facing natural and technological disasters. Based on five interconnected pillars information, prevention, protection, crisis management, and forecasting it aims to reduce the vulnerabilities of populations and infrastructure while anticipating hazards. Prevention identifies risks and limits dangerous activities, while protection mitigates direct impacts through appropriate mechanisms. Prevention tools, such as monitoring systems, advanced technologies (sensors, GIS), and data collection, allow for proactive management tailored to urban specificities. Crisis management emphasizes the importance of effective coordination between public, private, and international actors for rapid interventions. The post-crisis phase, centered on reconstruction and resilience, incorporates lessons learned to improve future strategies. In sum, a multidisciplinary approach, combining technologies, sciences, and citizen participation, is crucial to protect cities and ensure their long-term sustainability.

Reference Chapter 01

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Chapter 02: The Policy of Major Risk Prevention

Targeted Competencies
At the end of this chapter, the student will be able to:

- Understand the fundamental principles of major risk prevention;
- Explain the role of public policies in reducing territorial vulnerability;
- Identify the stakeholders involved in risk prevention and their respective responsibilities;
- Interpret the objectives and underlying rationales of regulatory prevention instruments;
- Analyze the effects of regulatory requirements on urban planning and development;
- Develop a critical perspective on prevention policies in light of climatic and territorial changes.

Introduction to Chapter 2

Major risks refer to events, natural or anthropogenic, whose exceptional severity can cause massive human losses, significant destruction of material goods, and lasting environmental impacts (Blaikie et al., 2004; Cutter, 1996). Their management constitutes a complex challenge for modern societies, requiring a multidisciplinary approach mobilizing natural, social, and political sciences (Birkmann, 2006; Pigeon & Rebotier, 2016). The prevention of major risks has thus become an essential component of public policies aiming to guarantee the safety and resilience of territories (Kelman et al., 2015).

1. Foundations of the policy of major risk prevention

The policy of major risk prevention is based on fundamental principles that guide public, regulatory, and operational strategies in order to reduce the vulnerability of territories and populations facing disasters (Renn, 2008; UNDRR, 2015). It relies on theoretical frameworks derived from risk sciences, on guiding principles integrated into public policies, and on established legislative and regulatory bases (Godschalk, 2003; Hermansson, 2019; Pigeon et al., 2017).

1.1. Guiding principles of major risk prevention

1.1.1. The principle of anticipation

Anticipation is a central pillar of prevention. It is based on the capacity to identify hazards and to assess vulnerabilities to limit the impacts of disasters before they occur (Renn, 2008; Wisner et al., 2004). This implies:

- The collection and analysis of data: use of historical studies, scientific modeling, and empirical observations to draw a panorama of potential risks (Godschalk, 2003; UNDRR, 2015).

- Preventive planning: integration of risks into spatial planning schemes, such as Local Urban Plans (PLU) (UNDRR, 2015).
- Proactive adaptation: implementation of measures aiming to reduce the sensitivity of infrastructures and populations to hazards, such as seismic standards or hydraulic developments (Godschalk, 2003).

1.1.2. The resilience of territories

Resilience denotes the capacity of territories to absorb shocks, reorganize, and function effectively after a catastrophic event (Alexander, 2013; Cutter et al., 2010). It manifests as:

- The strengthening of infrastructures: for example, elevating buildings in flood zones or securing power plants in seismic zones (Wisner et al., 2004).
- The development of continuity strategies: ensuring that essential services (hospitals, water networks, energy) can continue functioning during crises (Cutter et al., 2010).
- Education and training: raising awareness among populations so that they can react effectively to emergency situations (UNDRR, 2015).

1.1.3. The participation of stakeholders

Risk prevention requires a participatory approach involving all concerned actors (Renn, 2008; UNDRR, 2015):

- Local authorities: they play a key role in identifying local risks and in developing prevention plans (Pigeon & Rebotier, 2016).
- State and decentralized services: they provide technical and financial resources and ensure the implementation of regulatory frameworks (UNDRR, 2015).
- Citizens: as those first exposed, their involvement strengthens the effectiveness of measures, for example through family emergency plans (Wisner et al., 2004).
- Private sector: notably in critical infrastructures (industries, communication networks), their cooperation is essential to anticipate and reduce impacts (Godschalk, 2003).

1.2.Legislative and regulatory bases

The legislative and regulatory bases related to major risk prevention in France have evolved to respond to the growing challenges of natural and technological disasters. Initially reactive, the first laws emphasized crisis management rather than prevention. Over time, a coherent legal framework was established, integrating prevention tools, financing mechanisms, and transparency requirements, notably through Risk Prevention Plans (PPR) and compensation mechanisms (Bourdin, 2014). The regulatory evolution began with simple legislative instruments, progressively reinforced facing the diversification of risks (Lemaitre, 2016).

Before the Barnier Law of 1995, legislation was mainly reactive, focused on crisis management. Among the first laws are:

- The 1917 law on hazardous establishments, which introduced a legislative framework for industrial safety.
- The 1955 law on natural disasters, establishing a compensation system without preventive measures.
- The 1982 law on natural risks (PPRNP), which imposed on local authorities the identification and regulation of urbanization in areas exposed to natural risks.
- The Barnier Law of 1995 constituted a major reform, introducing a systematic approach to risk prevention. It enabled:
    - The creation of Risk Prevention Plans (PPR), now the main tool to manage risks, covering both natural and technological risks.
    - The creation of the Barnier Fund, intended to finance prevention and relocation of populations living in risk zones.
    - The establishment of Communal Information Documents on Major Risks (DICRIM), to ensure better citizen information (Pigeon & Rebotier, 2016). After the Barnier Law, several laws reinforced risk management, especially facing the challenges of climate change and technological risks. Among the main legislations:
- The Technological Risks Law (PPRT, 2003), which extended the principles of PPR to technological risks by imposing the creation of PPRT in zones near dangerous industrial facilities.
- The Grenelle II Law (2010), which strengthened the integration of risks into spatial planning policies, considering environmental impacts and risks related to climate change.
- The Climate and Resilience Law (2021), which marks a turn towards risk management focused on resilience and adaptation to climate challenges (Ministry of Ecological Transition, 2021).

1.2.1. The main current regulatory tools

- Risk Prevention Plans (PPR)

  PPRs are now mandatory for all types of major risks and must be integrated into urban planning documents (Ministry of Ecological Transition, 2021).

- Major Natural Risk Prevention Fund (Barnier Fund)

  It finances prevention measures, relocation of populations, as well as impact and vulnerability studies (National Assembly, 1995).
- Communal Information Documents on Major Risks (DICRIM)

  These public documents inform inhabitants about the risks to which they are exposed, disseminated by municipalities (Pigeon & Rebotier, 2016).
- International frameworks:
  - Adoption of the Sendai Framework (2015-2030) for disaster risk reduction, encouraging a global and inclusive approach (UNDRR, 2015).
  - France's commitment to align its policies with international objectives in resilience matters (Pigeon & Rebotier, 2016).

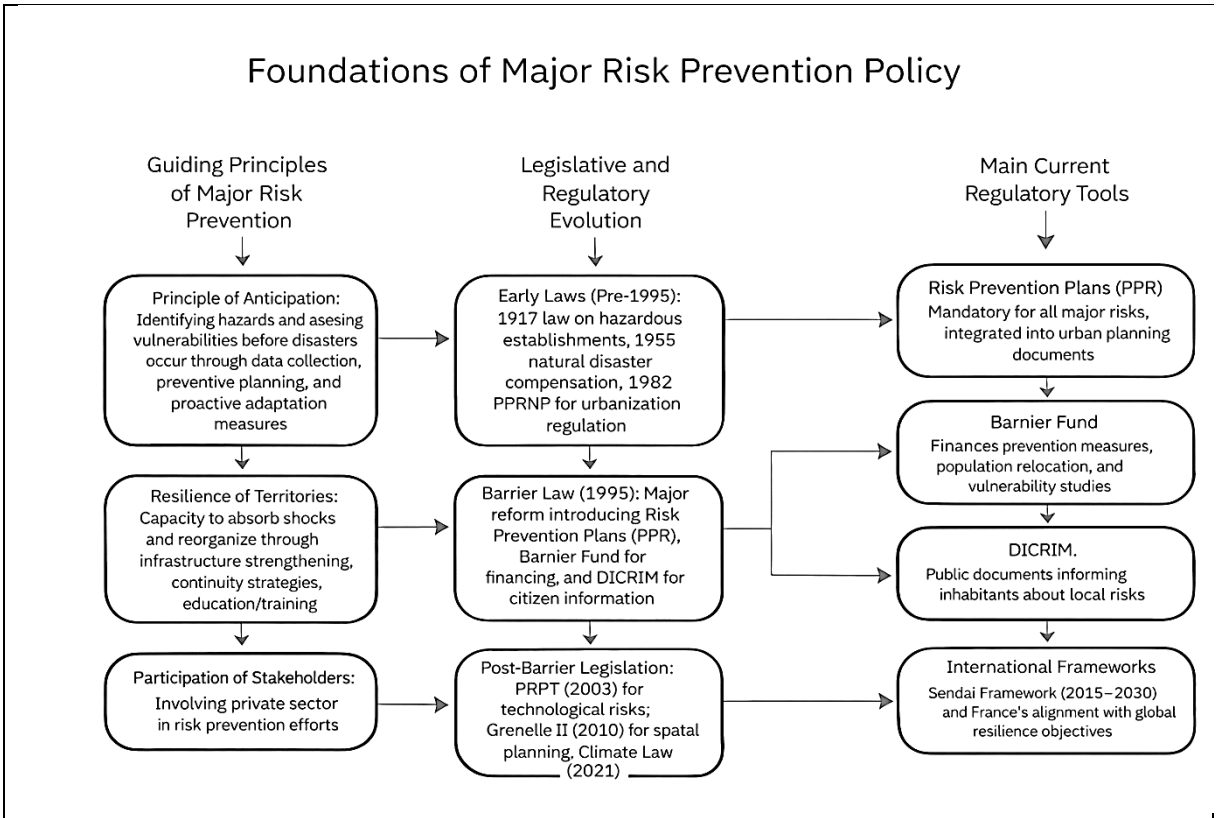

Figure 6: Foundations of the policy of major risk prevention.
Source: Author,2026

While the French system relies heavily on the PPR (Plan de Prévention des Risques) which is a regulatory zoning tool, Anglo-Saxon countries utilize different frameworks focused on "Preparedness" and "Resilience":

Table 1: Comparative Analysis of International Frameworks

Country	Framework Name	Key Focus
France	PPRN / PPRT	Regulatory Zoning: Ban construction in red zones. Strong state control.
USA	FEMA National Preparedness Goal	Capabilities: Focus on 32 "Core Capabilities" (e.g., Planning, Operational Coordination) rather than just zoning
UK	Civil Contingencies Act	Integrated Emergency Management: Uses a "Risk Register" and emphasizes Business Continuity Management (BCM)
Canada	Emergency Management Framework	All-Hazards Approach: Unified command structure handling natural and technological risks together

Source: Author,2026

2. Strategic Tools for Risk Prevention

2.1.The Natural Risk Prevention Plan (PPRN). Definition

The Natural Risk Prevention Plan (PPRN) constitutes a fundamental strategic instrument in the management of major risks associated with natural disasters, particularly for the prevention of the effects of hazards such as floods, earthquakes, landslides, and other natural phenomena (Ministry of Ecological Transition, 2020). This regulatory mechanism, based on principles of risk reduction and population protection, aims to delineate zones exposed to risks and to implement specific measures intended to mitigate human and material losses (Lemoine & Dupuis, 2018).

2.2.Role and scope of the PPRN

- The primary role of the PPRN is to identify and delineate risk zones, in order to integrate this information into urban planning documents (Vasseur et al., 2019).
- The objective of the PPRN is to reduce the exposure of populations and infrastructures to natural hazards by guiding territorial development choices and ensuring preventive risk management.
- This process relies on an in-depth analysis of natural hazards and associated stakes, such as densely populated areas, strategic infrastructures, and fragile natural resources (Gauthier & Martin, 2021).
- One of the key functionalities of the PPRN is the forecast of specific prescriptions adapted to each type of risk, such as floods or landslides.

- These prescriptions impose strict urban planning regulations, such as prohibiting building in certain risk zones, restrictions on building heights, or construction standards to make buildings more resistant (Dupont & Leroy, 2022).
- The PPRN also allows for long-term territorial management planning by integrating these prescriptions into urban planning documents such as Local Urban Plans (PLU) and Territorial Coherence Schemes (SCOT), to ensure coherence between future urban development and risk management (Gauthier & Martin, 2021).

2.3.Scope of application of the Risk Prevention Plan (PPR)

The Risk Prevention Plan (PPR) constitutes one of the main tools of a global national policy for natural risk prevention, developed to guarantee the safety of populations and property while promoting sustainable territorial development. This policy is part of a regulatory framework that emphasizes proactive management of hazards and vulnerabilities, based on the following actions:

- Better understanding of natural phenomena and their impacts: This includes collecting historical and scientific data, producing precise maps, and analyzing interactions between hazards and stakes (Cremona, 2010).
- Ensuring monitoring of phenomena: When possible, monitoring systems, such as hydrometeorological stations and seismic networks, are implemented to detect early warning signals (Ministry of Ecological Transition, 2019).
- Raising awareness and informing populations: Citizens are informed about the risks they face and the means to protect themselves through awareness campaigns and simulation exercises (Wisner et al., 2004).
- Integrating risks into planning decisions: The PPR prescriptions are legally binding and must be taken into account in urban planning documents, such as Local Urban Plans (PLU) and building permits (Besson & Vallée, 2016).
- Adapting current and future facilities: Existing infrastructures can be reinforced, while new constructions must comply with specific rules, notably in areas delineated as red or blue zones (Cremona, 2010).
- Learning lessons from damaging natural events: After each disaster, analyses are conducted to adapt prevention strategies and improve operational responses.

The PPR also delineates zones of the territory exposed to natural risks, classified according to their vulnerability, and imposes adapted prevention, protection, and safeguarding measures. These measures apply to private owners, developers, and local authorities, who have the responsibility to implement them in accordance with national strategic orientations (Ministry

of Ecological Transition, 2019). Thus, the PPR plays an essential role in reducing vulnerabilities and improving the resilience of territories facing natural hazards.

2.4.Responsibilities of actors in the elaboration and implementation of the PPRN

The implementation of the PPRN relies on a clear distribution of responsibilities between the State, local authorities, and other stakeholders. These responsibilities are essential to guarantee the effectiveness of the PPRN and its proper application on the ground (Ministry of Ecological Transition, 2020).

- The State: The State has responsibility for the elaboration and approval of PPRNs, a process generally led by prefects at the regional level (Dupont & Leroy, 2022). State services conduct field studies, produce risk maps, and prepare plans adapted to the specificities of each territory. The State also intervenes in supporting and controlling the application of PPRN prescriptions, ensuring that risk zones are properly delineated and that prevention measures are respected (Lemoine & Dupuis, 2018).
- Local authorities: Local authorities play a crucial role in the implementation of the PPRN. They are responsible for ensuring the dissemination of information to concerned populations, explaining the stakes of the prevention plan and the prescriptions imposed by the PPRN (Gauthier & Martin, 2021). This includes regular communication with citizens, organizing public meetings or information workshops, and implementing the measures provided for in local urban planning documents.

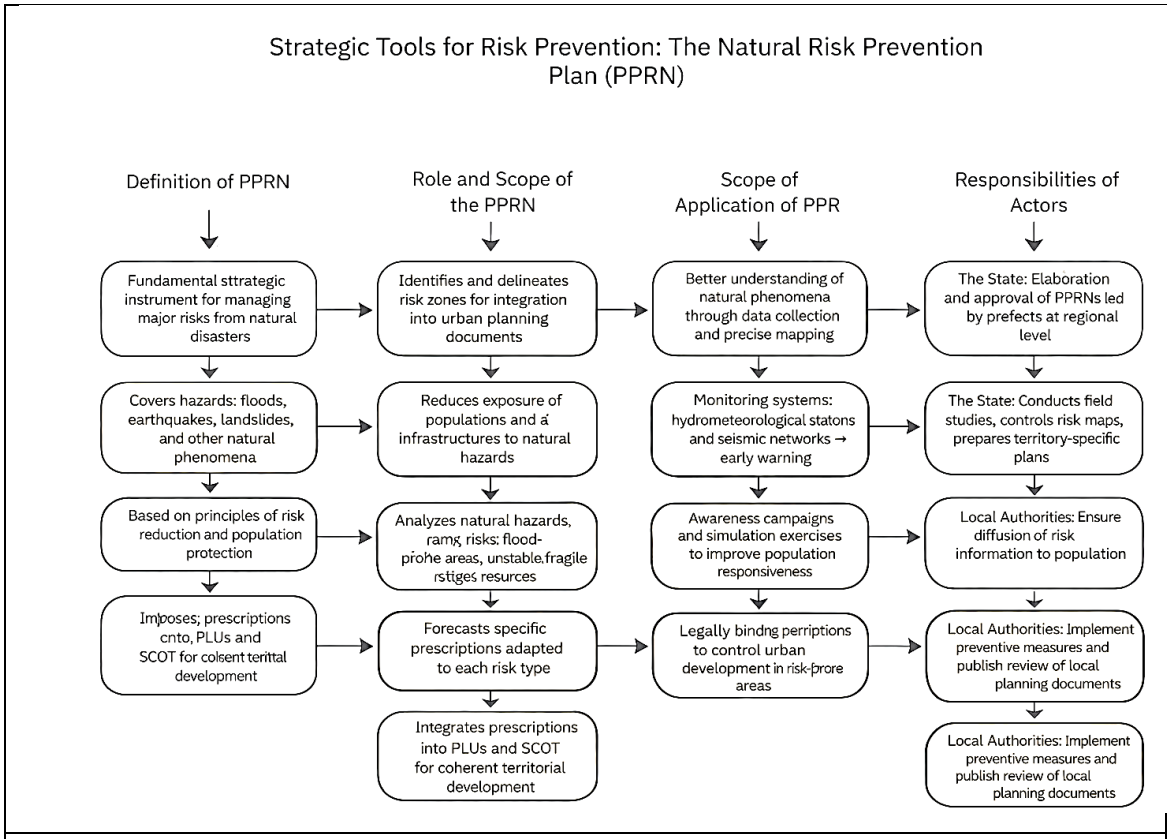

Figure 7: Strategic Tools for Risk Prevention
Source: Author,2026

3. Prescriptions and Strategic Objectives of the Risk Prevention Plan (PPR)

The Risk Prevention Plan (PPR) constitutes an essential regulatory tool to limit the impact of natural risks on populations and infrastructures. It is based on mandatory prescriptions and strategic recommendations that are integrated into territorial planning policies.

3.1.Typology of Regulatory Prescriptions

The prescriptions of the PPR are divided into several types:

- Prohibition measures: They concern the so-called "red" zones, where construction is strictly forbidden due to a high risk (floods, landslides, etc.).
- Adaptation measures: In the so-called "blue" zones, constructions may be authorized provided that certain constraints are respected, such as the elevation of buildings or the use of materials resistant to specific hazards.
- Safeguarding and evacuation measures: These prescriptions aim to ensure the safety of populations in case of a major event, for example through the development of evacuation plans or the installation of protective works (Beck, 2013). These measures must be integrated into local urban planning documents (PLU, SCOT) in order to guarantee their long-term application.

3.2.Mandatory Measures and Recommendations

Mandatory measures are legally binding and non-compliance may lead to sanctions. For example, authorities may impose strict restrictions on land use or construction in high-risk zones.

In parallel, the PPR also formulates recommendations which, although not binding, aim to encourage safer practices, such as greening to reduce runoff or the adoption of materials more resistant to weathering (Michel, 2005).

3.3.Controls and Monitoring of Implementation

The monitoring of the application of the PPR prescriptions relies on a system of regular controls conducted by local authorities and State services. These controls aim to ensure that rules are respected, notably during the issuance of building permits. Periodic audits and ex post evaluations make it possible to identify weaknesses and improve existing mechanisms. Furthermore, territorial authorities play a key role in raising awareness among populations and disseminating the prescriptions (Smith, 2010).

3.4.Operational and Strategic Objectives

The strategic objectives of the PPR are divided into several dimensions:

- Reduction of disaster impacts: The main objective is to minimize material, human, and environmental damages caused by natural disasters. This involves better knowledge of risks, adapted planning, and resilient infrastructures (Wisner et al., 2004).
- Integration into urban and territorial planning: The PPR must be integrated into planning tools, such as territorial coherence schemes (SCOT) and local urban plans (PLU). This guarantees systematic consideration of risks in development projects (Blaikie et al., 2014).

3.5.Concrete Examples and Case Studies

Feedback shows that the implementation of the PPR has made it possible to avoid significant human and material losses in several contexts. For example:

- **Case study 1:** Floods in France: The PPR applied in the flood-prone areas of the Loire Valley helped reduce material damages by limiting construction in risk zones.

Photo 1: Floods in the Loire Valley in France.

Source:https://france3-regions.franceinfo.fr/auvergne-rhone-alpes/loire/crues-et-inondations-dans-la-loire-lendemain-difficile-a-rive-de-gier-de-gros-degats-a-deplorer-3047143.html; https://www.eptb-loire.fr/nos-missions/evaluation-et-gestion-des-risques-dinondations/

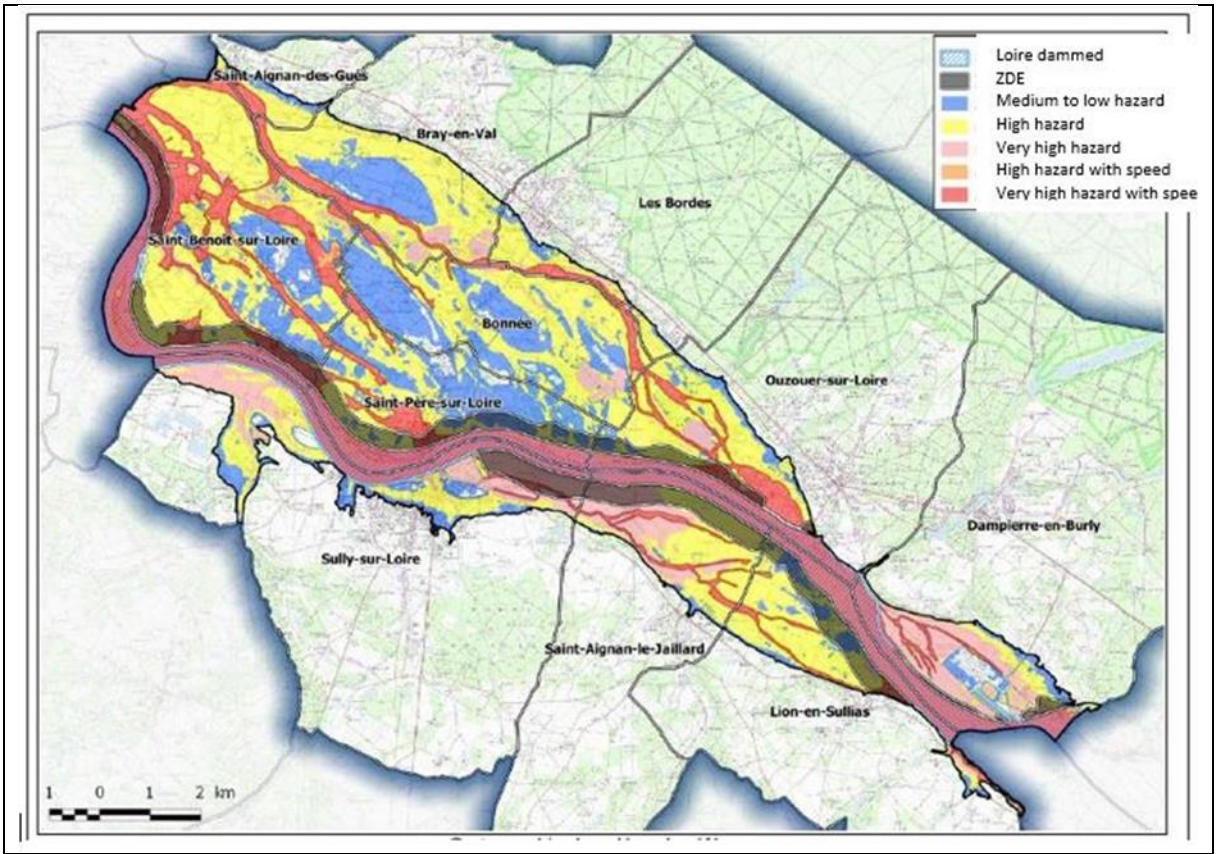

Figure 8: Reference hazard mapping.

Source: https://www.loiret.gouv.fr/contenu/telechargement/36807/265741/file/1+-+note_pr%C3%A9sentation.pdf

- **Case study 2:** Landslides in mountainous regions: In the Alps, the PPR prescriptions have led to the construction of anti-landslide dams and to soil stabilization works, thus protecting critical infrastructures.

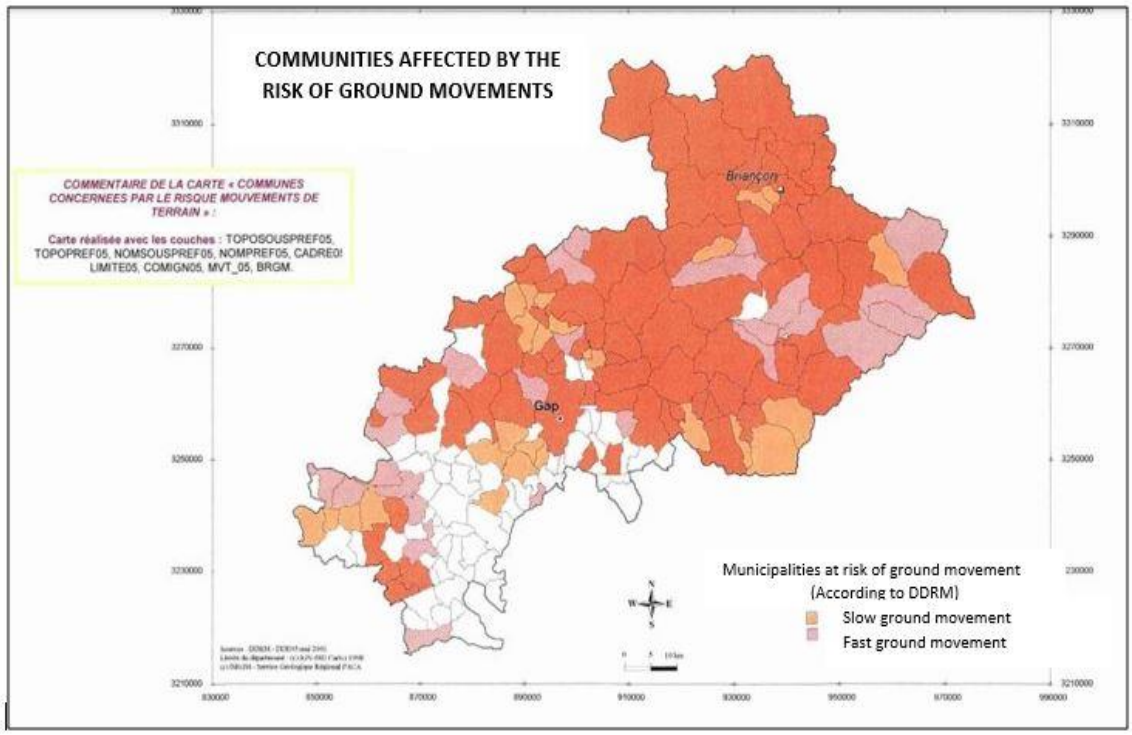

Figure 9: Mapping of Ground Movement in the Alps
Source: https://infoterre.brgm.fr/rapports/RP-51761-FR.pdf

Photo 2: Ground movements in Briançon.
Source: https://www.paysgrandbrianconnais.fr/girn/les-risques-naturels-en-montagne/mouvements-de-terrain

3.6.Feedback and Best Practices

The feedback resulting from the implementation of the PPR demonstrates the importance of:

- Local consultation: The involvement of citizens and local authorities from the drafting phase of the PPR promotes its acceptance and application.
- Regular revision of plans: Natural hazards evolve with climate change and urbanization, making periodic updates of the PPR necessary.
- Education and awareness: Informing populations about the risks they are exposed to contributes to a better appropriation of prevention measures (Hulme, 2009).

4. Perspectives of the Prevention Policy

The major risk prevention policy is at a strategic turning point, requiring constant adaptation to the evolution of threats and societal expectations. Improvement prospects rely on the integration of technological innovations, strengthening governance, and increased public awareness. However, these developments come with major challenges in coordination and implementation.

4.1.Innovations and New Technologies

Technological advances represent an essential lever to improve risk prevention.

- Artificial intelligence and predictive modeling Artificial intelligence (AI) plays an increasing role in the analysis of environmental data. Thanks to learning algorithms, predictive models allow better anticipation of catastrophic events, such as floods or earthquakes, by exploiting real-time data from sensors, satellites, or historical databases (Wegener & von Krogh, 2020). Example: In France, modeling systems integrating AI help identify the most vulnerable zones to landslides (Michel, 2005).
- Improvement of early warning systems Early warning systems evolve to become more precise and reactive. The use of technologies such as GPS or mobile telecommunication networks facilitates the rapid dissemination of alerts to populations at risk. These innovations also allow better coordination of rescue operations (UNDRR, 2019). Example: SMS alerts in case of tsunami or cyclone in coastal regions have demonstrated their effectiveness in reducing human losses.

4.2. Governance and Coordination Issues

Risk prevention requires multi-level governance and effective coordination among different actors.

- Cooperation between local, national, and international levels Local authorities, on the front line against disasters, must collaborate closely with national authorities and international organizations. This cooperation harmonizes strategies, shares resources, and increases the effectiveness of prevention measures (Gaillard & Texier, 2010).

Example: The European strategy for flood management aims to coordinate efforts of member states in prevention and response.

- Harmonization of legal and operational frameworks The diversity of legislative and regulatory approaches can complicate the management of cross-border risks. The development of common standards and the exchange of best practices are essential to overcome these obstacles (Beck, 2013).

4.3.Awareness and Citizen Involvement

Active participation of populations constitutes an essential dimension to guarantee the effectiveness of prevention policies.

- Role of education and communication Risk management education, integrated into school curricula, raises awareness from an early age about behaviors to adopt in the face of disasters. Communication, notably through media and social networks, also plays a key role in disseminating prevention and alert messages (Hulme, 2009). Example: Awareness campaigns on forest fires in Mediterranean areas, focused on responsible behaviors, have reduced accidental fire outbreaks.
- Citizen participation in planning Residents of risk zones must be associated with the design of local prevention plans. This strengthens their appropriation of measures and their capacity to act in case of crisis (Wisner et al., 2004).

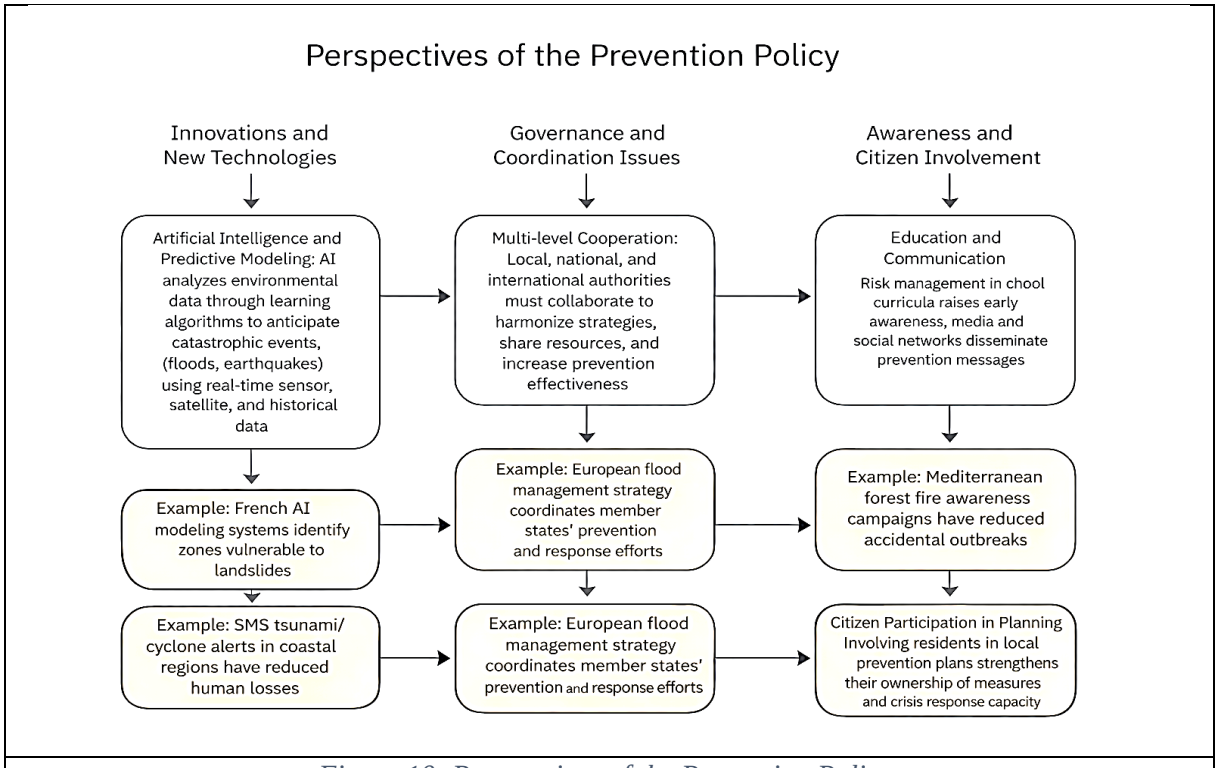

Figure 10: Perspectives of the Prevention Policy.
Source: Author,2026

Conclusion of Chapter 02

Major risk prevention constitutes a fundamental pillar of sustainable territorial management. Based on guiding principles such as anticipation, territorial resilience, and stakeholder participation, this policy relies on a robust legislative and regulatory framework, in constant evolution. The Natural Risk Prevention Plan (PPRN) presents itself as a key strategic tool, both normative and operational, enabling the reconciliation of land use planning and vulnerability reduction.

The effectiveness of this policy relies on the mobilization of all actors: State, local authorities, experts, citizens around common and shared objectives. The implementation of prescriptions, the rigorous monitoring of their application, as well as the integration of feedback and technological innovations strengthen the relevance and responsiveness of existing mechanisms.

In conclusion, the major risk prevention policy evolves towards a more integrated, participatory, and forward-looking approach, aiming to reinforce risk culture, local governance, and adaptation to growing climatic and environmental challenges.

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Chapter 03: Development of Natural Risk Prevention Plans (PPRN): From Initial Assessment to the Definition of Regulatory Zoning *(Mapping of PPRNs)*

Targeted Competencies
At the end of this chapter, the student will be able to:

- Understand the different phases involved in the preparation of a Natural Risk Prevention Plan (PPRN);
- Identify the technical and regulatory stages of a PPRN;
- Read and interpret hazard maps, exposure maps, and regulatory zoning maps;
- Analyze the interactions between natural hazards and urban assets/stakes;
- Understand the principles of regulatory zoning and its implications for urban development;
- Translate a level of risk into land-use planning and development regulations.

Introduction for Chapter 3

The mapping of Natural Risk Prevention Plans (PPRN) constitutes a central tool for anticipating and reducing the impacts of natural hazards on territories and populations. This tool makes it possible to identify risk areas, assess the issues related to spatial planning, and propose suitable measures for the prevention of natural disasters. It is based on a multidimensional analysis integrating the characteristics of hazards, socio-economic and environmental issues, as well as local specificities. From this perspective, PPRN mapping contributes to sustainable and resilient territorial development (EMA, 2020).

1. Phases in the Development of the Natural Risk Prevention Plan (PPRN)

The design of a PPRN is based on two major phases detailed in the flow diagram:

- Technical
- Administrative and regulatory (Figure N°. 09)

1.1. Technical Phase

- **Hazard identification**: This step consists in identifying and characterizing the natural phenomena likely to affect the territory, such as floods, landslides, or earthquakes. Specific studies are carried out to evaluate the nature, intensity, and probability of these hazards (Ministry for the Ecological Transition, 2023a).
- **Analysis of the issues**: This consists in identifying the individuals, properties, operations, and facilities that could be affected by the identified hazards. This study helps to determine the vulnerability of the territory (Ministry for the Ecological Transition, 2023a).

- **Risk zone mapping**: By cross-referencing data on hazards and stakes, maps are drawn up to delineate the risk zones, classified according to different levels (low, medium, high) (Ministry for the Ecological Transition, 2023a).

1.2. Administrative and Regulatory Phase

- **Consultation and public engagement**: Local authorities, State services, and the public are consulted to gather their opinions and observations on the draft PPRN. This step aims to ensure collective ownership of the proposed measures (Mayor's Handbook, 2012).
- **Drafting of the regulation**: A regulatory document is prepared, specifying the prevention measures, prohibitions, and requirements applicable in the different identified risk zones (Ministry for the Ecological Transition, 2023a).
- **Public inquiry**: The PPRN initiative is subject to a public consultation, offering residents the opportunity to express their views and submit comments. This approach ensures transparency and public engagement in the decision-making process (Mayor's Guide, 2012).
- **Approval and implementation**: After integrating the feedback from the public inquiry, the PPRN is approved by a prefectoral decree. It then becomes binding on third parties and overrides local urban planning documents (Ministry for the Ecological Transition, 2023a).

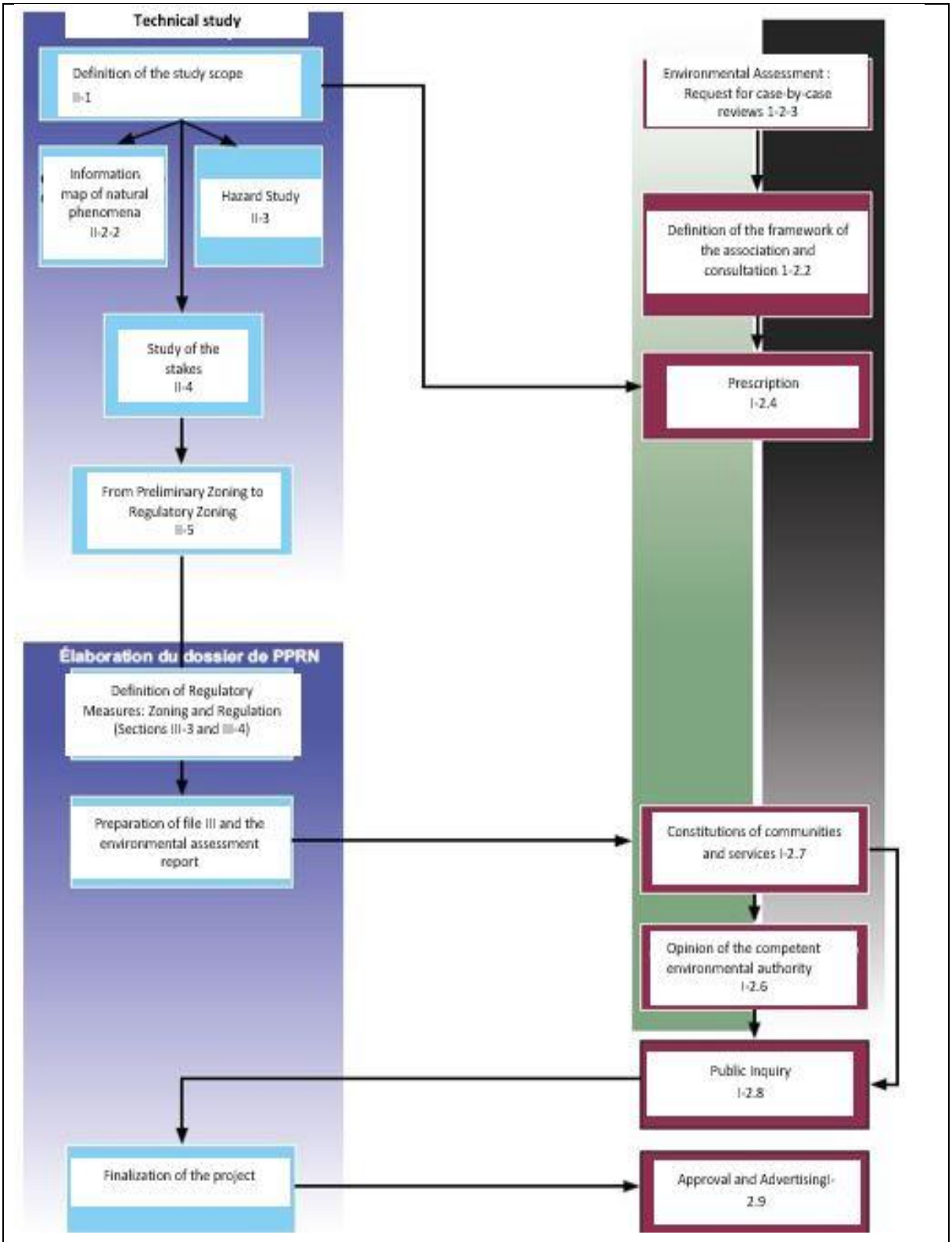

Figure 11: The stages of developing the PPRN.
Source: PPRN Guide, 2016

1.1.1. Delimitation of the Study Area (Study Perimeter)

1.1.1.1. Criteria for Defining the Study Area (Study Perimeter)

The delimitation of the study area is a fundamental step. It is based on:

- **Geographical aspects**: characteristics of the relief, proximity to coastal or mountainous areas, and hydrographic networks sensitive to specific hazards such as floods or avalanches (Alexander, 2006).
- **Socio-economic factors**: urban density, location of strategic infrastructures (roads, hospitals), and vital economic activities (industry, agriculture).
- **Environmental concerns**: preservation of protected areas, sensitive ecosystems, and listed sites, such as Natura 2000 zones (Cutter & Finch, 2008).

These criteria ensure a targeted analysis of vulnerabilities and the optimization of resources. Rural areas, often underestimated, must also be included to prevent issues related to limited access to emergency services.

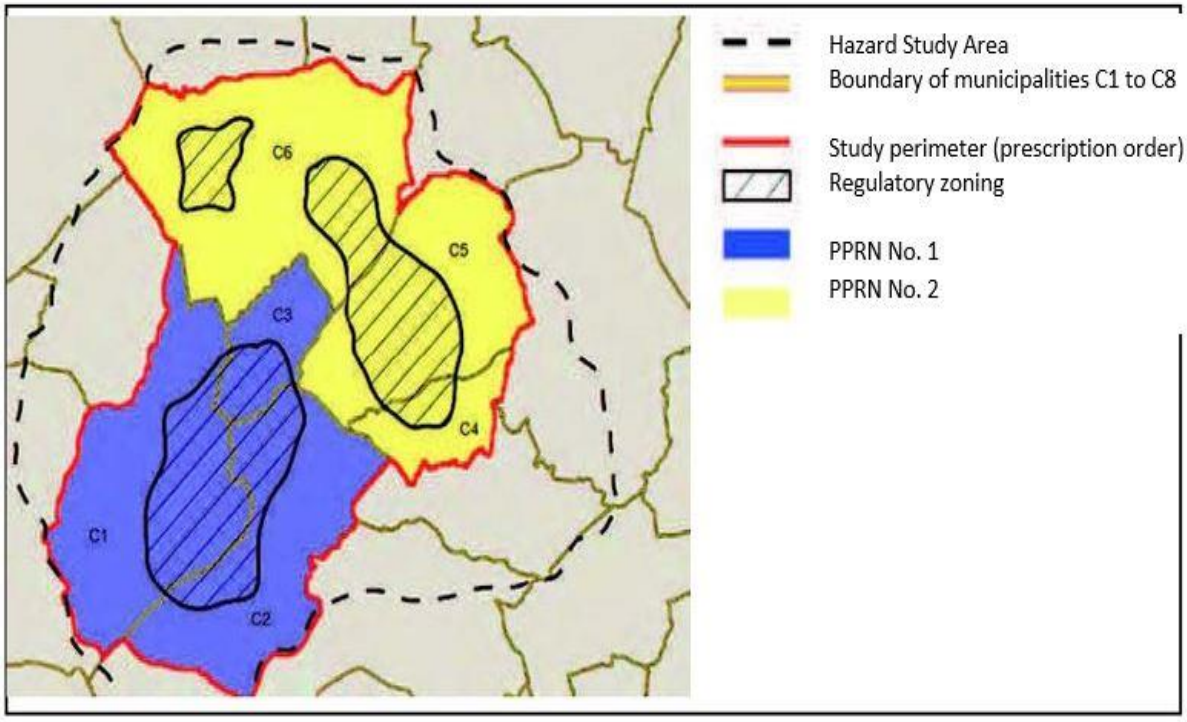

Figure 12: Example of the different study areas of a PPRN
Source: PPRN Guide, 2016.

1.1.2. Data Collection and Processing

The collection and processing of data are fundamental for mapping natural hazards. Three types of data are used: physical (geology, hydrology, climate), historical (disaster archives, modelling), and socio-economic (population density, infrastructure, economic activities). To these are added local knowledge derived from residents' testimonies. The sources include public institutions, academic research, and participatory approaches. Processing relies on GIS tools such as QGIS and ArcGIS, enabling spatial visualization and analysis. These data are used to develop predictive models and to identify risk-prone areas. The integrated approach enhances the accuracy and effectiveness of prevention policies.

1.1.3. Analysis and Mapping of Natural Phenomena

The analysis of natural phenomena relies on advanced cartographic techniques allowing for risk assessment and a better understanding of the underlying dynamics. These processes are crucial for identifying vulnerable areas and implementing appropriate risk management strategies.

1.1.3.1. The Informative Map: An Essential Tool for Risk Management

The informative map constitutes a crucial preliminary step in the development of risk mapping. It focuses on the collection and analysis of past events, such as floods, landslides, mudflows, and earthquakes. These data come from various sources, including geological service archives, meteorological data, and incident reports. This historical approach makes it possible to identify areas already affected by such phenomena, thus offering a retrospective perspective essential for understanding risks (Michel, 2005).

– The main role of this map is to raise awareness among local populations and decision-makers regarding the natural hazards to which they are exposed. By documenting the frequency, intensity, and location of past events, it facilitates informed decision-making in spatial planning and the prioritization of risk prevention investments. Moreover, the informative map serves as a foundation for urban planning and the development of public policies aimed at reducing territorial vulnerabilities.

– In addition to its retrospective function, the informative map helps anticipate future impacts and guide risk management strategies. It enables notably:

- **Identification of risk-prone areas**: The maps highlight regions likely to be affected by natural hazards such as extreme floods or earthquakes. For example, flood maps outline flood prone zones and high-risk regions (Pradhan et al., 2019).

- **Understanding the mechanisms at play**: These maps explain natural dynamics, such as river flow paths or the propagation of seismic waves. Hydrological visualizations, for instance, help anticipate areas likely to experience flooding (EMA, 2020).
- **Awareness and education**: Beyond their technical function, informative maps play a pedagogical role by helping local populations understand dangers and adopt appropriate behaviour. The accessibility of these tools strengthens prevention by making information understandable and relevant to the general public (Burby, 1998).

It is presented on a topographic base map or ortho-photography at 1:25,000 scale enlarged to 1:10,000, showing the occurrence of significant phenomena, that is:

- Their nature, their extent, the value of known physical parameters,
- As well as their major consequences for people and property.

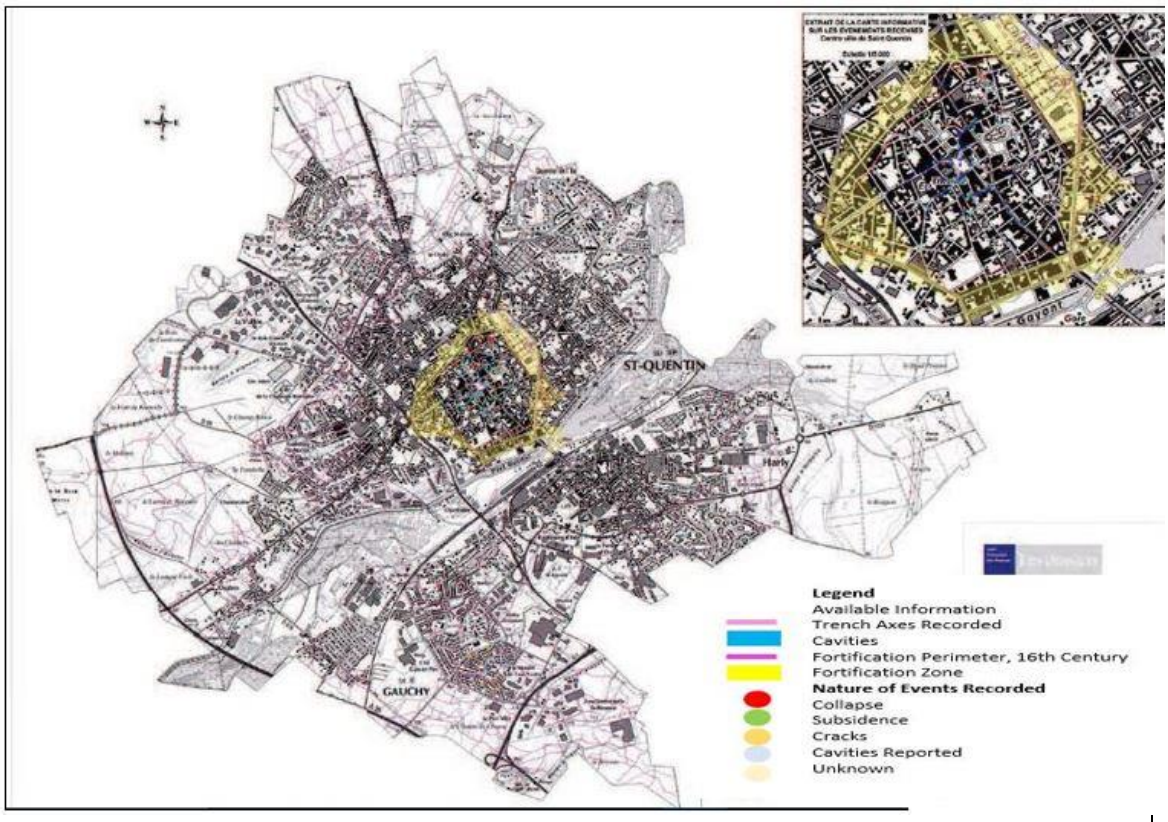

Figure 13: Informative map of natural phenomena linked to ground movements in Saint-Quentin (Aisne).

Source: PPRN Guide, 2016.

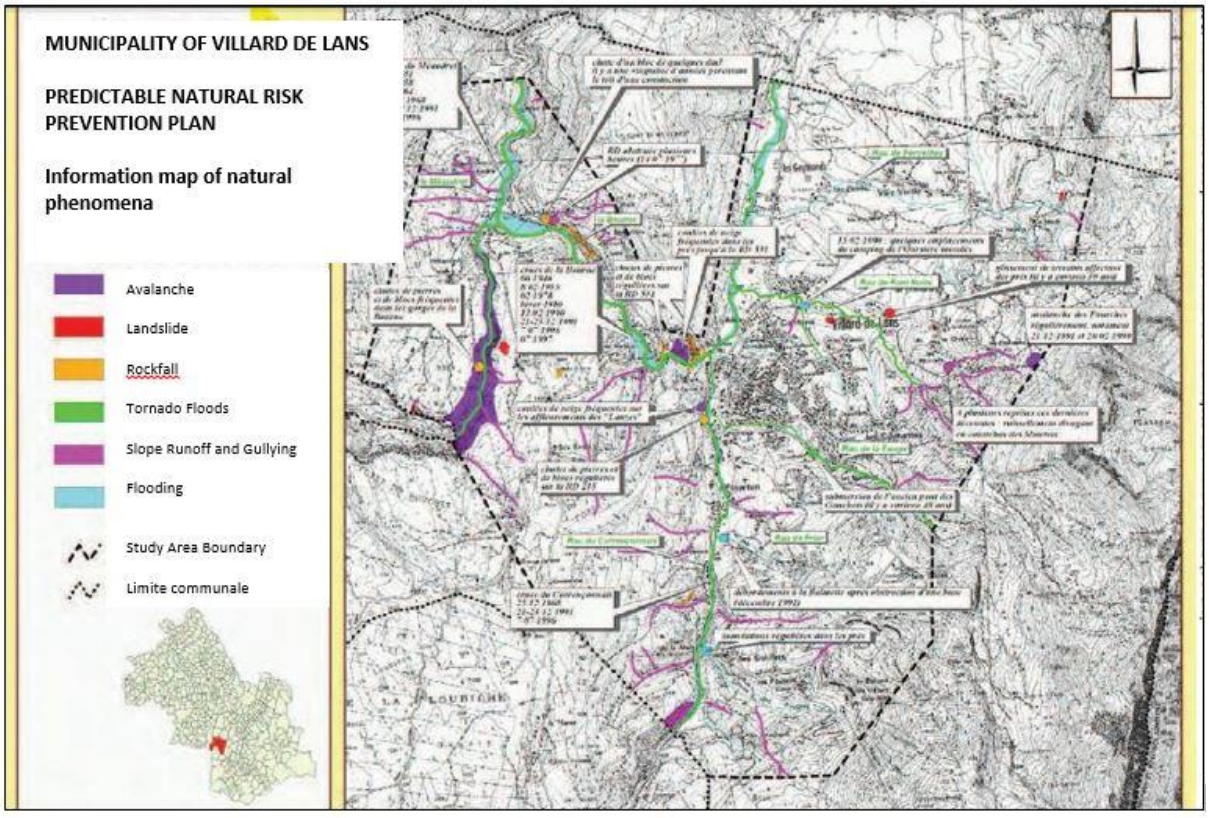

Figure 14: . Informative map on natural phenomena Municipality of Villard de Lans.
Source: PPRN Guide, 2016.

1.1.3.2. Hazard Identification and Mapping

The identification of hazards is based on determining several essential characteristics of natural phenomena. These criteria make it possible to classify risks by type, intensity, and frequency, thus providing a comprehensive assessment of potential danger.

• **Type of hazard**: Identifying the type of natural phenomenon is the first step in risk analysis. This includes events such as floods, earthquakes, landslides, hurricanes, etc. Each type of hazard requires a specific mapping and analysis approach. For example, floods are generally mapped according to water levels and river flows, while earthquakes require maps based on geophysical data (Alexander, 2006).

• **Hazard intensity**: The intensity of a hazard measures the severity of potential impacts on exposed areas. For example, flood intensity can be assessed by water height, duration of the event, and flow velocity. For earthquakes, intensity is measured using the Richter scale, which indicates the earthquake's magnitude. These data are essential to determine the scope of the prevention measures to be adopted.

• **Hazard frequency**: The frequency of a hazard is expressed as return periods, representing the probability that an event of similar intensity will reoccur over a given time span. For example, a 100-year flood return period indicates a one-in-one-hundred chance that the event will occur in any given year. Frequency analysis helps better understand long-term risks and to plan prevention measures accordingly (Alexander, 2006).

Hazard Mapping

Hazard maps combine information on the type, intensity, and frequency of natural phenomena to produce visual maps that highlight vulnerable areas. These maps are essential to risk management, as they enable understanding of the most exposed areas and the development of protective strategies.

Hazards are categorized into various levels generally three (or four): very high, high, moderate, and low considering, when possible, the nature of the phenomena, their probability of occurrence, and their intensity. These are usually illustrated on a topographic base map at a scale of 1:10,000, or even 1:5,000.

Cross-referencing geographical, historical, and climatic data

Producing a hazard map requires cross-referencing various types of data. For example, flood maps combine geographical data (relief, topography) with climatic information (rainfall) and historical data (past flood events). This cross-referencing allows the modelling of future risks and the identification of the most vulnerable areas (Pradhan et al., 2019).

Hazard maps serve as the basis for the implementation of regulatory zoning. These zones define areas where construction is either prohibited or subject to strict regulations. These maps are essential for urban planning and land management, as they ensure the safety of populations and infrastructure by taking natural hazards into account (Pradhan et al., 2019).

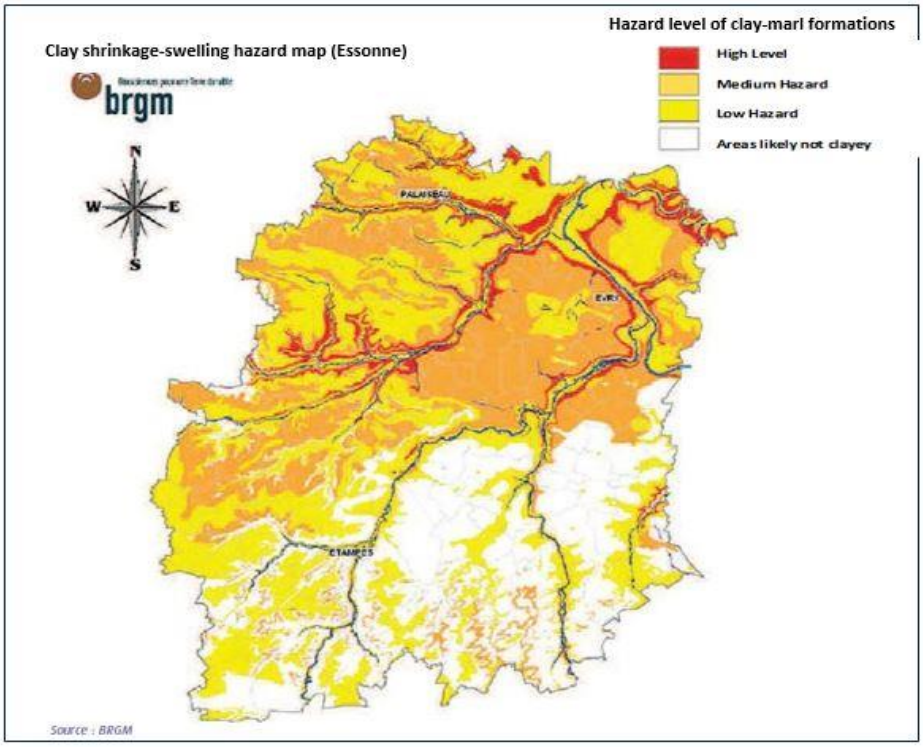

Figure 15: Clay shrinkage and swelling hazard map (Essonne).
Source: PPRN Guide, 2016.

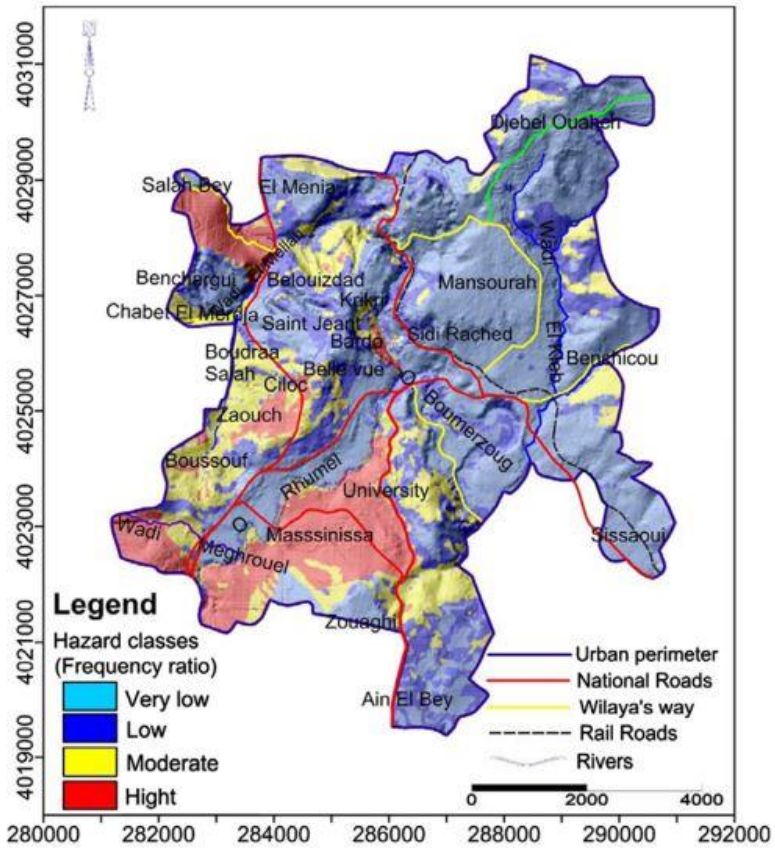

Figure 16: Landslid hazard map of Constantine
Source: Bourenane, Bouhadad 2021.
https://www.researchgate.net/publication/351063994_Impact_of_Land_use_Changes_on_Landslides_Occurrence_in_Urban_Area_The_Case_of_the_Constantine_City_NE_Algeria

1.1.3.3. Analysis and Mapping of Stakes (Exposed Elements)

The analysis and mapping of stakes aim to identify elements exposed to natural hazards, such as dwellings, critical infrastructure, and fragile ecosystems, in order to guide prevention strategies (Cutter & Finch, 2008). This approach relies on locating risk zones, including vulnerable residential areas, strategic facilities (schools, hospitals, networks), and sensitive natural environments.

The methodology combines a priority identification phase, based on socio-economic data and consultation with stakeholders, and a data overlay phase, where hazard and stake data are superimposed to locate critical zones (Schneider & Schauer, 2021).

Various sources are used: land use maps, urban planning documents, field studies, and information on existing infrastructure. The process involves civil protection services to anticipate crisis management.

The use of Geographic Information Systems **(GIS)** facilitates the spatial representation and analysis of stakes, which can be mapped in point, linear, or zonal form (Cutter & Finch, 2008). A scale of **1:10,000** is recommended, with the use of **1:5,000** for areas with high occupancy density.

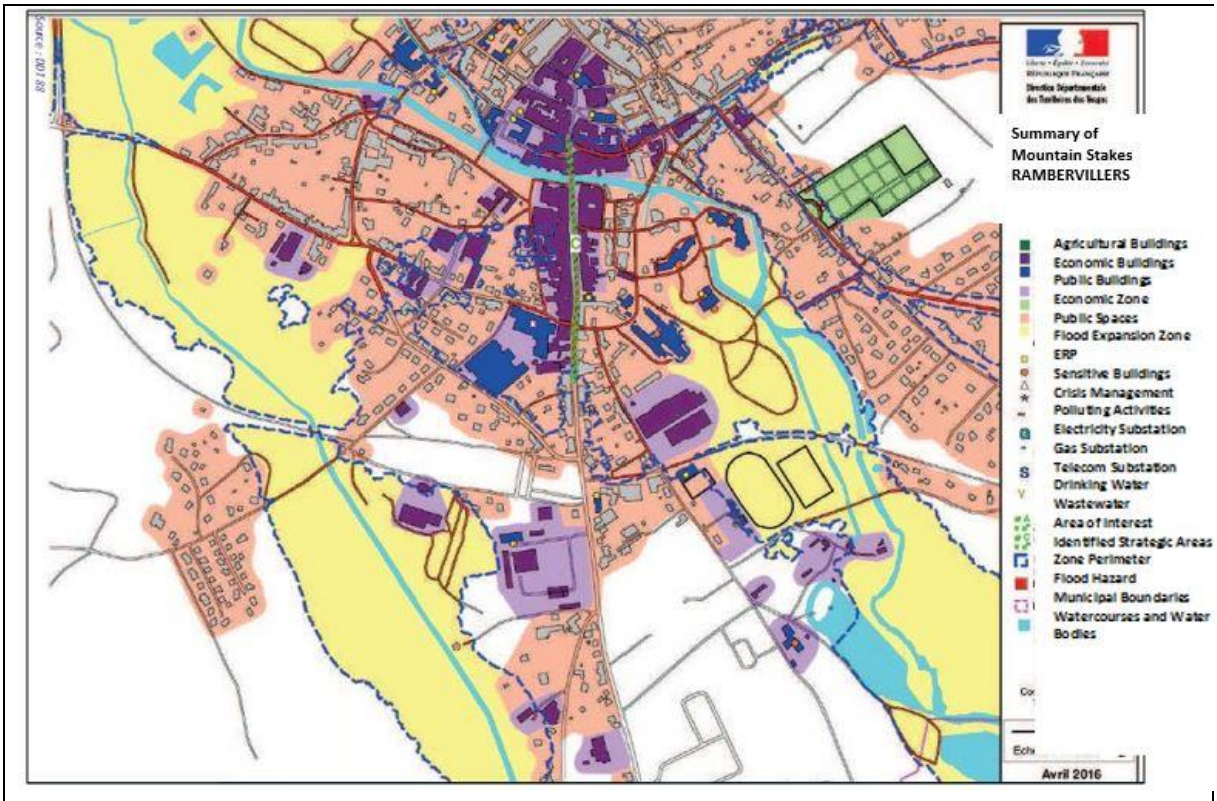

Figure 17: Mapping of Stakes for Rambervillers (Vosges).
Source: PPRN Guide, 2016.

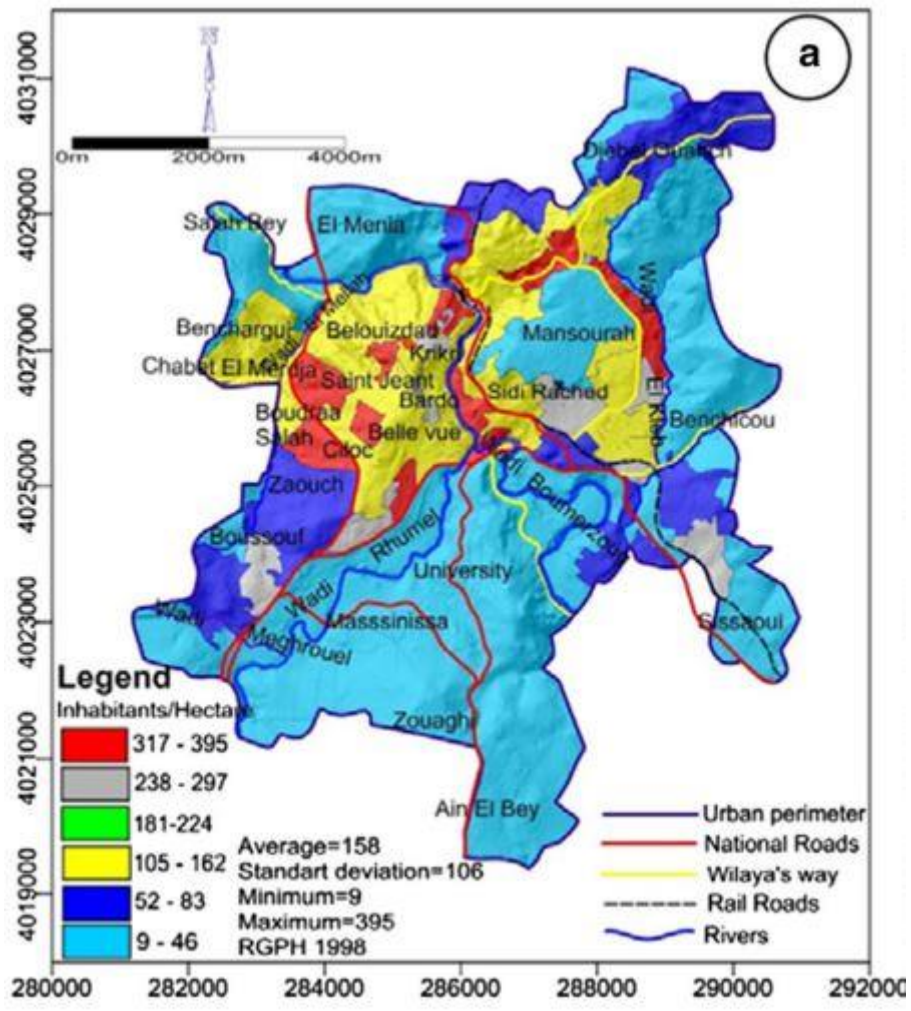

Figure 18: Mapping of Stakes in Constantine.

Source: Bourenane, Bouhadad 2021.
https://www.researchgate.net/publication/351063994_Impact_of_Land_use_Changes_on_Landslides_Occurrence_in_Urban_Area_The_Case_of_the_Constantine_City_NE_Algeria

1.1.3.4. Development of Regulatory Zoning

Regulatory zoning allows for the definition of specific land management measures based on the identified natural hazards. It is a fundamental tool for integrating risks into land-use planning and spatial development.

1.1.3.4.1. Principles of Regulatory Zoning

Regulatory zoning is based on the intensity and frequency of hazards to define risk zones and determine the actions to be undertaken. The conclusion of the technical studies is characterized by :

1. The intersection of the two maps: hazards and stakes;
2. The implementation of the "raw" zoning plan by applying delimitation principles.

These different phases will constitute a working and discussion basis for the final establishment of regulatory zoning.

1.1.3.4.2. Principles for Delimiting the "Raw" Zoning

The responsibility for designing the regulatory zoning lies directly with the service in charge of drafting the PPRN, which must work in close coordination with the consulting firm that conducted the hazard analyses.

The plan defines the zones where uniform prohibitions or regulatory directives apply to projects, and/or actions of prevention, protection, and safeguarding, as well as provisions related to existing assets and operations.

Generally, these zones are determined based on criteria of buildability or land use. However, in a later stage, they may also be based on hazard criteria.

This leads to the consideration of three categories of zones:

- **Red zones**: These are areas of very high risk, where construction is strictly prohibited. They correspond to areas exposed to frequent and violent phenomena, such as major floods or landslides. The objective is to protect human life and property by prohibiting any permanent installation in these zones (EMA, 2020).
- **Buildable zones under conditions, known as "orange zones"**: These zones are exposed to moderate or intermittent risks, requiring specific restrictions on construction and infrastructure. Building standards are reinforced to limit damage in case of a natural disaster. Risk management plans must be applied there to reduce impacts (EMA, 2020).
- **Buildable zones in "green" color**: These zones are of low or moderate risk. These areas present low risk and are not subject to major restrictions, although they may be subject to recommendations to ensure a certain resilience to risks.

For example: the implementation of alert systems may be established to manage the risk proactively (EMA, 2020).

In each of these zones, appropriate measures related to other types of land occupation, or collective prevention measures, may be prescribed. This map is drawn at a **1:5,000 scale**.

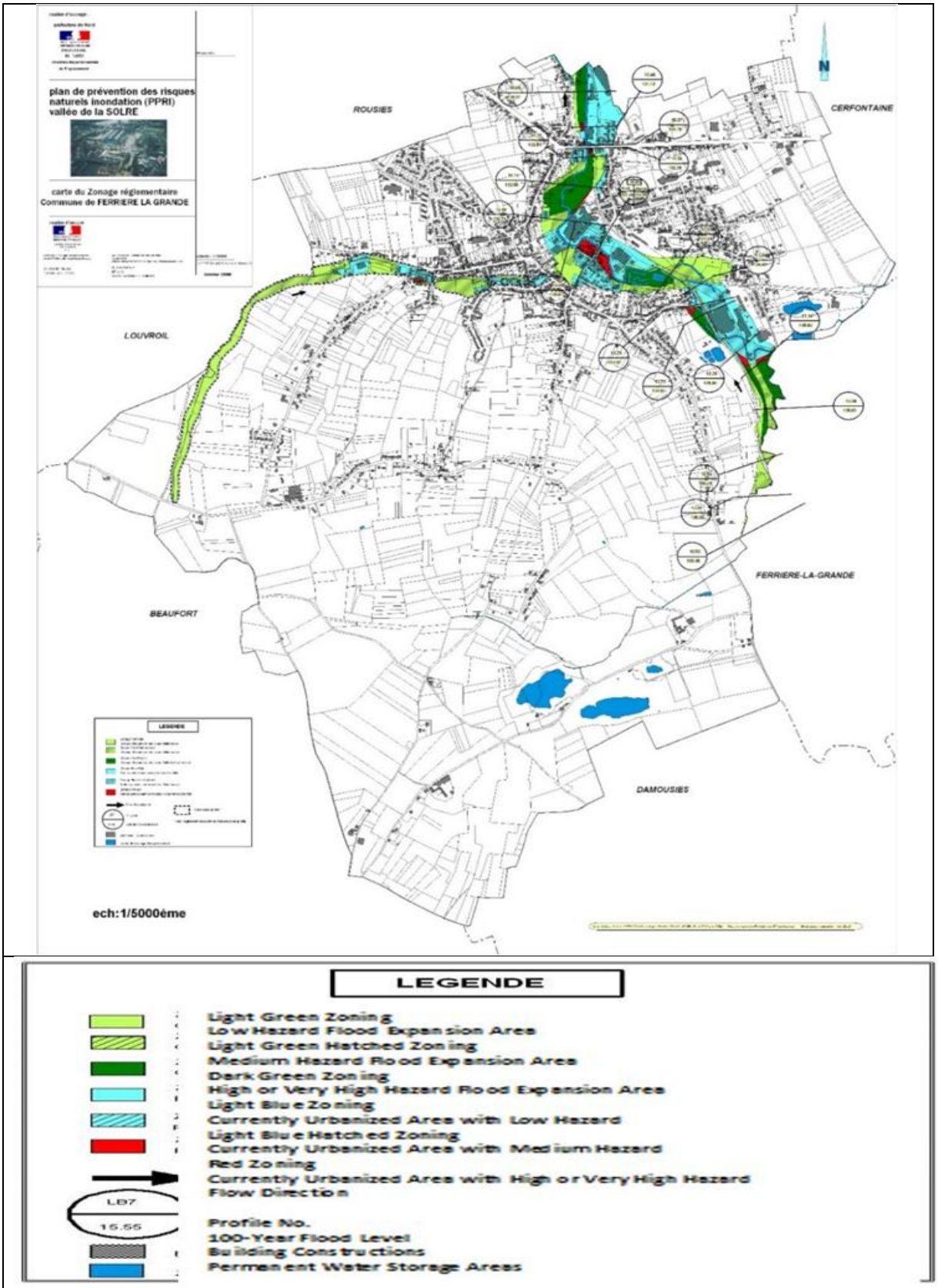

Figure 19: Regulatory zoning map of FERRIERE LA GRANDE.

Source: https://www.nord.gouv.fr/var/ezwebin_site/storage/images/media/pprn-approuves-et-modifies/ppri-de-la-vallee-de-la-solre/zonage_ferriere_la_grande_ap_cle589f71-1/97739-1-fre-FR/zonage_FERRIERE_LA_GRANDE_ap_cle589f71-1.jpg

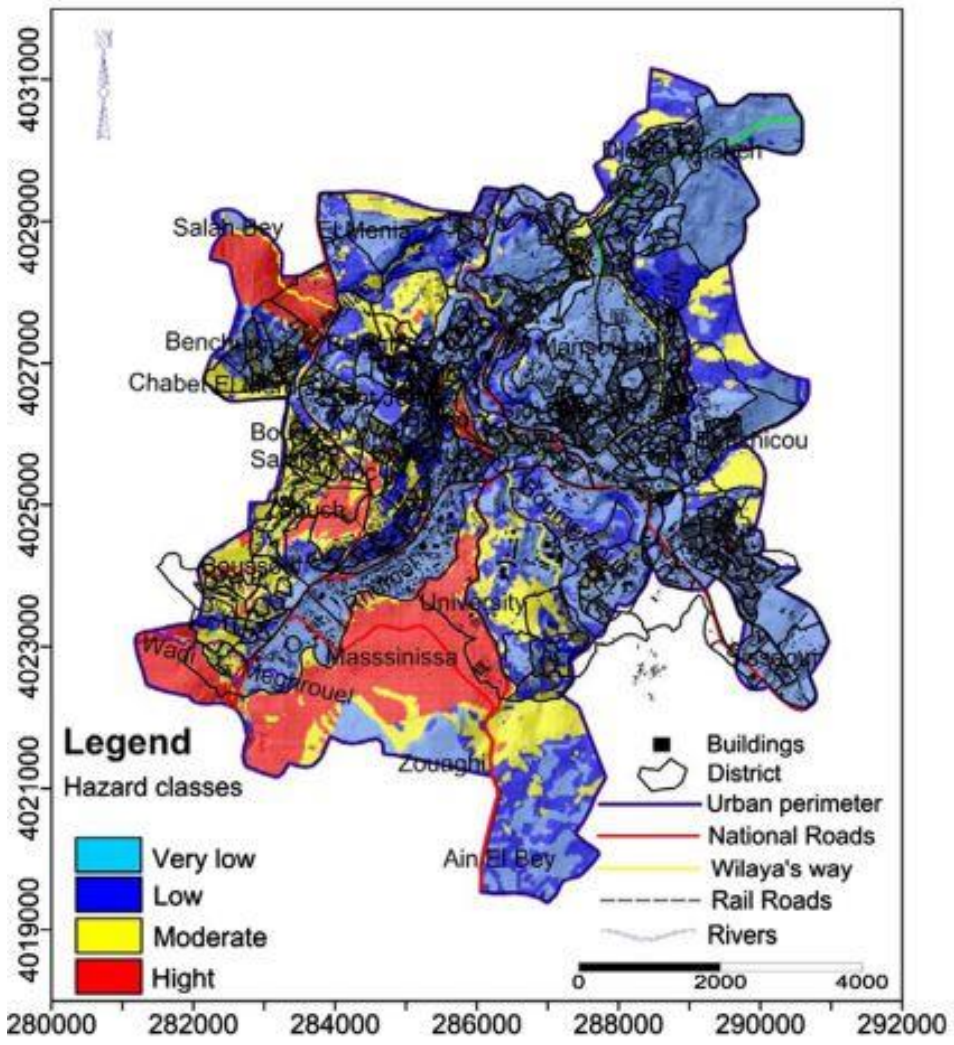

Figure 20: Regulatory zoning map of Constantine.
Source: Bourenane, Bouhadad 2021.
https://www.researchgate.net/publication/351063994_Impact_of_Land_use_Changes_on_Landslides_Occurrence_in_Urban_Area_The_Case_of_the_Constantine_City_NE_Algeria

1.1.3.5. Integration into Urban Planning Documents

The regulatory zoning is integrated into the Local Urban Plans (PLU) and the Territorial Coherence Schemes (SCOT). These documents ensure that natural risks are taken into account in the planning of urban development projects, thus guaranteeing that new developments comply with safety and sustainability criteria. This also ensures the coherence of public policies at both local and regional levels (Alexander, 2006).

Constituent Components of the PPRN Project (Administrative and Regulatory Phase)

The Natural Risk Prevention Plan (PPRN) includes three main components: an explanatory note, a regulatory zoning map, and a regulation. The explanatory note justifies the approach,

details the local and national prevention context, describes the reference hazards and territorial issues, and facilitates the understanding of the file by all stakeholders (Ministry of Ecological Transition, 2021).

The regulatory zoning identifies risk zones and defines land use conditions according to the intensity of the hazard, with a recommended scale of 1:5,000 (Environmental Code, art. R. 562-3). This zoning allows for a rigorous application of urban planning rules.

The regulation specifies the prohibition, protection, and safeguarding measures applicable in each zone, in accordance with Articles L. 562-1 and R. 562-3 of the Environmental Code. These three components ensure consistency between risk knowledge, territorial stakes, and regulatory actions (BRGM, 2018), thus forming the administrative and legal basis of the PPRN.

Title I: Scope of the PPRN – General Provisions
Article 1 – Scope of Application
Article 2 – Effects of the PPRN
Article 3 – Reference to Other Applicable Regulations

Title II: Regulation of Projects
This section applies to all new projects as well as projects affecting existing properties and activities.

Chapter X: Applicable Provisions in Zone [Zone Name] *(to be replicated for each regulated zone)*
1.1. Conditions for Implementation
1.1.1. Urban Planning Standards
1.1.1.1. Prohibitions
1.1.1.2. Requirements
1.1.1.2.1. Construction Standards
1.1.1.2.1.1. Prohibitions
1.1.1.2.1.2. Requirements
Examples of requirements:
– Extensions to existing commercial premises are limited to a 20% increase in ground coverage.
1.2. Conditions of Use
1.3. Operating Conditions
1.4. Recommendations (if applicable)

Title III: Measures of Prevention, Protection, and Safeguarding

- Prevention measures
- Protection measures
- Safeguarding measures

Title IV: Measures Pertaining to Existing Properties and Activities

- Land-use planning measures
- Measures related to the use of premises
- Measures related to operations

For every sub-section in Titles III and IV, list all prescribed measures and those that are mandatory, specifying compliance deadlines and identifying the categories of responsible parties. Where applicable, indicate the regulated zones defined under Title II to which they apply.

Figure 21: Example of the settlement plan.
Source: PPRN Guide, 2016.

Conclusion of Chapter 03

The course on the development of Natural Risk Prevention Plans (PPRN) highlights the importance of a methodical and integrated approach to anticipate and reduce risks related to natural hazards. It emphasizes that this development relies on two main phases: a technical phase, focused on data collection, analysis, and the mapping of hazards and stakes, and an administrative and regulatory phase, dedicated to the implementation of preventive measures within a legal framework.

The delimitation of the study area, the inventory of historical, physical, and socio-economic data, as well as the mapping of natural phenomena, are crucial steps to ensure a thorough understanding of risks. These analyses lead to the development of essential documents, notably the informative map, the hazard map, the stakes map, the regulatory zoning map, and the associated regulation, which guide land-use planning and risk prevention.

This process aims to protect populations and property while strengthening the resilience of territories to natural hazards, within a framework of consultation and transparency.

Reference Chapter 03

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Chapter 04: The Policy for Technological Risk Management (PPRT)

Targeted Competencies

At the end of this chapter, the student will be able to:

- Define the concepts of industrial risk, hazardous phenomena, and technological risk;
- Understand the different types of technological effects (thermal, toxic, overpressure);
- Analyze the territorial issues associated with the presence of high-risk industrial facilities;
- Interpret the principles of zoning applied to technological risks;
- Translate the outcomes of hazard (risk) studies into urban planning and building regulations;
- Distinguish the role of the urban planner from that of the engineer in the management of industrial risks.

Introduction Of Chapter 4

Technological risks, associated with industrial activities and sensitive infrastructures, constitute a major issue for modern societies. They may manifest through events such as explosions, fires, or the release of hazardous substances, which can lead to significant impacts on populations, the environment, and material assets (Leroy, 2006). The management of these risks is based on a preventive approach aimed at reducing the exposure of people and territories to hazards, while limiting the consequences of potential accidents.

The Bachelot Law of 2003 in France, established following significant industrial disasters such as the explosion of the AZF factory in 2001 (Ministère de la Transition écologique, 2022), governs the implementation of Technological Risk Prevention Plans (PPRT). The PPRT is a regulatory land-use planning mechanism whose objective is to safeguard populations by controlling urban development around classified SEVESO industrial sites, while encouraging operators to reduce hazards at their source. This mechanism is based on key principles such as regulatory zoning, land-use restrictions, and consultation with relevant stakeholders (INERIS, 2015).

This course is structured into several complementary sections, exploring the theoretical and practical foundations of technological risk management. The first part introduces key concepts, such as industrial risk, technological hazard, and vulnerability, which allow a better understanding of prevention policy issues. The following sections focus on the steps of development and implementation of PPRT, detailing technical analyses, the mapping of hazards and stakes, as well as the consultation process necessary to ensure social acceptability. Finally,

particular attention is given to the evaluation and monitoring of PPRT, which ensure their relevance and effectiveness in an evolving context (Vandromme & Faburel, 2017).

By combining theoretical, methodological, and operational dimensions, this course offers a comprehensive perspective on the management of technological risks. It is intended for students, professionals, and decision-makers engaged in risk prevention, sustainable planning, and territorial resilience.

1. Concepts of Industrial Risk, Dangerous Phenomenon, Technological Hazard

1.1. Industrial Risk – Definition

Industrial risk encompasses technical, economic, and social aspects, resulting from the presence of facilities handling hazardous substances, posing risks to populations and the environment. Its understanding is complex, especially as it may be subject to polarized debates when focusing on a single component.

Three key elements constitute the technical dimension of industrial risk:

1. The probability of occurrence of hazardous events.
2. The intensity of the effects of these phenomena.
3. The vulnerability of interests protected by legislation (Article L. 511-1 of the Environmental Code).

Several phases are necessary to assess this risk:

- Analyze the potential impacts on the industrial site and its environment.
- Evaluate the probability of these events.
- Determine the measures to be taken to minimize their impacts.
- Be aware of challenges related to the territory adjacent to industrial facilities.
- Possess knowledge of the functioning of this territory.

1.2. High-Risk Installation

"AS" installations, defined by the decree of May 20, 1953 as amended, include sites handling significant quantities of hazardous substances. They include chemical industries (basic products, pharmaceuticals), petrochemical industries (polymers, complex compounds), petroleum industries (fuels, tars, gases), those using explosive substances, and storage facilities for flammable liquids or gases. This classification regulates major risks to safety and the environment (Decree No. 53-578, 1953).

1.3. A Dangerous Phenomenon

A dangerous phenomenon is defined as a release of energy or matter likely to cause damage to human or material elements, regardless of their presence. It is characterized by a probability, a dynamic, and effects with varying intensity. By comparison, a flood illustrates a perilous natural phenomenon, defined by its frequency (e.g., ten-year or hundred-year) and its intensity (e.g., height, duration, speed) (Pons & Lefebvre, 2019).

1.3.1. Causes of the Occurrence of the Dangerous Phenomenon

A scenario is a sequence of events leading to the occurrence of a dangerous phenomenon. Several scenarios may lead to the same phenomenon, and the entirety of these scenarios is often represented by a "bow-tie" diagram, combining a "fault tree" (causes) and an "event tree" (consequences). This model helps identify possible causes, position safety barriers, and estimate the probability of the phenomenon, either qualitatively or quantitatively, depending on the available data (Coulon et al., 2015; Kletz, T. A., 2001).

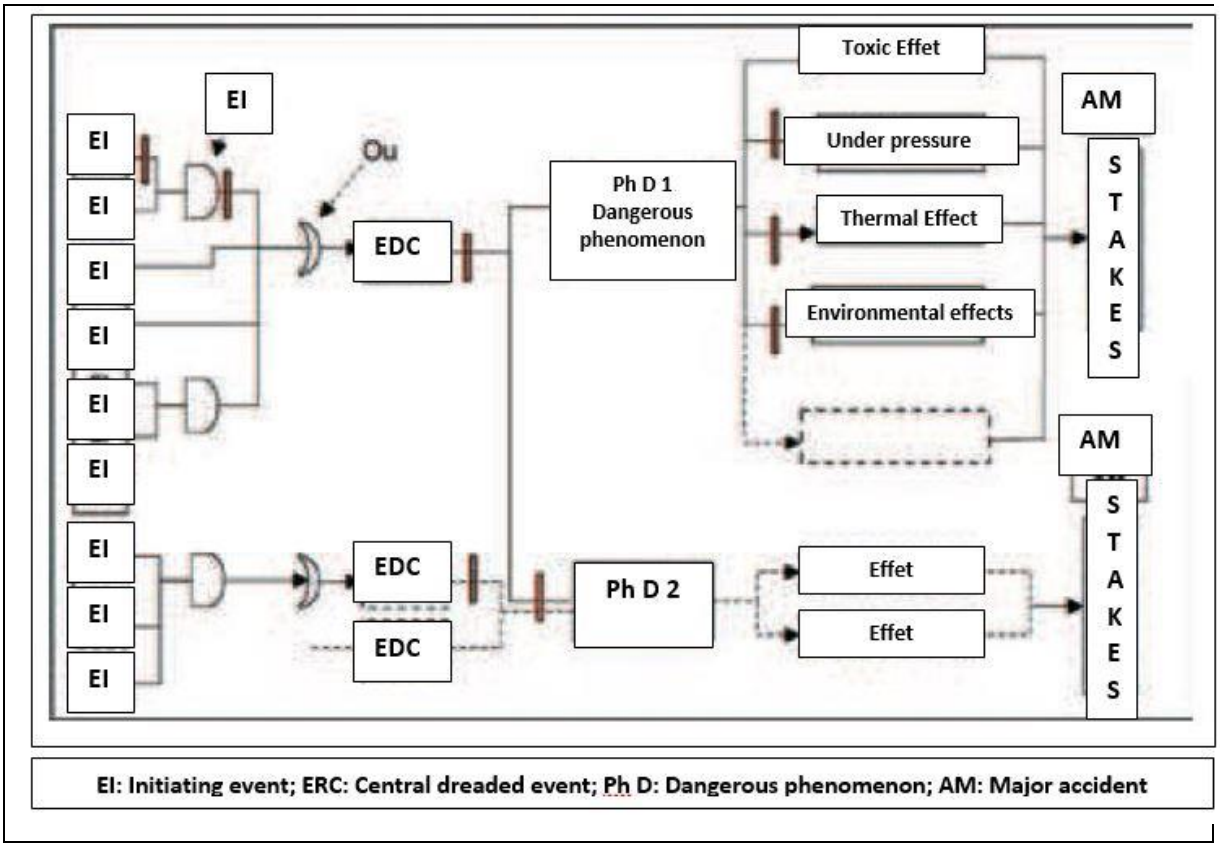

Figure 22: Simplified model of the bow tie.
Source: Methodical guide; PPRT

1.3.2. Types of Effects in Industrial Installations

Industrial risks are linked to hazardous phenomena generating three main types of effects:

1.3.2.1. Thermal Effects

They are related to the more or less rapid combustion of a flammable or combustible material, causing burns to exposed individuals. The heat produced can lead to a dangerous increase in temperature inside a building, resulting in the deterioration of windows, the breaking of glass, and the spread of fire within the dwelling.

The modes of thermal effect transfer can be classified into three types:

- **Convective**: Heat is transmitted through the movement of hot air.
- **Radiative**: Heat diffused by radiation, similar to that of the sun.
- **Conductive**: Heat transmitted by direct contact.

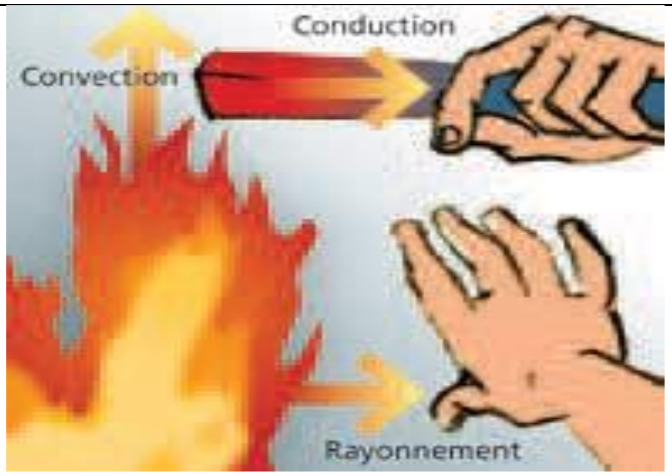

Figure 23: ***Thermal effect.***
Source: Methodical guide; PPRT

1.3.2.2. Overpressure Effects

Overpressure effects are produced by a pressure wave resulting from an explosion, which may be caused by an explosive, an intense chemical reaction, a powerful combustion, or the sudden decompression of a pressurized gas. This shock wave has the potential to cause direct damage, such as injuries to the eardrums and lungs, but also indirect consequences like the collapse of structures or the projection of debris. The exerted pressure can also induce deformations in materials and stresses on the human body. These phenomena affect multiple sectors, including the chemical, petrochemical, and petroleum industries.

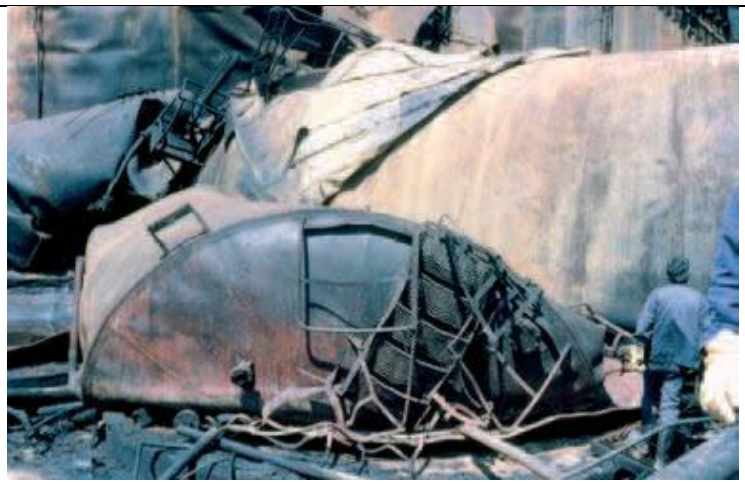

Photo 3: Hydrocarbon tank after an internal explosion.
Source: Methodical guide; PPRT

1.3.2.3. Toxic Effects

Toxic effects result from spills or emissions of harmful chemical substances such as chlorine or ammonia, generally following industrial accidents. Inhalation represents the major hazard for exposed groups, while ingestion or skin absorption primarily affects workers. These substances can spread in liquid, gaseous, or two-phase form. The impact on health is related to their toxicity, their concentration, and the duration of exposure (Pons & Lefebvre, 2019).

Photo 4: Ammonia release following a pipe rupture.
Source: Methodical guide; PPRT

1.4. Technological Risk

Technological risk is a technical, economic, and social concept resulting from the combination of equipment involving hazardous materials or processes, which may trigger a "hazardous phenomenon," and an area presenting stakes for people and property.

The technical dimension of technological risk arises from the combination of the following three criteria:

- the probable frequency of hazardous events;
- the intensity of the potential consequences of hazardous events;
- the vulnerability of the elements at stake.

The combination of the first two criteria defines technological risk.

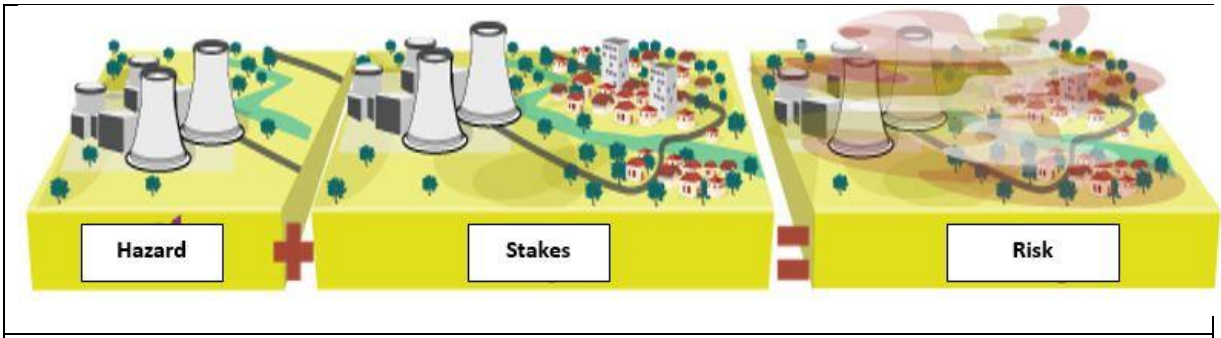

Figure 24: The components of technological risk
. Source: https://www.maxicours.com/se/cours/les-risques--seconde--geographie/

1.4.1. Technological Hazard

The technological hazard, which is part of industrial risk, refers to the probability that a hazardous phenomenon will cause consequences of a certain physical intensity at a given location.

In Technological Risk Prevention Plans (PPRT), the evaluation of this hazard is carried out by considering the various potential effects of a hazardous phenomenon. This principle was codified in France by the law of July 30, 2003, which introduced the term "technological hazard."

To characterize this hazard, it is necessary to:

- identify the hazardous phenomena,
- determine their probability,
- analyze the intensity of their effects,
- take into account their dynamics.

However, the technological hazard does not consider the susceptibility of exposed elements, such as individuals or property, and therefore does not assess the severity of industrial accidents. (Delmas, 2015)

2. Characteristics, Modalities of Development and Implementation of a PPRT

2.1.Scope of Intervention of the PPRT

The Technological Risk Prevention Plan (PPRT) is a crucial regulatory measure aimed at minimizing industrial risks at their source and ensuring the safety of populations. This mechanism complements the risk management strategies stated in Articles L. 515-16 and L. 515-19 of the Environmental Code, and relies on a tripartite collaboration between the State, municipalities, and the industrial sector.

The PPRT delineates a risk zone based on hazard studies, regulates urban planning by imposing prohibitions or rules, and uses land management tools (pre-emption, abandonment, expropriation) to manage high-risk areas. It also imposes safety modifications depending on the value of the assets concerned and suggests measures to enhance community protection. In accordance with Law No. 2003-699 and Decree No. 2005-1130, the actions to be undertaken must be completed within a maximum period of five years.

2.2.Study Perimeter

Before initiating the process of creating a Technological Risk Prevention Plan (PPRT), it is crucial to delimit a specific study perimeter, which differs from the risk exposure zone. Once the plan is validated, this zone is defined as regulated, while the study perimeter may extend over a broader area. If this scope is too wide for example, if it relies on the Industrial Protection Plan (PPI) it can lead to consequences such as mandatory information for owners and tenants, even though their properties are not truly exposed to dangers.

This may also generate additional costs and delays for departments responsible for assessing the stakes. Thus, a three-step approach is recommended: collect hazard studies from industrial operators, hold an informational meeting for concerned stakeholders, and define the study area based on hazard maps (Environmental Code, Article L. 125-5, Decree No. 2005-134 of February 15, 2005).

2.3.Procedure for Developing the PPRT

According to Decree No. 2005-1130 of September 7, 2005, the procedures for developing Technological Risk Prevention Plans (PPRT) are defined. A PPRT must include an explanatory note, a regulatory zoning map, rules, and recommendations. It must be approved within 18 months following the issuance of the prescriptive order. However, if the complexity of the plan or the duration of consultations justifies it, the prefect may grant an extension by a justified decree.

The design phases of a PPRT:

1. Start of technical studies and presentation of the PPRT process.

2. Consultation of the concerned municipalities: implicit approval within one month.
3. Issuance of the prescriptive order by the prefect: it specifies the study perimeter, the considered risks, the investigating authorities, and the modalities for consultation.
4. Evaluation of the consultation: the prefect informs individuals and entities concerned of the outcome.
5. Opinion of individuals and concerned bodies: the opinion is deemed favorable if no response is given within two months, and this opinion is collected by the prefect.
6. Public inquiry: the draft plan, adjusted if necessary, is submitted to a public inquiry.

These steps ensure the implementation of a PPRT in collaboration with the relevant stakeholders, in accordance with regulatory procedures. The PPRT includes:

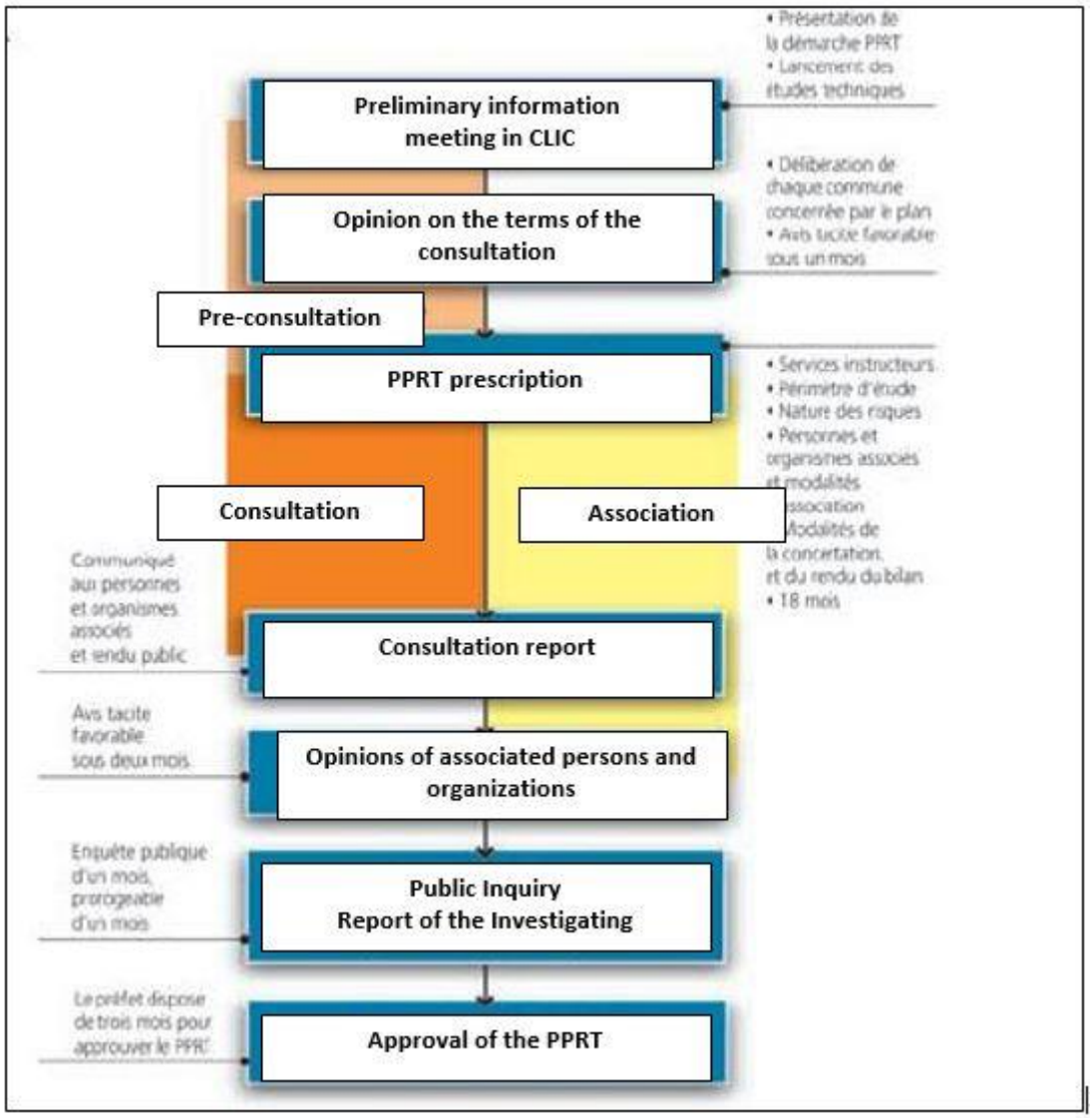

Figure 25: Procedure for developing the PPRT

Source : Methodical guide; PPRT

1.A Presentation Note

Detailing the installations or warehouses at the origin of the risks, their nature and intensity, as well as the reasons for delimiting the risk exposure perimeter. This definition may include actions and measures already imposed on operators by environmental or mining legislation, provided that their implementation is scheduled within a time frame not exceeding five years.

2. Regulatory Zoning Plan

The objective is to define risk zones according to their intensity and probability.
Content:

- **Red zones:** The most exposed areas where urbanization is prohibited or requires abandonment measures.
- **Blue or Orange zones:** Areas with moderate risks where certain constructions are allowed under conditions (building reinforcement, specific usage).
- **Detailed mapping** of the zones at the local scale, based on simulations of the potential effects of accidents.

3. Regulation

The objective is to govern land and building uses within each zone.
Content:

- **Prohibitions:** Types of constructions or activities strictly banned in the highest-risk zones.
- **Prescriptions:** Mandatory technical measures (specific construction materials, risk shelters).
- **Occupancy restrictions:** Limited density, types of allowed dwellings or activities.

4. Recommendations

The objective is to complement the regulation with non-binding but incentive-based measures to improve safety.

Content:

- **Evacuation plans** in the event of an industrial accident.
- **Information and awareness systems** for residents (drills, signage).
- **Suggested technical improvements** for industrial operators (reduction of danger zones, reinforcement of safety systems).
- **Inter-municipal collaboration** to optimize risk management.

2.4.Technological Risk Management Policy

The PPRT represents the application of the "urbanization control" component of the industrial risk prevention policy around SEVESO AS installations. It is part of a global system based on managing risks at their source (on the site of industrial production), ensured upstream by the authorization process and including, downstream, emergency response efforts. This system is supplemented by informing citizens about the types of risks they may be exposed to and the behaviors to adopt during an alert.

2.4.1. Control of Risks at the Source

Controlling risks at the source requires identifying hazardous phenomena at industrial sites and implementing measures intended to reduce these risks to an acceptable threshold. A hazard study detailing these phenomena is required to obtain an operating permit for an installation classified for environmental protection (ICPE) (Environmental Code, Article L.512-1). Since the 1970s, stricter legislative measures in France and Europe have been implemented to prevent large-scale accidents. The law of July 19, 1976, relating to ICPE (Law No. 76-663) and the Seveso Directive of 1982 established rigorous provisions regarding risk prevention and management (Directive 82/501/EEC). Law No. 2003-699 enriched these frameworks, aiming to reduce the consequences of industrial accidents, primarily through the establishment of PPRTs.

These strategies include a probabilistic risk assessment to minimize the population's exposure to hazards (Ministry of Ecology, 2023). Catastrophic events such as those of Seveso (1976), Bhopal (1984), and Toulouse (2001) highlighted the need for early and strict regulation of hazardous industrial zones (Guerrin, 2001).

2.4.2. Control of Urbanization

Controlling urbanization is a key element in managing industrial risks, with the objective of reducing population exposure to the consequences of major accidents. In France, this issue originated in the Imperial Decree of 1810, which gave prefects the power to impose minimum safety distances between hazardous sites and residential zones (Environmental Code, Article L.515-8).

The law of December 19, 1917 (Law No. 1917-0408) strengthened this regulation by prohibiting the establishment of new dangerous sites near residential areas.

2.5.The Process of Developing the PPRT

The development of the Technological Risk Prevention Plan (PPRT) takes place according to a procedure organized into two consecutive phases.

2.5.1. The First Phase: The Technical Study Sequence

This phase involves evaluating the risks within the perimeter defined by the prefect. It includes characterizing technological hazards (probability, dynamics, intensity of phenomena) based on risk studies, as well as determining the territorial stakes. This leads to a visualization of risk exposure (thermal, toxic, etc.) and the identification of additional studies to be conducted.

A - Characterization of Technological Hazards

This task is carried out by the inspection teams for classified installations, based on hazard studies submitted by the operators of industrial sites (Environmental Code, Article L.515-8). It leads to the creation of three distinct hazard maps, each corresponding to a type of effect: toxic, thermal, and overpressure. For rapid or slow-onset hazardous phenomena, each section of the territory is assigned a hazard classification among the seven established regulatory categories, which include:

TF+ (Very High +), TF (Very High), F+ (High +), F (High), M+ (Medium +), M (Medium), and Fai (Low) (Decree No. 2005-1130 of September 7, 2005, related to Technological Risk Prevention Plans).

Method for Characterizing Technological Hazards

It includes the following steps:

- **Step 0:** Setup for the study (hazardous phenomena derived from hazard studies)
- **Step 1:** Selection of hazardous phenomena “Probability filter”
- **Step 2:** Study of technological hazards.
- **Step 2a:** Assignment of hazard levels (high-speed hazardous phenomena)
- **Step 2b:** Envelope curve of irreversible effects (low-speed hazardous phenomena)
- **Step 3:** Mapping of technological hazards.

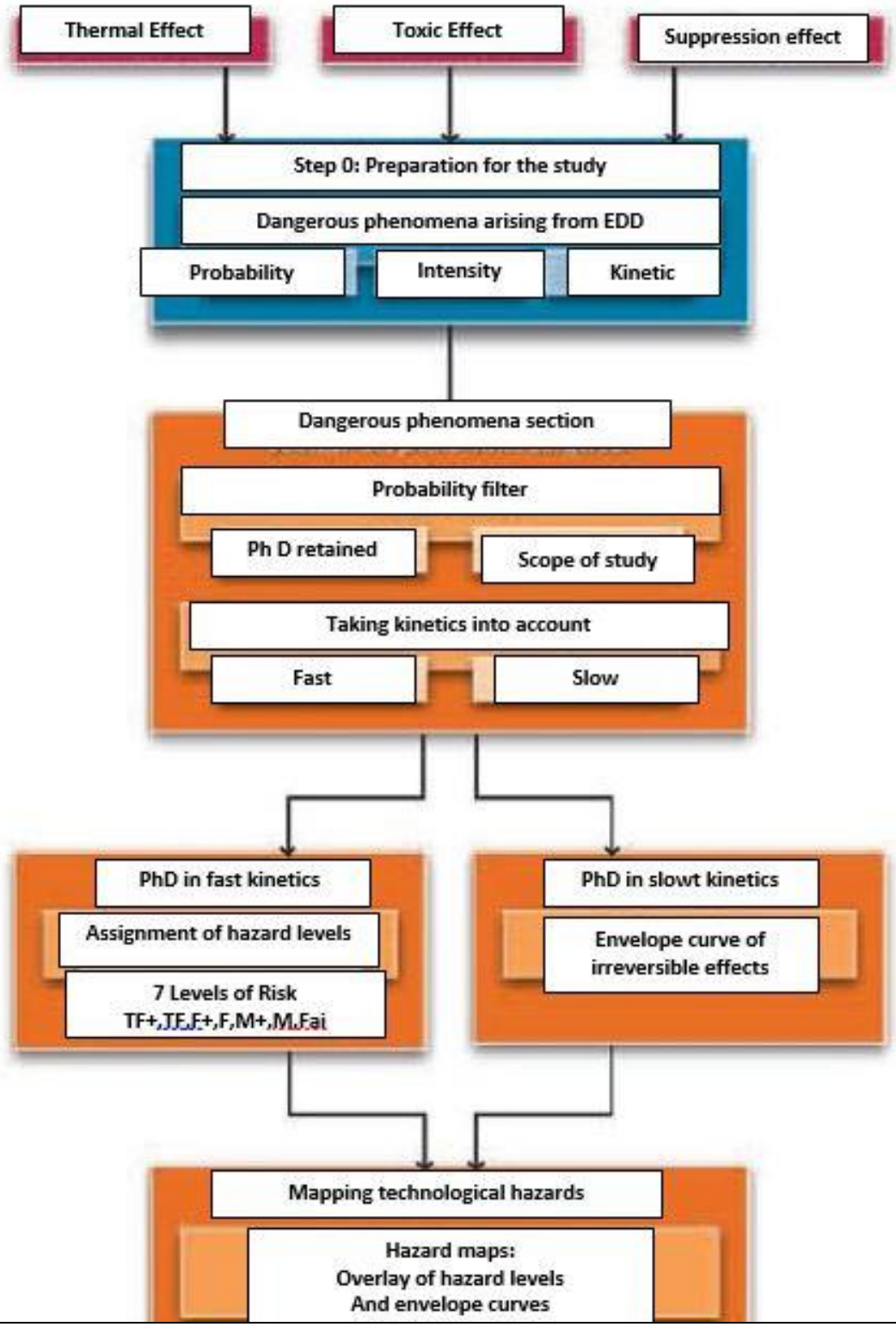

Figure 26: Approach to characterizing technological hazards.

Source : Methodical guide; PPRT

B - Stake Analysis

This step enables the identification of the components of the territory that may be subject to regulation, such as populations, constructions, land use, and developments (reference: Environmental Code, Article L. 515-9). Its objective is to assess the potential risks affecting these elements and to determine appropriate protective measures.

• **The mapping of stakes** notably includes a **synthesis map** illustrating the main elements to be preserved in the territory, such as existing urbanization, public-access facilities, transport infrastructure, uses of open public spaces, as well as structures and equipment of general interest (in accordance with Decree No. 2005-1130 of September 7, 2005, related to Technological Risk Prevention Plans). Depending on the needs, additional maps may be produced to detail specific stakes related to land use or the functioning of the territory.

C - The Superposition of Hazard Maps and Stake Maps ("Raw Zoning Plan")

Offers the possibility to observe the exposure of populations to technological hazards (Decree No. 2005-1130 of September 7, 2005, concerning Technological Risk Prevention Plans). This study provides an accurate illustration of technological risk over the territory and serves as an essential technical foundation for the creation of the PPRT. It enables, among other things, to:

- generate an initial zoning map, also called **raw zoning**,
- determine the additional studies required for a comprehensive risk assessment.

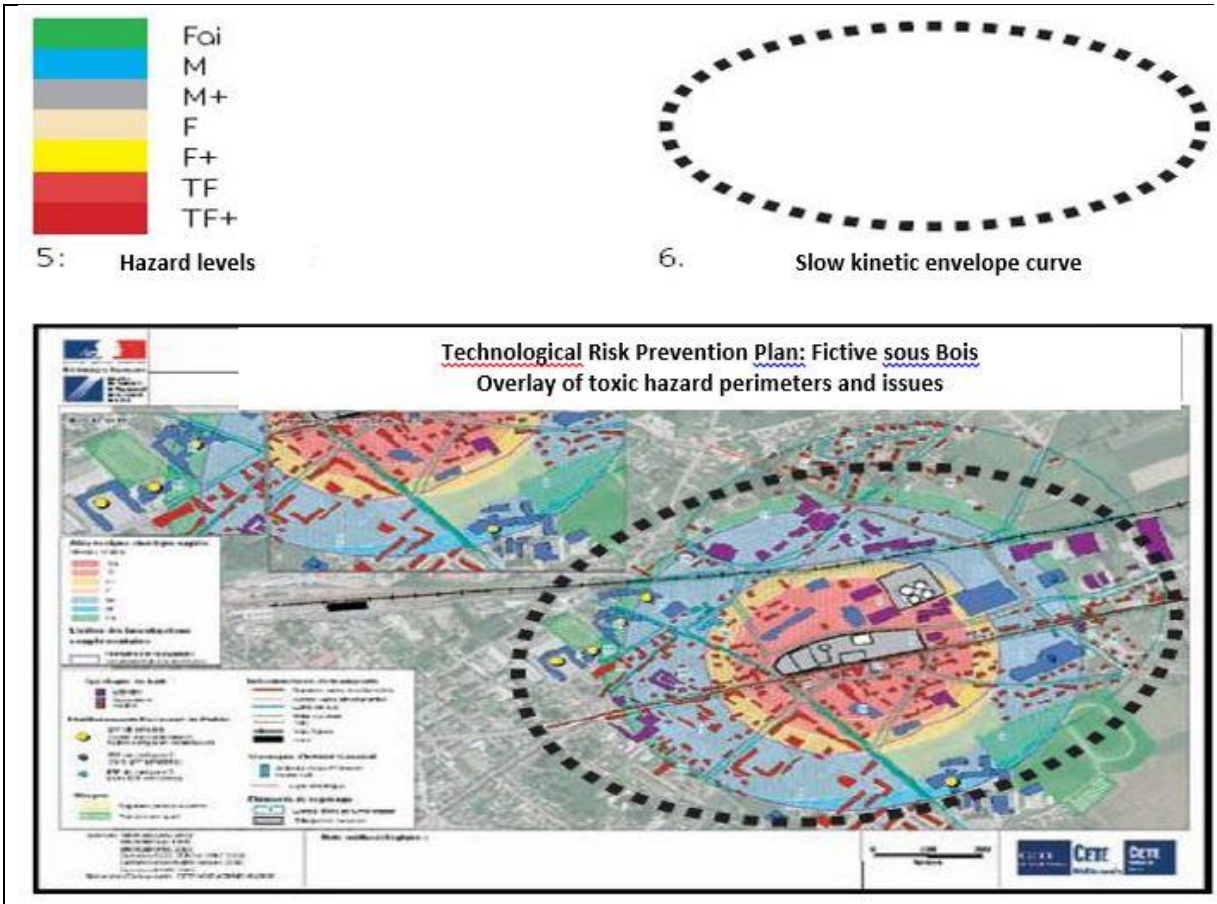

Figure 27: Overlay of hazards and challenges.
Source: Methodical guide; PPRT

The development of the Technological Risk Prevention Plan (PPRT) begins with the creation of a raw zoning plan. This results from the superposition of technological hazard maps and territorial stake maps, with the aim of defining areas likely to be exposed to industrial risks. This plan identifies the zones to be preserved or controlled according to the levels of hazards, without yet incorporating specific risk management actions, such as expropriation or easements. The raw zoning plan provides a reference for refining the risk management strategy and land-use planning. By connecting this map with the local context, questions may arise, requiring answers and reference points to guide thinking.

This process contributes to the regulation and management of urbanization based on the identified risks (Decree No. 2005-1130, September 7, 2005).

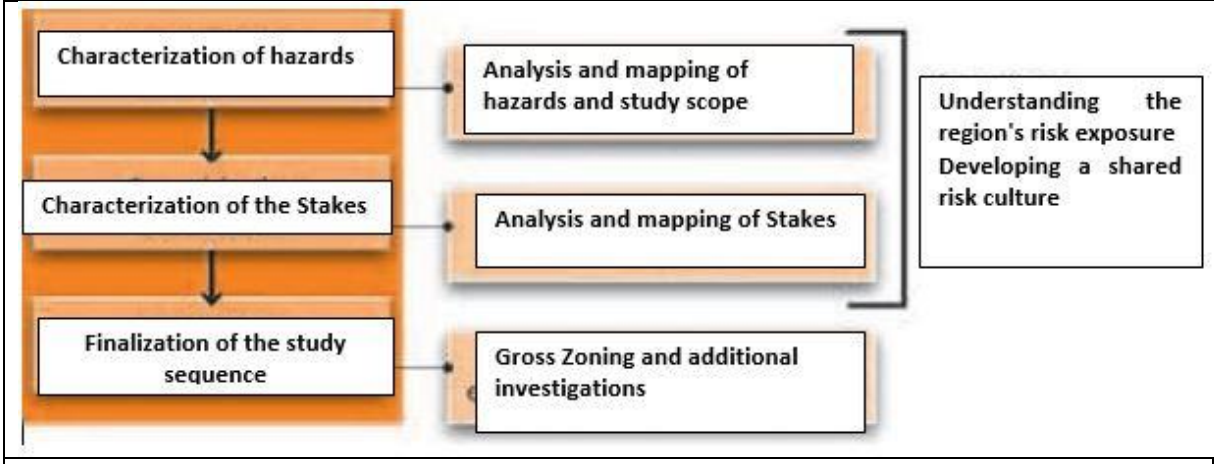

Figure 28: The development of the Technological Risk Prevention Plan (PPRT)
Source: Methodical guide; PPRT

– The technical study phase of the Technological Risk Prevention Plan (PPRT) constitutes a key process for the dissemination and analysis of knowledge related to technological risk, while integrating the social and economic dimensions of the concerned territory. The collaboration of local stakeholders, including industrial operators and local authorities, is crucial for the formulation of appropriate solutions. This phase, led by the prefect, aims to present the relevant technical data, the applicable regulatory principles, and the essential measures of the PPRT, such as urbanization restrictions or expropriation in high-risk zones. It thus allows for the definition of necessary strategic choices, according to the specific characteristics of the territory and the identified levels of risk (Decree No. 2005-1130, September 7, 2005).

2.5.2. The second phase: the development of the PPRT project

This involves the drafting of the plan documents and the finalization of the administrative procedure in preparation for its approval. This process is supervised by a strategic phase, during which the principles of the PPRT are established. The objective of the strategy is to explain the risk control measures and to select from the available options in order to ensure the protection of the territory and its inhabitants.

The PPRT strategy represents a key stage in the development of the plan, based on data from the technical study. It involves the superposition of hazard and stake maps, complemented by analyses of vulnerability and the cost of land-related actions. This offers the involved parties a better understanding of technological risks and facilitates the definition of the plan's guidelines. The objective is to determine, through consultation, the zoning principles and the solutions for

controlling urban development. The choices made will guide the drafting of the final PPRT project (Decree No. 2005-1130, September 7, 2005).

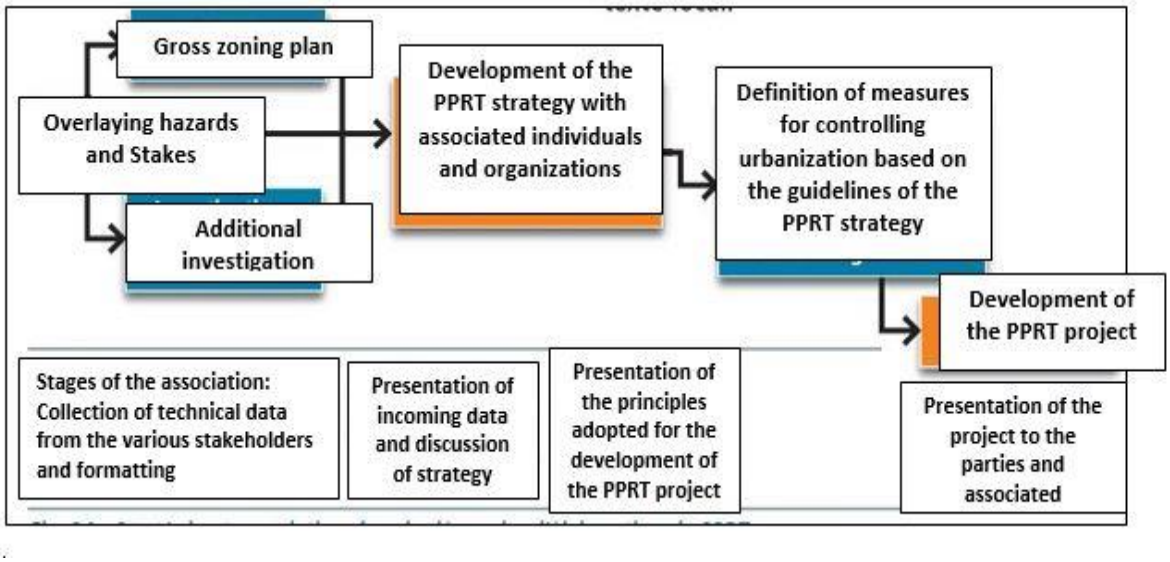

Figure 29: Strategy and association in the process of developing the PPRT.
Source: Methodical guide; PPRT

2.6.The tools of the PPRT

The PPRT aims to regulate technological risk on the territory by targeting three major objectives:

- Not to intensify the risk.
- To decrease the present risk.
- To eliminate the risk if this is possible.

Regulations are established inside zones presenting a risk:

- Surveillance of new constructions.
- Limits are imposed on extensions and modifications, according to the levels of risk.

The following objectives are pursued by the adopted measures:

- To acquire control over urbanization around the risk sites.
- To reduce the exposure of populations.
- To ensure the protection of vulnerable individuals.
- Sensitive projects, such as emergency facilities, are subject to particular limitations.

The measures are progressive:

- Adaptation of measures according to the degree of hazard.
- Reduction of the territory's vulnerability to industrial risks.

3. Provisions and prescriptions on future and existing buildings

3.1.Provisions on urban planning and future buildings

3.1.1. Definition

Measures relating to urban planning and future construction provided by the Technological Risk Prevention Plan (PPRT) aim to regulate urbanization and building in areas exposed to significant technological risks. These measures seek to protect inhabitants by restricting construction in these regions or by imposing strict safety criteria for recent constructions (Ministry of Ecological and Inclusive Transition, 2019).

3.1.2. Prescriptions and arrangements

- Construction in risk zones is prohibited or restricted according to the nature and degree of hazards (Decree No. 2005-1130, September 7, 2005).
- Strict rules apply to new constructions or the extension of existing buildings in these zones to ensure residents' safety (Ministry of Ecological and Inclusive Transition, 2019).
- Increased safety actions for buildings located in risk zones (robust materials, fire-resistant standards, etc.) (PPRT, 2005).
- Decree No. 2005-1130 of September 7, 2005 prohibits sensitive activities such as schools, hospitals, or retirement homes in zones presenting high risk.
- Avoid concentration of populations in risk zones by avoiding recreational or commercial structures that could attract crowds (Ministry of Ecological and Inclusive Transition, 2019).
- Development of buildings following particular standards intended to ensure occupants' safety in case of industrial accidents (PPRT, 2005).
- Control of urban expansion to prevent growth of vulnerable populations and restrict urbanization in sensitive zones (Decree No. 2005-1130, September 7, 2005).

3.2.Provisions on existing buildings (technical prescriptions on existing stock)

3.2.1. Definition

In the context of the Technological Risk Prevention Plan (PPRT), measures relating to buildings seek to adjust existing constructions and equipment facing technological risks. These provisions aim to minimize dangers in case of industrial accident by ensuring the protection of residents and reducing the vulnerability of existing infrastructures in threatened zones.

3.2.2. Prescriptions and arrangements on existing buildings

- Structural reinforcement: Existing buildings in risk zones must be reinforced to resist hazardous phenomena (fires, explosions, etc.), with adapted materials or technologies.

- Improvement of airtightness: Implementation of protections to prevent penetration of dangerous substances into buildings (especially for sensitive establishments).
- Securing technical installations: Risky installations (electricity, gas, ventilation systems) must comply with standards to avoid becoming sources of danger in case of incident.
- Compliance with fire safety standards: Implementation of devices aiming to limit fire risks and facilitate occupant evacuation in emergencies.
- Protection of sensitive zones: Buildings housing vulnerable populations (schools, hospitals) must be equipped with reinforced protection devices (shelters, alert systems, etc.).
- Review of building uses: Certain uses of existing buildings (e.g., industrial activities) may be modified or prohibited to reduce associated risks.
- Safety plans: Development of specific plans for buildings in risk zones, including emergency protocols and adapted evacuation systems.
- Maintenance regulations: Obligation to maintain buildings and equipment to preserve their safety against identified risks (regular maintenance of critical infrastructures).

A. Toxic effect: principle of confinement

Confinement is a technical method aiming to protect individuals located in a dwelling, a public-access establishment (ERP), a factory, or any other building by placing them in a space with low permeability to outside air for a determined duration. The objective is to reduce the quantities of contaminants to which individuals are exposed, while waiting for the dissipation of the harmful cloud or their evacuation by emergency teams.

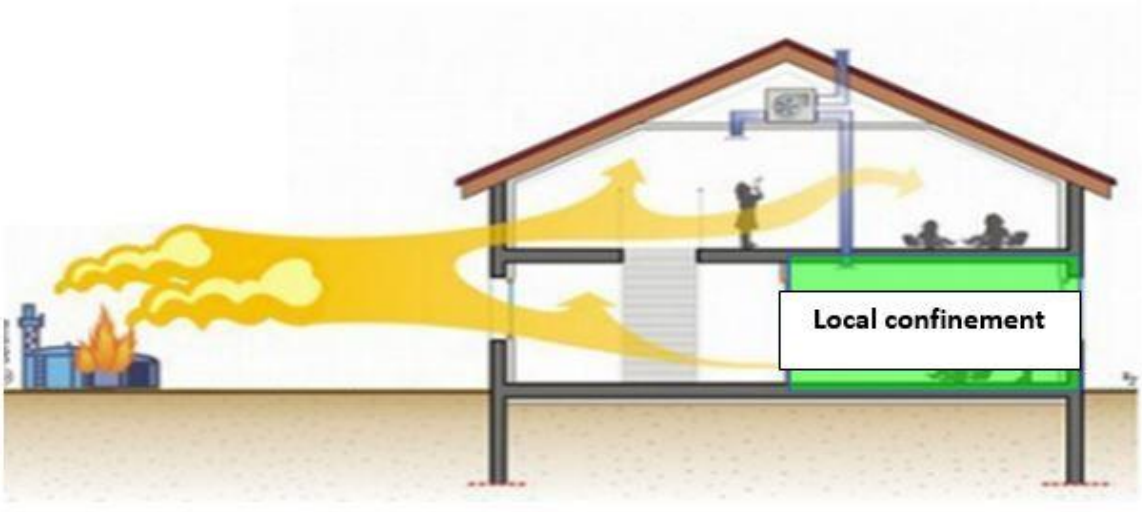

Figure 30: Principle of confinement Solution.
Source: Methodical guide; PPRT

The concept of confinement implies:

1 - The determination of a space capable of becoming impermeable to air during a specific period.

2 - The presence or establishment of an early warning system for individuals potentially exposed to a harmful cloud;

3 - A warning mechanism intended for the affected population;

4 - An evacuation procedure within a timeframe compatible with guaranteed temporary protection.

It is imperative to ensure the entirety of these measures.

It is necessary to establish the criteria for arranging the confinement space based on clear principles. For example, this involves guaranteeing the impermeability of glazing and planning the sealing of openings.

For establishments with increased sensitivity (ERP), a technical analysis can establish the conditions for implementation and control to guarantee that the indoor concentration does not exceed thresholds causing irreversible effects during exposure to the toxic cloud.

B. Thermal effect

It is possible to bring modifications to the building, whether existing or new, to reduce the vulnerability situation of individuals facing thermal effects by using non-combustible protective materials. One can:

- minimize the risk of fire on exposed facades by substituting or covering flammable materials with non-flammable materials;
- secure glazed joinery using shutters on windows (thick non-resinous wood or equivalent material);
- preserve metallic structures against heat.

C. Overpressure effect

In case of overpressure, damages inflicted on structures can compromise the safety of individuals. When the intensity of the overpressure risk is not excessive, it is possible to apply reinforcement measures:

- installation of laminated glazing;
- protection of windows by film;
- reinforcement of the fixings of the frames of external openings.

In case of excessive overpressures, no protection is conceivable.

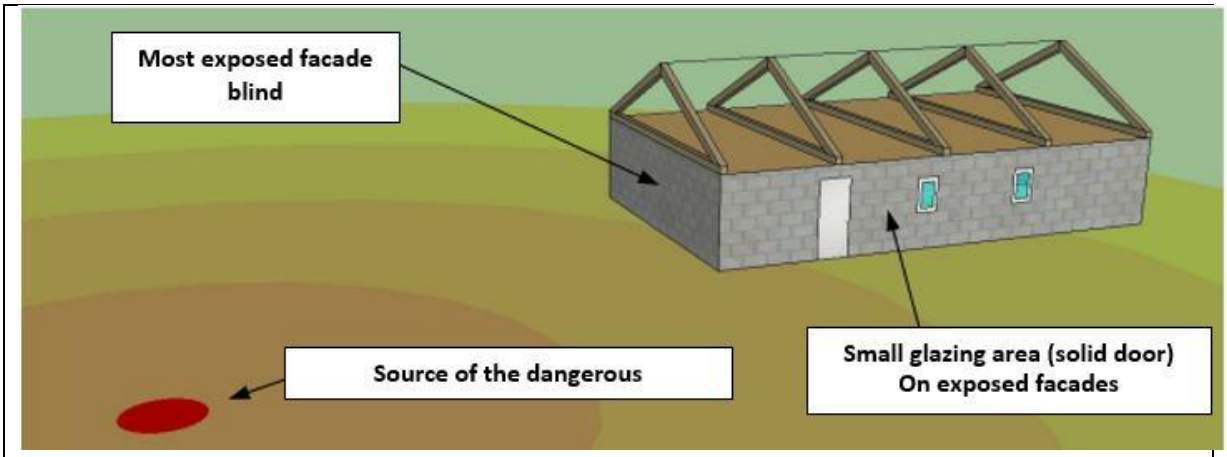

Figure 31: Overpressure effect Solution
Source: Methodical guide; PPRT

4. From Technical Hazard to Urban Regulation: The Planner's Role

Introduction

As an urban planner, your role is not to perform complex engineering calculations. Your mission is to translate the results of hazard studies (provided by engineers) into concrete land-use rules. You must transform a physical phenomenon into a Public Utility Easement that will be inscribed in urban planning documents

Here is how to translate the three main technological effects into urban planning regulations:

1. Thermal Effects (The Fire Risk)

The Urban Planning Translation: Managing Distance

Since heat decreases with distance, the planner's main tool is **zoning based on setbacks**.

- **In High-Intensity Zones:** You must apply a strict **"Non-Aedificandi" rule** (Building Ban). No construction is allowed to prevent the fire from spreading to the city (Domino Effect).
- **In Medium-Intensity Zones:** You can allow construction, but with **safety setbacks**. For example: *"Any new building must be located at least 50 meters from the site boundary."*
- **Material Prescriptions:** You may require the use of fire-resistant materials for facades facing the industrial site to slow down fire propagation.

2. Overpressure Effects (The Explosion Risk)

The Urban Planning Translation: Managing Density and Structure

Shockwaves can travel very far, so it is often impossible to ban all construction. The strategy shifts to **reducing vulnerability**.

- **Limiting Density:** The goal is to minimize the number of potential victims.

- *Rule:* Prohibit high-occupancy buildings (Shopping malls, Stadiums, High-rise towers) in the exposure zone.

- **Constructive Rules:** Buildings must be designed to resist the shock.
  - *Rule:* Use laminated glass (like car windshields) instead of standard glass to prevent dangerous shards.
  - *Rule:* Reinforce window frames so they do not blow inward during an explosion.

3. Toxic Effects (The Gas Leak Risk)

The Urban Planning Translation: Managing Confinement

Unlike fire or explosion, you cannot "block" a gas cloud with a wall. The safety strategy relies on **"Shelter-in-Place"** (*Confinement*).

- **Confinement Zones:** In these areas, new housing must be equipped with a "confinement room" (a room with airtight windows and independent ventilation) where residents can stay safe for a few hours.
- **Usage Restrictions:** You must prohibit **"Sensitive Institutions"** (schools, hospitals, nursing homes) in these zones.
  - *Why?* Because it is impossible to quickly evacuate sick patients or young children during a sudden gas leak.

Table 2: Overview Table: From Physical Effects to Urban Planning

Type of Risk	The Physical Effect	The Urban Planning Rule (What the student writes)
Fire (Thermal)	Heat Radiation	**Safety Distances:** "No building allowed within X meters."
Explosion (Overpressure)	Shockwave	**Density Control:** "No High-Rise buildings or Stadiums." **Building Code:** "Reinforced glass windows mandatory."
Toxic Gas (Chemical)	Gas Cloud	**Confinement:** "Mandatory shelter room in every apartment." **Usage Ban:** "No Hospitals or Schools allowed."

Source: Author, 2026

Conclusion of Chapter 04

This chapter studied the policy of management of technological risks, focusing on the PPRT, an essential instrument to prevent and minimize the consequences of industrial risks. It explained the basic principles related to industrial risks, dangerous phenomena, and technological hazards, while specifying the thermal, overpressure, and toxic effects that may result.

The examination of the attributes and processes of creation of the PPRT underlined its crucial importance in the control of risks at the source and in the structuring of urbanization around high-risk installations. The collaborative and meticulous approach is highlighted by the methodology of elaboration of the PPRT, which includes a detailed technical study and local consultations.

Finally, the provisions concerning future and existing buildings illustrate the intent to reduce the vulnerability of territories while protecting populations. In conclusion, this chapter shows that the PPRT constitutes an essential instrument to reconcile industrial development and territorial safety, thanks to a proactive and structured management of technological risks.

Reference Chapter 4

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Chapter 05: The Algerian National Policy for Disaster Risk Prevention and Reduction

Targeted Competencies

At the end of this chapter, the student will be able to:

- Identify the major risks affecting the Algerian territory;
- Understand Algeria's institutional and legal framework for risk management;
- Analyze national mechanisms for prevention, emergency response, and crisis management;
- Situate Algerian risk management policy within international frameworks (Sendai, Hyogo);
- Develop a critical analysis of the challenges and limitations of risk management in Algeria;
- Link national policies to local territorial and urban realities.

Introduction to Chapter 5

The prevention and reduction of major disaster risks represent critical challenges for nations, particularly for countries such as Algeria, where the diversity of natural and anthropogenic hazards highlights the need for proactive and integrated risk management. The course titled *"The Algerian National Policy for Disaster Risk Prevention and Reduction"* aims to examine the strategies implemented to mitigate the impacts of such phenomena, while simultaneously strengthening the resilience of territories and populations. Algeria has experienced several major disasters, some of which rank among the most destructive in its contemporary history. The Chlef earthquake (formerly El Asnam) in 1980 stands as a pivotal event, with a magnitude of 7.3 on the Richter scale, resulting in nearly 2,600 deaths, over 9,000 injuries, and widespread destruction in the region (Benouar, 1994). This tragedy exposed significant shortcomings in preparedness and seismic-resistant construction. Similarly, the Boumerdès earthquake in 2003, which caused 2,300 deaths and destroyed 200,000 housing units, reaffirmed the urgency of reinforcing regulatory and technical frameworks (Chergui et al., 2007). Furthermore, the 2001 floods in Algiers, which claimed 751 lives, revealed vulnerabilities related to urban planning and inadequate drainage systems (Belhamel et al., 2003). Beyond the human and material losses, these disasters had profound intangible consequences: psychological trauma, mass population displacement, disruption of economic and social activities, and deterioration of human–environment relations (Bensaid, 2010). These multidimensional impacts underscore the need for public policies centered on prevention, crisis management, and post-disaster resilience. This course offers a critical analysis of the Algerian national policy for disaster risk prevention and management, drawing upon statistical assessments, emblematic case studies, and relevant

theoretical frameworks. Its objective is to provide learners with the necessary tools to assess, design, and implement sustainable and context-appropriate strategies at both local and national levels, while taking into account international norms and experiences.

1. Algeria and Risks: Management is Unavoidable

Algerian cities, like many cities worldwide, have undergone rapid urban growth, particularly after independence (CNES, 2003). This urbanization has often been characterized by unregulated occupation of hazardous areas, without prior planning, thereby distorting the urban landscape and undermining the sustainable development of cities. Northern Algeria, which hosts the majority of the population, is especially exposed to natural hazards, notably earthquakes, landslides, and floods. Although various measures have been taken, the consequences of disasters continue to escalate, intensifying public concerns in urban areas. These risks highlight the imperative for effective and adapted risk governance. Risk management in Algeria is based on a national strategy aimed at preventing and reducing the impacts of these hazards, with a specific emphasis on anticipation and both qualitative and quantitative risk assessment.

1.1. The Risk Problematic in Algeria

Algeria is confronted with a wide array of risks that affect cities in various ways but often result in similar consequences in terms of economic, human, and environmental damage. Eighteen types of major risks have been identified on Algerian territory, based on a classification inspired by Article 3 of Law No. 24-04 of February 26, 2024, which concerns the rules for disaster risk prevention, intervention, and reduction within the framework of sustainable development. These risks include:

1-Seismic risks
2-Geological risks
3-Flood risks
4-Extreme climatic risks
5-Forest fire risks
6-Industrial and energy-related risks
7-Space-related risks
8-Radiological and nuclear risks
9-Risks to human health
10-Risks to animal and plant health
11-Atmospheric, marine, and water pollution risks
12-Risks associated with large human gatherings
13-Desertification risks
14-Drought risks
15-Coastal erosion and sea level rise risks
16-Cyber risks

17-Locust infestation risks
18-Biotechnological risks

The diversity and severity of these risks emphasize the need for an appropriate management framework that integrates preventive approaches, early warning systems, and resilient planning. The involvement of various stakeholders including local authorities, NGOs, and citizens is also essential to strengthening national capacity to address these challenges (UNISDR, 2015).

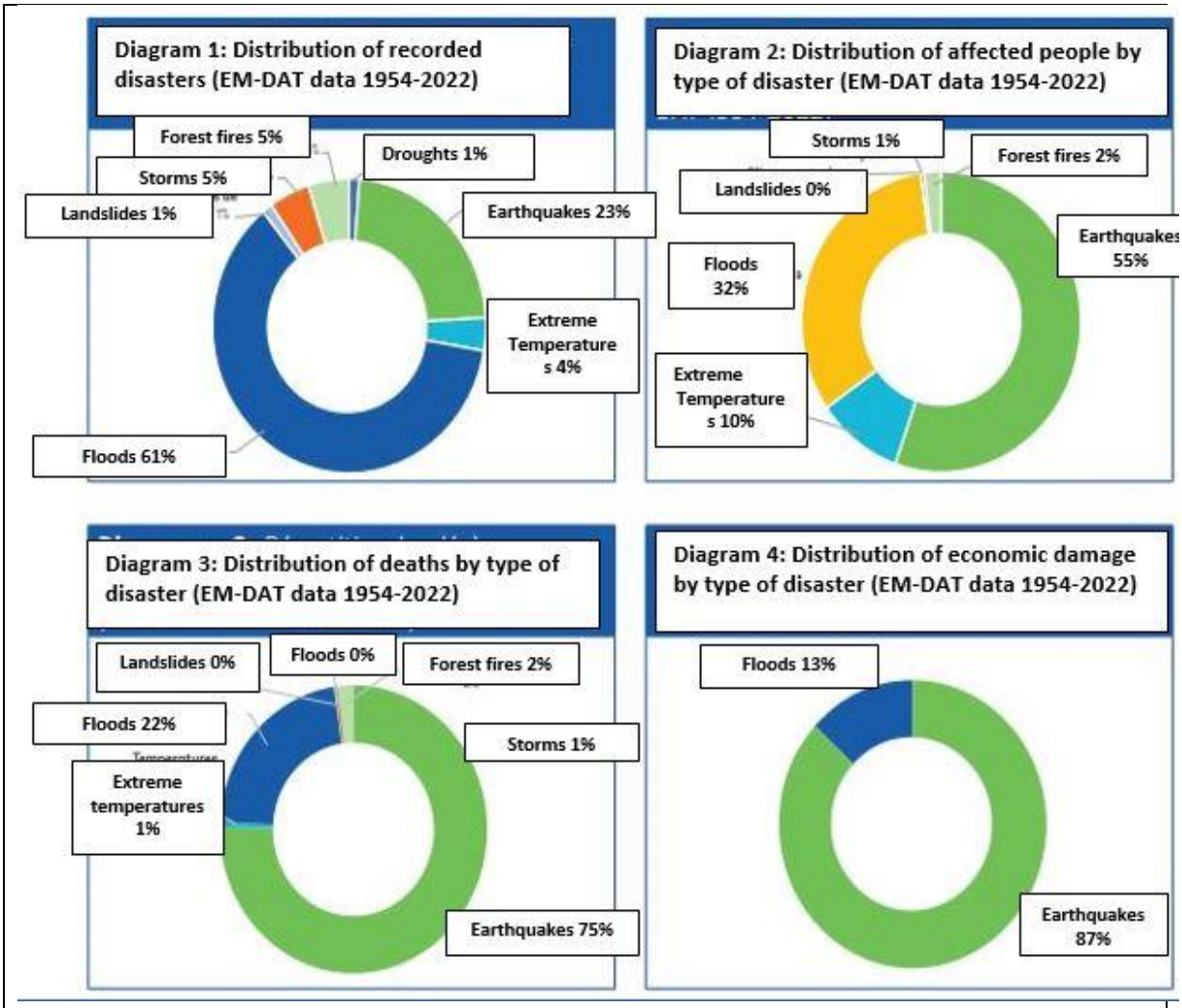

Figure 32: Annual Average of Disaster Impacts Recorded in the EM-DAT Database (1954–2022)

- Number of recorded events: 1.3
- Number of deaths: 127
- Economic losses (in million USD): 173.7
- Number of people affected: 36,867

Source:
https://documents1.worldbank.org/curated/en/099121023122035477/pdf/P16287912eaf5a01d1a1941a72376b420e5.pdf

Table 3: Disasters recorded in the EM-DAT database (1954-2022)

Type of disaster	Number of recorded events	Number of deaths	Total number of people affected	Economic losses Thousands USD
Floods	51	1870	809145	154917
Earthquakes	19	6483	1387704	10270929
Storms	4	27	10122	Not available
Extreme temperatures	3	48	250025	Not available
Forest fires	4	164	49271	Not available
Landslides	1	15	696	Not available
Droughts	1	Not available	Not available	Not available
Total	**83**	**8607**		**11814846**

Source: https://documents1.worldbank.org/curated/en/099121023122035477/pdf/P16287912eaf5a01d1a1941a72376b420e5.pdf

1.2. Major Legislative and Regulatory Frameworks

Over the years, Algeria has developed a set of legislative and regulatory frameworks to structure the management of risks and major disasters. These legal mechanisms aim to enhance the country's resilience to natural and anthropogenic hazards while ensuring a coordinated and effective response in the event of a crisis. The evolution of these legislative frameworks reflects the growing awareness of Algerian authorities regarding the need to manage disasters systematically and integrally. See Law No. 24-04 of February 26, 2024. (Official Journal, No. 16 of March 6, 2024) This law aims to establish the latest rules for disaster risk prevention, intervention, and reduction within the framework of sustainable development in Algeria.

1.2.1. PRINCIPLES AND OBJECTIVES

1.2.1.1. PRINCIPLES

The rules for disaster risk prevention, intervention, and reduction should be based on the following principles:

•The principle of precaution and prudence,

• The principle of concomitance: which, when identifying and evaluating the consequences of each hazard or vulnerability, takes into account their interactions and the exacerbation of risks due to their simultaneous occurrence,

• The principle of preventive action and correction with priority to the source: which dictates that, as much as possible, using the best techniques and at an economically acceptable cost, it is necessary to address vulnerability factors first before implementing any measures,

• The principle of participation: according to which every citizen should have the right to

access information regarding the risks and hazards they are exposed to, the vulnerability factors related to those risks, and the entire system associated with them,

• The principle of integrating new technologies.

1.2.1.2. OBJECTIVES

The rules for disaster risk prevention, intervention, and reduction aim to prevent and address the effects of these risks on human settlements, their activities, and the environment, with the objective of preserving and securing development and heritage for future generations.

The strategic objectives of disaster risk prevention, intervention, and reduction are:

• Reducing the number of deaths caused by disasters,

• Reducing the number of people affected by disasters,

• Reducing direct economic losses due to disasters,

• Reducing the disruption of basic services and the damage caused by disasters to essential infrastructure, including healthcare and educational facilities, by strengthening their resilience,

• Improving citizen access to early warning systems and information on disaster risks.

Achieving these strategic objectives relies on the following:

• Improving and updating knowledge of potential disaster risks,

• Strengthening monitoring, forecasting, and the development of preventive information on disaster risks,

• Considering risk analyses at various scales: sensitive sites, municipalities, provinces, inter-provincial, and national levels, in land use planning, construction, and the reduction of vulnerability of people and property to hazards,

• Implementing mechanisms aimed at a coherent, integrated, and adapted approach to managing the effects of any disaster risk on people, property, and the environment.

1.3. Information, Communication, and Scientific Research on Disaster Risks

The State ensures that citizens have equal and continuous access to all information related to disaster risks. This right covers:

• Knowledge of the risks, hazards, and vulnerabilities of their place of residence and activity,

• Knowledge of the prevention, intervention, and recovery systems applicable to their place of residence or activity,

• The State also provides this information to the various stakeholders,

• The State organizes an annual awareness and training program on disaster risks for local authorities, various stakeholders, and civil society,

• The State develops and implements the national communication strategy related to disaster risks,
• A curriculum on disaster risks is established in all levels of education.
The objectives of disaster risk education programs are:
• To provide general information on disaster risks,
• To instill training on the knowledge of risks, hazards, vulnerabilities, and means of prevention, intervention, and recovery,
• A national scientific research and technological development program on disaster risks is established within the relevant research bodies.
The objectives of these research programs are:
• To define and continuously develop appropriate, effective, and economically viable scientific and technological methods and tools.

1.4. Specialized Institutions and Bodies

Disaster risk prevention, intervention, and reduction, within the framework of sustainable development, constitute a comprehensive system initiated and led by the State, supported by scientific bodies, and implemented by institutions, public bodies, and local authorities within their respective competencies, in collaboration with public and private economic operators, and involving civil society.
• Under the authority of the Minister in charge of the Interior, a national delegation for disaster risks is established for the evaluation and coordination of preventive actions within the national system.
Regulatory provisions may establish institutions, structures, and committees to:
• Strengthen scientific research and technological development in the field of disaster risks by adopting an intersectoral and multidisciplinary approach,
• Ensure the promotion, coordination, and evaluation of sectoral programs related to disaster risk management.

1.5. Disaster Risk Prevention

- General rules and prescriptions applicable to all disaster risks
- Development of a general disaster risk prevention plan (Art. 20-21)
  • Each identified risk is subject to a general prevention plan adopted by decree.
  • The objective is to reduce vulnerability to hazards and prevent their effects.
  • The plan is developed based on data collected from administrations and partners,

allowing for:

o A national monitoring system to observe, analyze, and evaluate the evolution of hazards and risks.

o A structured national alert system at three levels: national, local (zone, city, village), and site-specific.

o Simulation programs to test and improve prevention measures and raise awareness among populations.

o Designation of institutions or reference laboratories for monitoring and alerting.

- **Content of the general prevention plan (Art. 22)**

  • Evaluation of the significance of risks and hazards.

  • Identification of vulnerable zones, provinces (wilayas), and municipalities.

  • Measures adapted to reduce vulnerability based on risks, including specific adjustments for human settlements and land use.

- **Servitudes and construction restrictions (Art. 23-24)**

  • Identification of areas under servitude or non-buildable due to disaster risks.

  • Strict prohibition of construction in risk-prone areas, particularly:

  o Active seismic faults.

  o Geologically hazardous terrain.

  o Safety zones around industrial areas and high-risk installations.

  o Flood-prone areas, riverbeds, and areas downstream of dams.

  o Hydrocarbon, water, or energy pipeline corridors.

- **Sectorial regulations and coordination (Art. 25)**

  • The sectors involved in the development, amendment, update, and execution of the plans are determined by regulatory provisions.

- **Specific prescriptions for each disaster risk**

1. **Seismic Risk**

   • Seismic zoning (Art. 26): Classification of areas according to exposure to guide urbanization and the relocation of buildings.

   • Integrated studies (Art. 27): Incorporation of microzoning studies into urban planning; inspection of old structures.

   • Reinforcement (Art. 28): Ministerial programs to assess and strengthen structures not meeting seismic standards.

2. **Geological Risk**

   • Geological zoning (Art. 29): Classification of areas according to hazards (landslides, cavities, swelling-shrinking, etc.).

   • Integrated studies (Art. 30): Integration of results into urban planning and development documents.

3. **Flood Risk**

   • Zoning (Art. 31): Identification of exposed areas; construction permits conditional upon flood risk reduction measures.

   • Plan content (Art. 32): Flood risk maps, mapping of stakes, reference thresholds, construction restrictions.

4. **Extreme Climate Risk**

   • Typology of hazards (Art. 33): Identification of extreme events (winds, rainfall, heat, cold, etc.).

   • Planning (Art. 34): Zoning, monitoring systems, urbanization standards, renewal of weather networks, health assessments.

5. **Forest Fires**

   • Zoning (Art. 35): Classification of forests based on risk.

   • Interfaces & construction: Definition of urban/forest interfaces and appropriate materials.

   • Infrastructure: Tracks, firebreaks, water points integrated into a GIS system.

6. **Industrial and Energy Risks**

   • Regulation (Art. 36): Rules for sites (mines, hydrocarbons, etc.).

   • Specific measures (Art. 37): Technical studies, identification of high-risk sites, control mechanisms.

7. **Space Risks**

   • Identification (Art. 38): Types of risks and affected areas.

   • Organization (Art. 39): Institutional mechanisms to reduce impacts on people and the environment.

8. **Radiological and Nuclear Risks**

   • Inventory & analysis (Art. 40): Development based on the assessment of predictable risks.

   • Prevention (Art. 41): Specific rules to anticipate incidents and accidents.

9. **Public Health Risks**

   • Identification (Art. 42): Mapping of areas vulnerable to contagious diseases.

• Health management (Art. 43): Distribution of healthcare facilities for diagnosis and prevention.

10. **Animal and Plant Health Risks**
    • Mapping & diseases (Art. 44): Identification of zoonoses, plant quarantine risks.
    • Health response (Art. 45): Healthcare facilities mobilized for prevention and control.
11. **Pollution Risks (air, sea, water)**
    • Sources & mapping (Art. 46): Identification of pollution zones and sources.
    • Protection measures (Art. 47): Targeted actions for ecosystems and exposed populations.
12. **Large Human Gatherings**
    • Adapted measures (Art. 48): Specific plans for large institutions and public places.
    • Resources (Art. 49): Definition of human and material resources necessary for security.
13. **Desertification Risks**
    • Mapping (Art. 50): National map of sensitive areas, classified by vulnerability level.
    • Prevention (Art. 51): Prescriptions to slow down desertification.
14. **Drought Risks**
    • Resilience (Art. 52): Measures to ensure food, water, and health security.
    • Monitoring (Art. 53): Indicators for meteorological, agricultural, and hydrological droughts.
15. **Coastal Erosion and Sea Level Rise**
    • Assessment (Art. 54): Coastal retreat, marine intrusion, vulnerability mapping.
    • Land use: Urban management tailored to limit exposure.
16. **Cyber Risks**
    • Typology & targets (Art. 55): Definition of threats and exposed institutions.
    • Prevention: Security protocols, awareness programs, incident response plans.
17. **Locust Risks**
    • Mapping & monitoring (Art. 56): Risk zones, alert mechanisms, sectorial coordination.
18. **Biotechnological Risks**
    • Control of GMOs (Art. 57-58): Border monitoring, precautions in confined environments, institutional reinforcement.
    • Risk studies: Mandatory before any use or transfer.

1.6. Intervention

Articles 65 to 72 concern the organization of intervention in the event of a disaster, specifically through the emergency response organization plans (ORSEC) and specific intervention plans.

- **ORSEC Plans:** These plans are organized based on the scale of the disaster and the resources to be mobilized, with hierarchical levels ranging from the national plan to the municipal and sensitive site plans. They may be combined during large-scale disasters (Article 66).
- **Content of ORSEC Plans:** Each ORSEC plan includes several parameters linked to specific aspects of a disaster. Parameters are activated based on the nature of the event, including material and human resources for each intervention area (Article 67).

(Continue with the same structure for other aspects of intervention.)

1.7. Strengthening Resilience to Disasters in Algeria: Policy Evolution and Institutional Challenges

Algeria, facing major natural risks such as earthquakes, floods, droughts, and wildfires, has recognized the need to strengthen its resilience to these disasters. Over 90% of the population lives along the coasts, which increases their vulnerability due to high population density, migration, poverty, and social crises. Algeria's commitment to disaster management intensified after the 1980 El Asnam earthquake, which resulted in thousands of victims and highlighted the gaps in risk management. Following this event, the country established a seismic construction code, a disaster risk reduction plan, and strengthened its seismic monitoring capabilities. Subsequent disasters, such as the 2003 Boumerdès earthquake, the floods of 2001 and 2008, and wildfires, led to improvements in risk management. In 2004, Algeria adopted a law on the prevention of major risks and disaster management, along with a National Spatial Planning Scheme to integrate these issues into urban planning. Since 2005, cooperation with the United Nations Development Programme (UNDP) has supported the strengthening of local disaster risk management capacities. In 2012, the National Delegation for Major Risks (DNRM) was established to coordinate intersectoral efforts in risk management. Despite these advancements, institutional and social challenges remain, particularly due to the lack of consolidated national coordination.

Conclusion of Chapter 5

Algeria's national policy for the prevention and reduction of major disaster risks demonstrates a clear commitment to systematically and proactively address the multiple natural and anthropogenic hazards affecting the territory. Through the adoption of Law No. 24-04 of February 26, 2024, Algeria has established an ambitious legislative and regulatory framework that incorporates the principles of precaution, citizen participation, integration of innovative technologies, and adapted territorial planning. This framework aims to coordinate efforts for prevention, intervention, and recovery within a shared governance structure involving the State, local authorities, scientific institutions, economic operators, and civil society. The risk typology approach, supported by specific prescriptions for each type of disaster, enables better assessment of vulnerabilities, strengthens the resilience of human settlements, and adapts responses according to territorial realities. Finally, the emphasis on communication, education, and scientific research serves as a key lever for developing a national risk culture. Thus, this chapter lays the groundwork for an integrated, sustainable, and resilient strategy, in alignment with international standards and the goals of sustainable development.

References Chapter 05

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Chapter 06: Urban Resilience in the Face of Major Risks

Targeted Competencies
At the end of this chapter, the student will be able to:

- Define the concept of resilience as applied to cities and territories;
- Distinguish between the notions of adaptation, mitigation, and resilience;
- Analyze strategies for strengthening urban resilience;
- Identify the structural, social, economic, and institutional levers of resilience;
- Propose resilience-building actions adapted to urban contexts, particularly in Algeria;
- Integrate the concept of resilience into urban planning and development projects.

Introduction of Chapter 6

Major risks, whether natural (earthquakes, floods, hurricanes) or anthropogenic (industrial accidents, economic crises, conflicts), constitute significant threats to territories and populations. In response to these challenges, the concept of *resilience* has become central to disaster risk management and sustainable planning strategies. Resilience refers to the ability of systems, communities, and infrastructures to anticipate, absorb, adapt to, and recover from shocks, while minimizing long-term negative impacts (Cutter et al., 2008).
The study of resilience in relation to major risks takes place in a context marked by the increasing frequency and complexity of disasters, largely due to climate change and rapid urbanization (IPCC, 2014). Effective risk management can no longer rely solely on prevention and immediate response; it must incorporate adaptive and transformative approaches aimed at enhancing the robustness of territories and populations (Folke, 2006).

1. Definition of Resilience in the Context of Major Risks

Resilience, in the context of major risks, is based on a systemic approach that considers the interdependencies between environmental, social, economic, and institutional dimensions. It involves:

- **Risk anticipation**: Development of monitoring tools and early warning systems.
- **Shock absorption capacity**: Infrastructure resistance, economic diversification, and social cohesion.
- **Adaptation and learning**: Strategic adjustments based on experiences from past disasters.
- **Transformation**: Structural changes to reduce long-term vulnerability (Vale & Campanella, 2005).

2. Distinction Between Adaptation, Mitigation, and Resilience

Although often conflated, these three concepts have distinct meanings:

- **Adaptation** refers to adjustments made in response to new climatic conditions or emerging risks (Smit & Wandel, 2006).
- **Mitigation** aims to address the root causes of risks, particularly by reducing greenhouse gas emissions to curb climate change (IPCC, 2014).
- **Resilience** encompasses both adaptation and mitigation, but places greater emphasis on the capacity to absorb disturbances, make adjustments, and evolve in order to strengthen the overall robustness of a system.

3. Issues and Importance of Resilience in Disaster Management

The stakes related to resilience are manifold and operate at various levels of intervention:

- **Human and social dimension**: Protecting vulnerable populations, reducing inequalities, and strengthening community solidarity (Wisner et al., 2004).
- **Economic dimension**: Minimizing financial losses, ensuring continuity of activities, and promoting sustainable reconstruction (Adger, 2006).
- **Environmental dimension**: Preserving ecosystems, promoting nature-based solutions, and reducing disaster impacts on biodiversity (McPhearson et al., 2016).
- **Institutional and political dimension**: Strengthening regulatory frameworks, improving coordination among stakeholders, and developing integrated public policies (UNDRR, 2015).

4. Conceptual and Theoretical Frameworks

The analysis of resilience to major risks draws on several theoretical approaches:

- **The systemic approach** views cities and territories as complex systems where the interactions among infrastructures, populations, and the environment shape resilience (Gunderson & Holling, 2002).
- **Vulnerability theory** highlights the social, economic, and environmental factors that determine exposure to risks (Wisner et al., 2004).
- **The resilience paradigm** incorporates the notions of persistence, adaptation, and transformation, emphasizing the need for a dynamic and evolutionary approach (Folke, 2006).

5. Resilience Strategies in the Face of Major Risks

5.1.Structural and Infrastructural Resilience

Structural and infrastructural resilience refers to the ability of buildings and infrastructure to withstand disasters and reduce their impacts. It encompasses several approaches:

- **Design of resilient buildings and infrastructure**: The integration of earthquake-resistant materials, urban drainage systems to manage flooding, and architectural designs that promote adaptability is essential (Vale & Campanella, 2005). The "Build Back Better" approach encourages reconstruction with improved standards following a disaster (UNDRR, 2015).
- **Building codes and risk-sensitive urban planning**: Urban planning must take risk-prone areas into account by regulating land use and limiting density in exposed zones. Policies such as restrictions on construction in flood-prone areas and the development of Natural Hazard Risk Prevention Plans (PPRN) are key tools (Burby, 1998).
- **Resilience engineering and nature-based solutions**: Integrating nature into urban planning through green infrastructure such as parks and restored wetlands—enhances the absorption of environmental shocks (McPhearson et al., 2016). Resilience engineering also includes early warning systems and adaptive infrastructures (e.g., elevated bridges, modular buildings).

5.2.Social and Institutional Resilience

Social and institutional resilience is based on the engagement of public and private actors and the awareness of populations:

- **Governance and public policies for risk management**: Effective governance relies on clear regulatory frameworks, long-term planning, and coordination across administrative levels (local, national, international) (Godschalk, 2003). The adoption of comprehensive strategies such as the Sendai Framework for Disaster Risk Reduction is essential (UNDRR, 2015).
- **Role of local, national, and international institutions**: Local authorities play a key role in implementing adaptation policies, in collaboration with national governments and international organizations (World Bank, 2019). Cooperation among institutional actors facilitates resource sharing and harmonization of intervention strategies.
- **Education, training, and public awareness**: A well-informed and trained population is better equipped to respond effectively to disasters (Cutter et al., 2008). Awareness raising involves communication campaigns, simulation exercises, and the integration of resilience into school curricula.

5.3.Economic Resilience and Adaptation of Productive Systems

A territory's ability to recover from a disaster also depends on its economic resilience and the adaptability of its productive systems:

- **Insurance and financial mechanisms for reconstruction**: The development of insurance for natural disasters, compensation funds, and reconstruction aid mechanisms supports the rapid recovery of economic activities (Hallegatte et al., 2017). Parametric insurance, which automatically triggers payouts based on predefined thresholds, is particularly effective.
- **Adaptation strategies for businesses and key sectors**: Businesses must anticipate risks by diversifying supply chains, enhancing cybersecurity, and adopting business continuity plans (Tierney, 2012). Industry and agriculture should integrate more sustainable practices to reduce vulnerability to climatic shocks.
- **Economic diversification and reduction of dependencies**: A diversified economy is more resilient to external shocks. Promoting innovation, the development of SMEs, and the circular economy helps reduce sectoral dependencies and ensures greater stability during crises (Adger, 2006).

Figure 33: Resilience Strategies in the Face of Major Risks

Source: Author,2026

6. Resilient City and Adaptive Urbanism

6.1.Definitions and Concepts of the Resilient City

A resilient city is one that can anticipate, absorb, and recover from shocks while maintaining its essential functions (Meerow et al., 2016). It is founded on several core principles:

- **Core principles of a resilient city**: Flexibility, redundancy in infrastructure, diversity of urban functions, and the adaptive capacity of institutions (Godschalk, 2003). Urban resilience aims to reduce the structural, economic, and social vulnerabilities of territories exposed to risks.
- **Integration of climate and environmental challenges**: Resilient urbanism must address climate change adaptation through the incorporation of nature-based solutions (McPhearson et al., 2016). Managing natural resources, preserving biodiversity, and mitigating urban heat islands are essential components.
- **Role of local authorities and citizens in urban resilience**: Local governments play a central role in implementing adaptation strategies through urban planning policies and risk management plans. Resilience also depends on citizen involvement through participatory approaches and increased risk awareness (Ahern, 2011).

6.2.Adaptive Urbanism and Land Use Management

Adaptive urbanism involves continuously revising land-use planning and territorial management strategies to anticipate and respond to major risks.

- **Urban planning in the face of major risks**: Urban planning must integrate risk assessments to guide development and avoid urbanization in high-exposure areas. The "No Regret" approach advocates for actions that benefit the city even in the absence of disaster (Burby, 1998).
- **Risk zone management and adaptation strategies**: Resilient urban planning depends on the identification and regulation of flood-prone, seismic, and other hazardous areas. The establishment of Natural Hazard Risk Prevention Plans (PPRN) and the relocation of vulnerable populations are critical measures (Pelling, 2003).
- **Zoning, densification, and natural space preservation**: Controlled densification helps limit urban sprawl and reduce pressure on ecosystems. The protection of buffer zones (e.g., mangroves, urban forests) contributes to risk mitigation and the maintenance of ecosystem services (Beatley, 2012).

6.3.Innovative Approaches for Resilient Cities

Technological and institutional innovation plays a key role in building resilient cities.

- **Smart cities and technologies for resilience**: Digital technologies, such as the Internet of Things (IoT), enhance the monitoring and anticipation of risks (Batty et al., 2012). Smart infrastructure including resilient power grids and adaptive transport systems—reduces urban vulnerability.
- **Digital tools and urban risk modeling**: Geographic Information Systems (GIS), remote sensing, and simulation models help identify high-risk areas and optimize resource management (Cutter et al., 2008). These tools support decision-making in resilient urban planning.
- **Citizen participation and adaptive governance**: Urban resilience relies on flexible and inclusive governance processes. Participatory mechanisms such as participatory budgeting and public consultations promote citizen engagement and the integration of local knowledge in risk management (Loorbach, 2010).

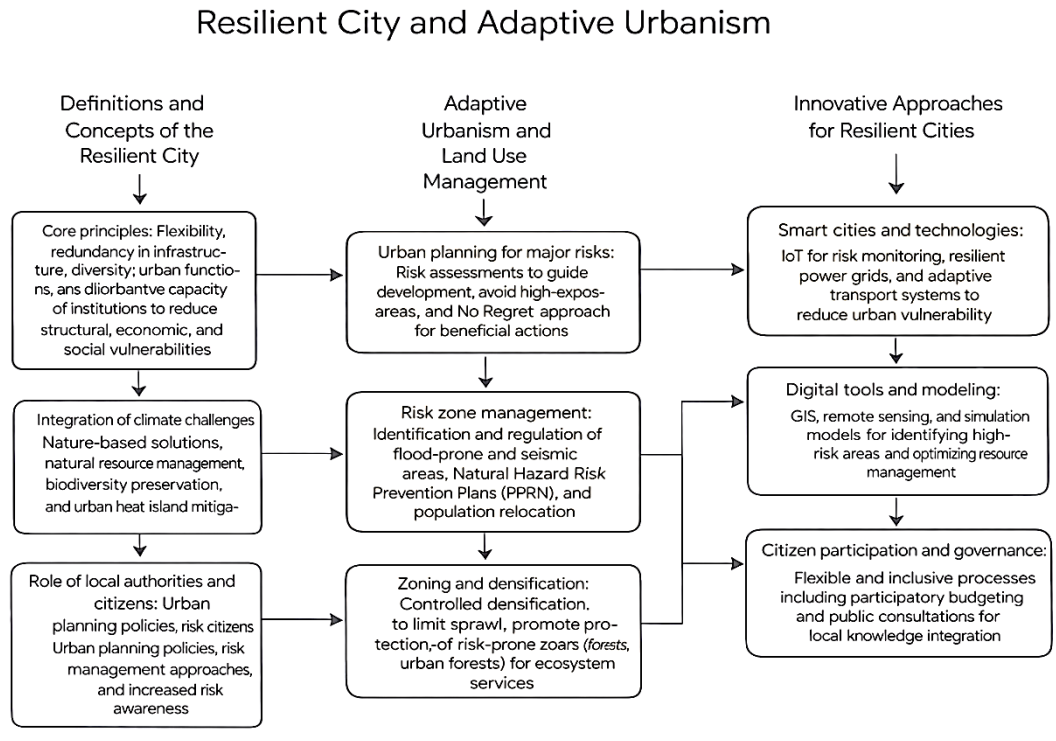

Figure 34: Resilient City and Adaptive Urbanism
Source: Author,2026

7. Urban Planning Themes for a Resilient City

7.1.Sustainable Mobility and Urban Resilience

Sustainable mobility is a key component of urban resilience, as it helps limit vulnerabilities during crises and ensures equitable access to essential resources.

- **Public transport and reduction of car dependency**: An efficient public transportation network helps reduce congestion and pollution while offering alternative means of movement in times of crisis (Banister, 2008). Infrastructures must be robust and flexible to withstand disruptions.
- **Multimodal networks and disaster-adapted infrastructure**: Integrating multiple transport modes such as trams, buses, cycling, and walking enhances resilience by diversifying mobility options (Newman & Kenworthy, 2015). Infrastructures should be designed to resist extreme events, for instance through elevated bridges or permeable roads.
- **Crisis impacts on mobility flows and adaptive solutions**: In times of disaster, managing mobility flows becomes a critical challenge. Evacuation plans, emergency mobility corridors, and adaptive transport systems enhance urban resilience (Bertolini, 2012).

7.2.Resource Management and Urban Infrastructure

Sustainable access to essential resources (water, energy) is fundamental to ensuring urban resilience.

- **Water and energy supply in crisis contexts**: Water and energy supply systems must be secured through resilient and diversified infrastructures, including renewable energy sources and storage systems (Brown et al., 2010).
- **Local resource management and circular economy**: Implementing circular economy principles reduces dependence on imports and optimizes the use of local resources (Ghisellini et al., 2016).
- **Energy sobriety strategies and infrastructure efficiency**: Enhancing energy efficiency and reducing consumption are essential to maintain resilience during crisis situations (Lovins, 2011).

7.3.Sustainable Solid Waste and Sanitation Management

Effective waste and sanitation management is crucial for limiting environmental and public health impacts.

- **Waste reduction, recycling, and recovery**: The implementation of waste sorting, reuse, and composting policies reduces waste production and fosters energy recovery (Ellen MacArthur Foundation, 2017).
- **Sanitation infrastructure planning in crisis settings**: Sanitation systems must remain functional during crises, relying on autonomous systems and decentralized treatment stations (UN-Habitat, 2020).
- **Decentralized and autonomous waste management solutions**: Localized waste treatment systems reduce dependency on centralized infrastructure and increase urban resilience (Hoornweg & Bhada-Tata, 2012).

7.4.Urban Resilience to Major Risks

Disaster prevention and management strategies are vital for minimizing the impact of urban crises.

- **Prevention and impact mitigation strategies**: Resilient urban planning incorporates preventive measures such as hazard zoning and the construction of disaster-resistant buildings (Pelling, 2011).
- **Early warning tools and emergency protocols**: Real-time data-based warning systems, mobile applications, and smart sensors facilitate rapid response to disasters (UNDRR, 2019).
- **Post-disaster reconstruction and adaptation**: Post-disaster recovery should follow the "Build Back Better" principle, incorporating improved standards and innovative approaches to reduce future vulnerabilities (Hallegatte et al., 2017).

7.5.Health, Well-Being, and Social Cohesion

Urban resilience also depends on the health and cohesion of communities.

- **Social factors and inequalities in risk exposure**: The most vulnerable populations are often the most exposed to disasters. Inclusive and equitable policies are essential to reduce disparities in risk exposure (Cutter et al., 2003).
- **Accessibility of healthcare infrastructure during crises**: The capacity of healthcare facilities to function during disasters is a major concern. Local care networks and strategic medicine stockpiles enhance health system resilience (WHO, 2020).
- **Community solidarity and social resilience**: Community mobilization, strengthening social ties, and establishing mutual aid networks are essential to coping with crises (Aldrich & Meyer, 2015).

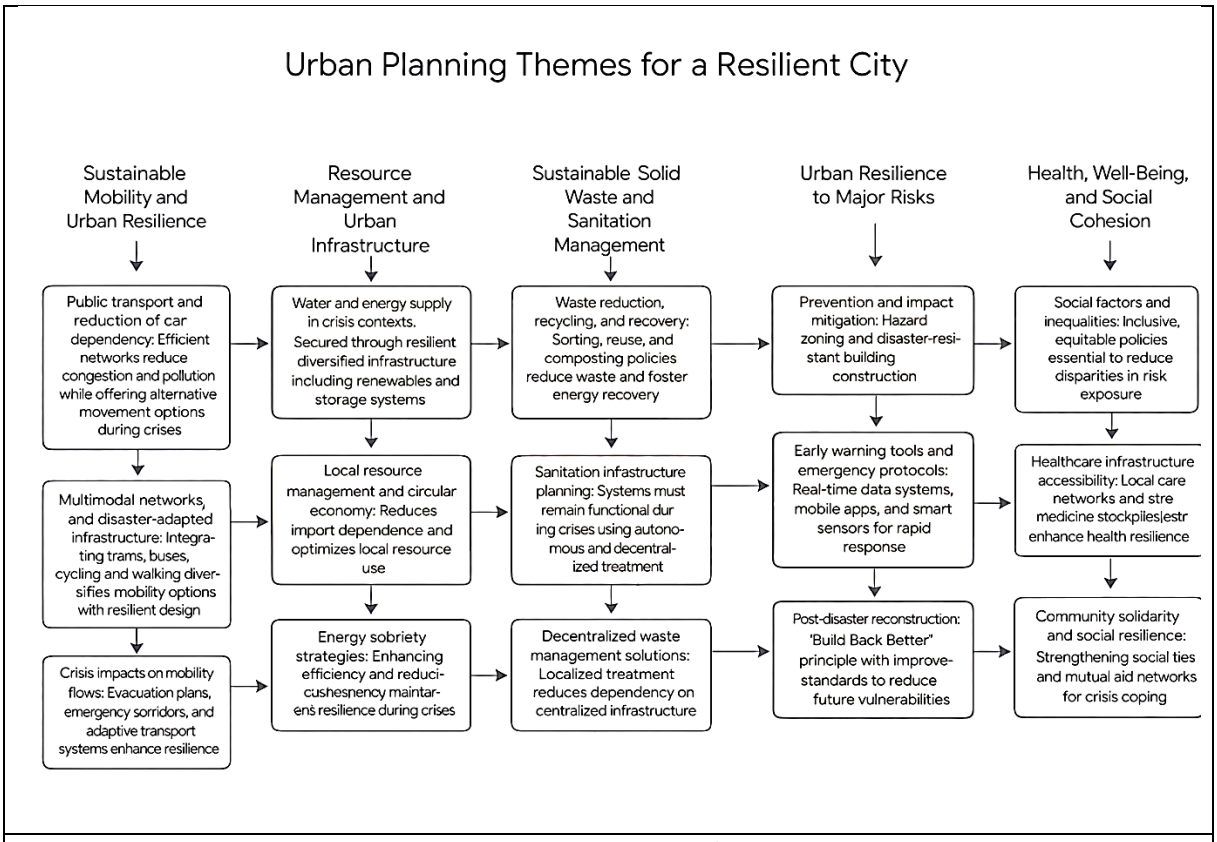

Figure 35: Urban Planning Themes for a Resilient City
Source: Author,2026

8. Tools and Methodologies to Strengthen Resilience

8.1.International Approaches and Reference Frameworks

Urban resilience policies are supported by various international frameworks that define objectives and strategies to reduce vulnerability to major risks.

- **Sendai Framework for Disaster Risk Reduction**: Adopted in 2015, this global framework promotes a proactive approach to risk management by emphasizing vulnerability reduction, institutional capacity building, and the engagement of local communities (UNDRR, 2015).
- **Sustainable Development Goals (SDGs) and resilience**: The United Nations 2030 Agenda integrates resilience into several goals, particularly SDG 11, which aims to make cities inclusive, safe, resilient, and sustainable (United Nations, 2015).
- **European and national resilience strategies**: The European Union and several countries have developed dedicated strategies incorporating climate change adaptation, the management of natural and technological hazards, and the protection of critical infrastructure (European Commission, 2020).

8.2.Emergency Plans and Early Warning Systems

The implementation of prevention and early warning systems is essential to anticipate and mitigate the impacts of disasters.

- **Monitoring systems and disaster modeling**: The use of satellite data, environmental sensors, and predictive algorithms enables continuous threat monitoring and disaster scenario modeling for improved preparedness (Gall et al., 2015).
- **Emergency planning and business continuity**: Cities must develop integrated emergency plans outlining actions to be taken during crises, with special attention to critical infrastructure and vulnerable populations (Alexander, 2013).
- **Technologies and innovations in crisis management**: Artificial intelligence, mobile alert systems, and drones are increasingly employed to enhance the speed and effectiveness of post-disaster interventions (Mehrotra et al., 2020).

8.3.Citizen Participation and Multi-Level Governance

Inclusive and participatory governance is a fundamental element in strengthening urban resilience.

- **Community engagement and participatory approaches**: Involving citizens in risk management fosters ownership of solutions and greater responsiveness during crises. Collaborative tools such as participatory mapping and co-design workshops have proven to be effective (Carmin et al., 2012).
- **Role of NGOs and private sector stakeholders**: Non-governmental organizations and businesses play a key role in risk reduction by contributing expertise, financial resources, and context-specific technological solutions (Pelling & Holloway, 2006).
- **Experiences and best practices worldwide**: Many cities across the globe have implemented innovative resilience strategies, such as Rotterdam with its green flood-control infrastructure or Tokyo with its enhanced seismic building codes (Vale & Campanella, 2005).

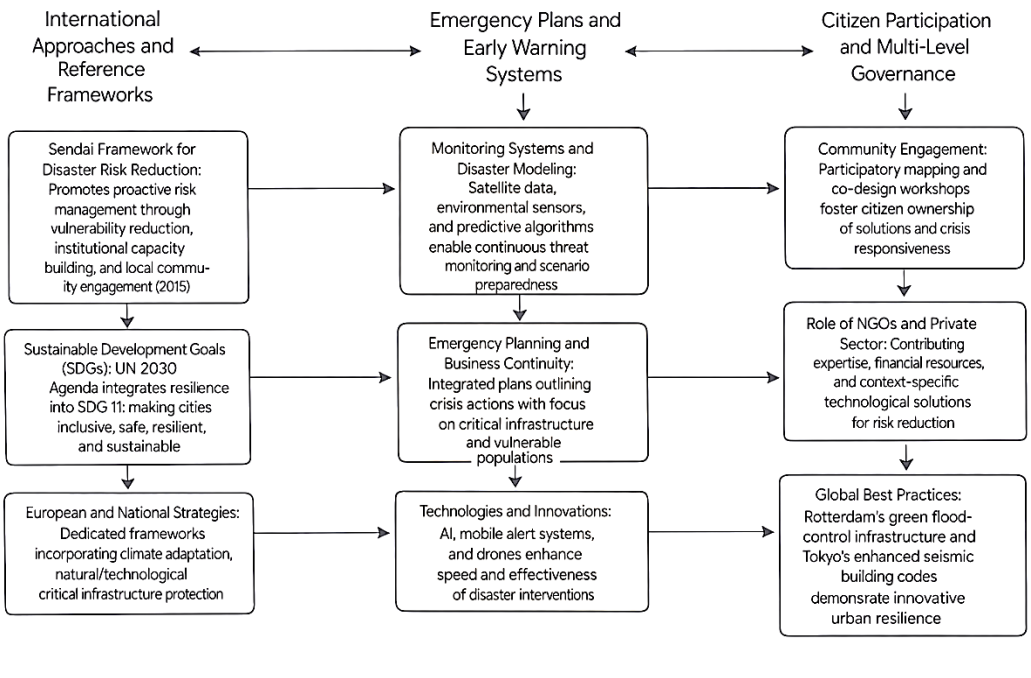

Figure 36: Tools and Methodologies to Strengthen Resilience
Source: Author,2026

9. Case Studies and Lessons Learned

9.1.Natural Disasters and Resilient Reconstruction

Natural disasters have prompted many cities to reconsider their resilience strategies and approaches to reconstruction.

- **Examples of cities rebuilt after earthquakes or tsunamis**: Cities such as Kobe (Japan) and Christchurch (New Zealand) implemented reconstruction strategies that included strengthened seismic building codes, diversified infrastructure systems, and community engagement to enhance resilience (Vale & Campanella, 2005).
- **Adaptation strategies in coastal areas facing sea level rise**: Cities like Rotterdam and New York have adopted nature-based solutions such as green infrastructure and flood barriers to reduce their vulnerability to climate change and rising sea levels (Dawson et al., 2011).

Case study:

International Benchmark: Rotterdam "Living with Water" Resilient City

Rotterdam RPP (Delta City + Major Industrial Port)

Rotterdam faces a combination of major flood risks (fluvial/coastal), extreme rainfall, and significant technological/industrial risks associated with the port

Unlike traditional approaches that seek to evacuate water as quickly as possible (pipes), Rotterdam uses the city as a sponge to manage flood risk.

Water Squares: Public plazas that serve as basketball courts in dry weather but act as retention basins during heavy rains. Green Roofs: Slow down runoff before it hits the streets.

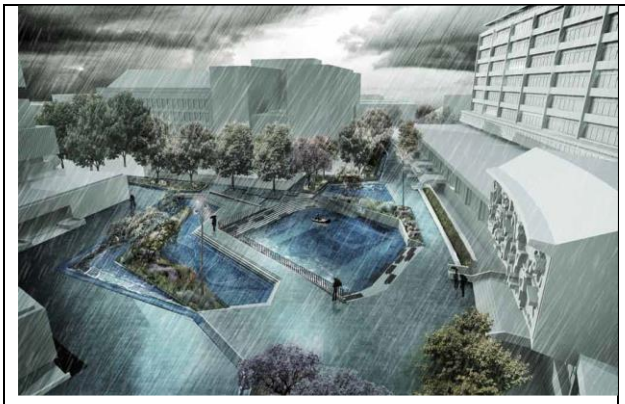

Figure 37: the Benthemplein water square as temporary water storage facility

Figure 38: The Blue Corridor creates an attractive environment for living and spending leisure time

Table 4: Strategic and operational objectives of Rotterdam project

Strategic Objective	**Operational Objectives**
1) Achieve a "Base Level" of Protection (Flood mortality ≤ 1/100,000/year by 2050)	Reinforcement of dikes/structures, management of probability and consequences (risk-based approach)
2) Urban Adaptation to Extreme Rainfall (Sponge City / Blue-Green)	Water squares, temporary storage, blue-green corridors, green roofs
3) "Multi-Shock" Urban Resilience (Social, Climatic, Economic)	Resilience programs, governance, education/communication
4) Port Continuity & Economic Activities in the Face of Floods/Submersion	Risk mapping by port sectors, protection/adaptation of terminals
5) Control of Industrial Risks (Fire/Explosion/Toxic Gas) & Transport of Dangerous Goods (DG)	Hazard zoning, intervention plans, control of DG flows
6) Territorial Crisis Management (VRR Region)	Planning, multi-service command (fire/ambulance/medical), exercises
7) Warning & Evacuation (Flood + Industrial)	Evacuation/confinement plans, signage, reception centers
8) Common Operational Picture (COP) "Delta + Port" (Real-Time Situation)	Fusion of weather/hydrology + industry + mobility data

Source: Author, 2026.

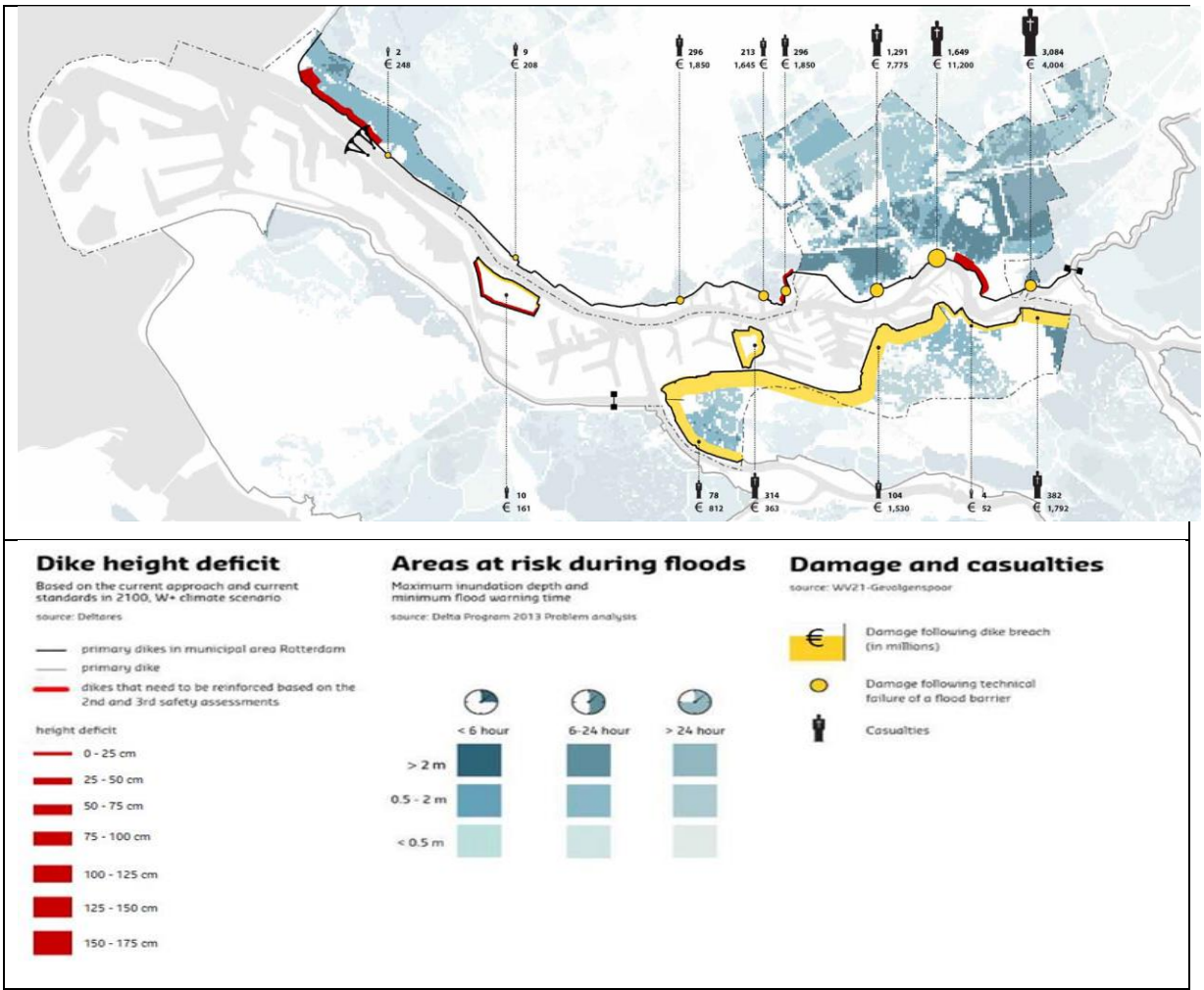

Figure 39: Inner-dike water safety risk map
Source: City of Rotterdam, 2013.

Relevance for Algeria: This "Adaptive Urbanism" approach is highly relevant for cities like Ali Mendjeli, where rapid urbanization has sealed the soil, creating flash floods. Using public spaces for temporary water storage is a cost-effective solution compared to widening underground sewage pipes.

9.2.Industrial Risks and Post-Disaster Management

Major industrial accidents have highlighted the importance of post-disaster management and the resilience of exposed territories.

- **Cases of major industrial accidents and key lessons**: The AZF factory explosion in Toulouse (2001) and the Bhopal disaster (1984) underscored the need to reinforce safety mechanisms, improve hazardous materials management, and develop effective emergency response plans (Perrow, 1999).

- **Resilience of territories exposed to technological risks**: Strategies implemented include the strengthening of environmental regulations, improvement of critical infrastructure, and public awareness and training programs to reduce risks associated with chemical and petrochemical industries (Lindell & Perry, 2004).

9.3.Pandemics and Health System Resilience

The COVID-19 pandemic exposed systemic weaknesses in public health systems and emphasized the need for enhanced health resilience.

- **Lessons from the COVID-19 pandemic**: The health crisis revealed the importance of flexible hospital infrastructure, the management of medical supply chains, and effective coordination between public and private stakeholders to ensure rapid and efficient responses (WHO, 2021).
- **Adaptation strategies for health infrastructure**: The use of digital technologies (telemedicine, artificial intelligence), decentralization of care services, and the implementation of continuity plans have improved the resilience of health systems in the face of future crises (Kruk et al., 2015).

10. The Role of Urban Planners in Risk Management and Urban Resilience to Major Hazards

Urban planners play a central role in anticipating, managing, and reducing major risks in urban environments. They intervene at various levels to enhance the resilience of cities against natural, technological, and socio-political disasters.

10.1. Spatial Planning and Land Use Management for Major Risk Prevention

Land use planning is a key tool for preventing and reducing major urban risks. It relies on strategic planning aimed at minimizing the exposure of populations and infrastructure to natural and technological hazards.

10.1.1. Regulatory Zoning and Land Use

- **Identification of risk-prone areas**: Urban planners must assess territorial vulnerabilities using tools such as risk mapping and Geographic Information Systems (GIS). These analyses help delineate flood-prone zones, seismic areas, and landslide-prone slopes (Burby et al., 2000).
- **Urbanization restrictions**: In hazard-prone areas, strict regulations must be enforced, including bans on construction in riverbeds or near fault lines. Natural Risk Prevention Plans (PPRN) are designed to regulate these restrictions.

- **Mixed land use**: To limit disaster impacts, it is advisable to incorporate resilient natural areas (e.g., forests, wetlands) that function as buffers against climate-related hazards (Füssel, 2007).

10.1.2. Densification and Preservation of Natural Areas

- **Balancing densification with open spaces**: Excessive urbanization increases vulnerability (e.g., flooding due to soil sealing). Resilient urbanism seeks to densify built-up areas while preserving green spaces and natural buffers (Dawson et al., 2011).
- **Role of natural spaces in urban resilience**: Urban parks, green roofs, and green infrastructure help absorb runoff and mitigate urban heat island effects (Meerow et al., 2016).
- **Prevention of hydrometeorological risks**: Managing coastal and riverine areas through nature-based solutions—such as mangrove restoration and natural levees—reduces storm and erosion impacts (Jabareen, 2013).

10.1.3. Planning of Critical Infrastructure

- **Securing strategic facilities**: Hospitals, fire stations, and water treatment plants must be located in safe, accessible areas even during disasters (Alexander, 2013).
- **Redundancy and diversification**: A multimodal transport network, decentralized renewable energy systems, and diversified supply chains ensure continuity of urban services during crises (Mehrotra et al., 2020).
- **Adaptive infrastructure**: Flexible designs (e.g., stilt buildings in flood zones, smart grids) improve territorial resilience to environmental shocks and stresses (Vale & Campanella, 2005).

10.2. Designing Resilient Cities for Major Hazards

Resilient urbanism aims to adapt the city to risks and enhance its capacity to absorb, adapt, and recover from disasters.

10.2.1. Adaptive Infrastructure and Nature-Based Solutions

- **Retention basins and green roofs**: These systems manage stormwater and reduce flood risks by promoting water infiltration into the soil (Cutter et al., 2008).
- **Revitalization of urban rivers**: Rehabilitating urban waterways improves flood regulation while creating biodiversity and recreational spaces (Dawson et al., 2011).
- **Multifunctional infrastructure**: Public spaces and facilities should serve multiple purposes; for instance, a park can also function as a flood retention area (Meerow et al., 2016).

10.2.2. Building Codes and Resilient Materials

- **Seismic and cyclone-resistant standards**: Implementing building techniques suited to local hazards (e.g., flexible structures in seismic areas, aerodynamic forms in cyclone zones) is vital to reduce vulnerability (Jabareen, 2013).
- **Innovative materials**: Resilient urbanism promotes the use of durable, low-impact materials such as water-permeable concrete or eco-friendly thermal insulators (Mehrotra et al., 2020).
- **Retrofitting existing buildings**: Upgrading aging infrastructure is a priority to strengthen buildings against natural and anthropogenic hazards (Vale & Campanella, 2005).

10.2.3. Development of Eco-Districts and Smart Cities

- **Eco-districts incorporating resilience principles**: Planning eco-districts helps reduce environmental impacts and improve adaptation to risks through high-efficiency buildings and smart urban networks (Jabareen, 2013).
- **Smart cities and resilience technologies**: Digital tools (sensors, open data platforms, AI) optimize urban management and improve disaster forecasting and response (Mehrotra et al., 2020).
- **Citizen participation and adaptive governance**: Involving residents in urban management (e.g., participatory budgets, neighborhood committees) enhances resilience by fostering locally appropriate solutions (Pelling & Holloway, 2006).

10.3. Stakeholder Engagement and Multi-Level Governance

Urban planners act as mediators among stakeholders to ensure effective governance.

- **Collaboration with local and national authorities**: Implementation of risk adaptation strategies as defined in urban resilience plans (IPCC, 2014).
- **Citizen participation and awareness raising**: Organizing workshops and consultations to integrate residents into risk governance and enhance their adaptive capacity (Pelling & Holloway, 2006).
- **Integration of new technologies**: Use of GIS and simulation tools to anticipate disaster impacts and develop appropriate planning responses (Gall et al., 2015).

10.4. Crisis Management and Post-Disaster Reconstruction

Urban planners are also involved in emergency management and post-disaster reconstruction:

- **Evacuation strategies and infrastructure accessibility**: Designing transport networks and public spaces to enable rapid and effective evacuation (Mehrotra et al., 2020).

- **Resilient reconstruction**: Redeveloping disaster-affected areas using resilience principles, as seen after the Kobe (Japan) and Christchurch (New Zealand) earthquakes (Vale & Campanella, 2005).
- **Adaptation to new climatic conditions**: Revising urban plans to integrate climate projections and emerging risks (Dawson et al., 2011).

Urban planners play a pivotal role in anticipating and managing major risks by developing sustainable planning strategies and integrating urban resilience into policy and design. Their mission extends beyond spatial design to include governance, technological integration, and stakeholder engagement, making cities safer and more adaptive in the face of future crises.

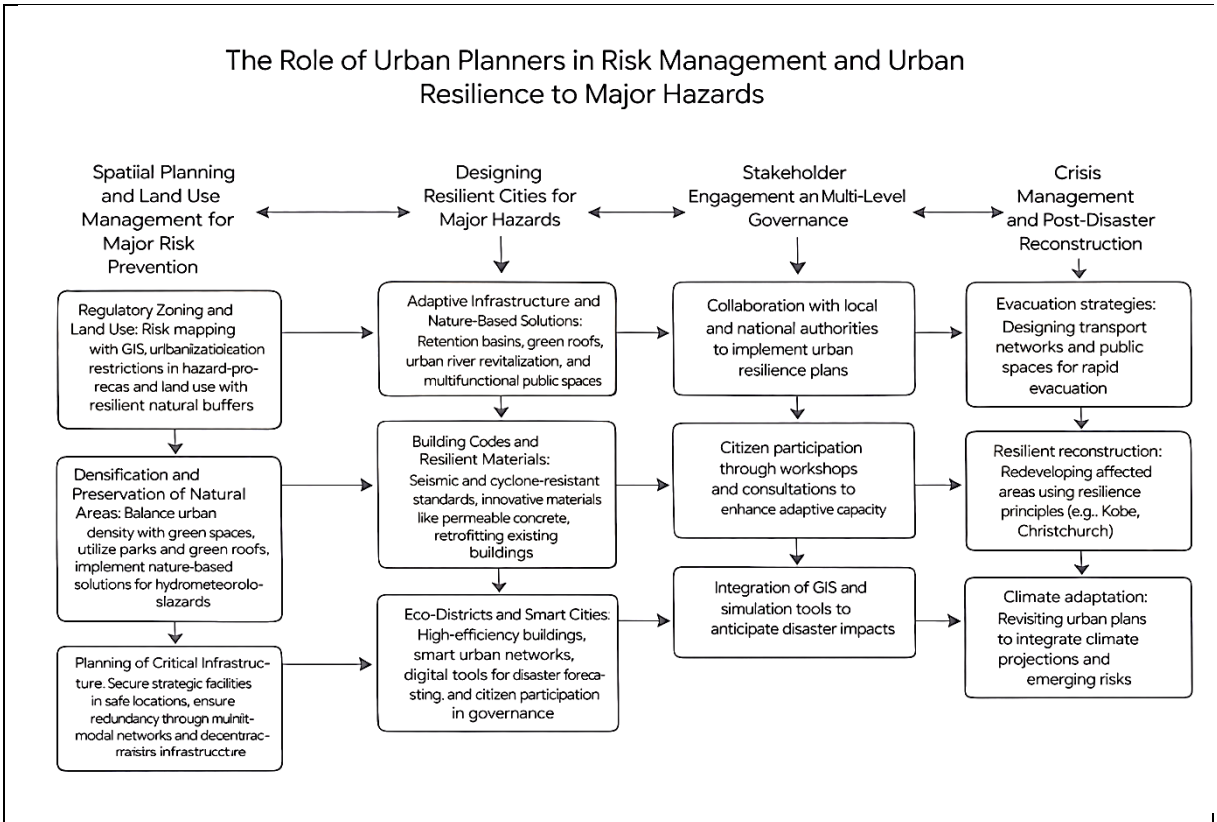

Figure 40: The Role of Urban Planners in Risk Management and Urban Resilience to Major Hazards
Source: Author,2026

Chapter 6 Conclusion

Resilience to major hazards constitutes a critical challenge for enhancing the capacity of territories and societies to anticipate, absorb, adapt to, and recover from disasters. This chapter has explored the multiple dimensions of resilience, emphasizing conceptual frameworks, risk classifications, and the vulnerability factors that determine population exposure to hazards.

Adopting a comprehensive and integrated approach is essential to strengthening resilience, combining structural and infrastructural strategies with social, economic, and institutional dimensions. Adaptive urban planning emerges as a key lever for reducing vulnerabilities

through rigorous spatial planning, effective resource management, and the integration of innovative solutions based on nature and technological advancements.

The implementation of international reference frameworks, such as the Sendai Framework for Disaster Risk Reduction and the Sustainable Development Goals, is indispensable for structuring resilience policies and improving crisis management. The analysis of concrete case studies highlights the importance of lessons learned to refine resilience strategies by drawing on experiences from natural, industrial, and health-related disasters.

Finally, the role of the urban planner is fundamental in the design and management of resilient cities, through an integrated approach to planning, land use management, and multi-level governance. The incorporation of resilience principles into urban strategies and crisis management mechanisms is imperative to ensure the safety, sustainability, and adaptability of territories in the face of contemporary challenges.

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Chapter 07: Risk Management and Urban Governance

Targeted Competencies
At the end of this chapter, the student will be able to:

- Understand the links between risk management and urban governance;
- Identify the actors involved in risk governance at different spatial scales;
- Analyze coordination mechanisms between institutions and territories;
- Assess the importance of citizen participation in risk management;
- Apply governance principles to strengthen urban resilience;
- Articulate public policies, territorial planning, and the management of major risks.

Introduction to Chapter 7

The rapid and often unplanned urbanization of recent decades has significantly increased the vulnerability of cities to a multitude of risks, whether natural, technological, or social. Indeed, urban environments concentrate population, infrastructure, and economic activities, which exposes them to major threats such as floods, earthquakes, industrial accidents, or health crises (Benouar, 2006). In this context, urban risk management emerges as a crucial issue to ensure the safety, resilience, and sustainability of cities (Renn, 2008).

However, the success of such management largely depends on urban governance, understood as the set of processes, actors, and mechanisms that enable the making and implementation of decisions in the city (Wolff, 2021). Urban governance thus encompasses coordination between public authorities, the private sector, civil society, and citizens, ensuring transparency, participation, and accountability in risk management. This close link between risk management and governance is fundamental, as only effective governance can mobilize resources, enable integrated planning, and adapt policies to the growing challenges posed by climate change and urbanization (UN-Habitat, 2024).

In this chapter, we will examine governance models at the international level and the specificities of the Algerian context. Finally, we will identify good practices and perspectives to strengthen the resilience of cities, emphasizing the key role of inclusive and proactive governance.

1. Understanding the Concepts: Risk Management and Urban Governance

1. Urban risk management refers to a set of processes and measures aimed at identifying, assessing, preventing, reducing, and managing threats that may affect the population, infrastructure, and economic activities in cities. This concept includes several interdependent phases, namely prevention, preparedness, response, and post-disaster recovery (Aitsi-Selmi et

al., 2016). Prevention consists of anticipating and reducing vulnerability factors, while preparedness aims to strengthen the capacity for rapid and effective intervention. Risk management is therefore based on a proactive approach that integrates the understanding of hazards, vulnerabilities, and local capacities (UNDRR, 2015).

2. Urban governance, for its part, corresponds to the mode of organization and decision-making in the city, involving a diversity of public, private, and associative actors, as well as citizens (Pierre, 2011). It goes beyond mere public administration to include coordination, transparency, participation, and accountability in the management of urban affairs (Healey, 2006). Urban governance relies on institutional mechanisms, policies, collaborative practices, and networks that foster the integration of actors in the definition and implementation of urban strategies.

The link between risk management and urban governance is fundamental, as the growing complexity of contemporary risks exacerbated by climate change and accelerated urbanizationrequires coordinated and inclusive responses (Wamsler & Brink, 2014). Effective governance facilitates resource mobilization, information dissemination, the participation of vulnerable populations, and the establishment of integrated policies that enhance urban resilience (Chelleri et al., 2015). Conversely, poor governance often results in fragmented management, weak anticipation, and increased vulnerability to crises.

2. Actors Involved in Urban Governance

Urban governance involves a diversity of actors, each with specific roles and responsibilities:

- **Local authorities**: they constitute the central pillar, responsible for urban planning, infrastructure management, public services, and coordinating risk prevention actions (UN-Habitat, 2016).
- **The private sector**: often involved in the provision of infrastructure, resource management, or funding urban projects, playing a key role through public-private partnerships (Healey, 2006).
- **Associative organizations and NGOs**: they are essential actors in representing the interests of populations, especially the most vulnerable, and in promoting awareness, education, and community mobilization actions.
- **Civil society and citizens**: increasingly recognized as indispensable actors of urban governance. Their participation may occur through public consultations, neighborhood committees, or collaborative digital platforms, contributing to more transparent and democratic governance (Ansell & Gash, 2008).

3. Interaction Between Risk Management and Urban Governance

Urban risk management and urban governance are two intrinsically linked domains, whose interaction determines cities' capacity to anticipate, prevent, and effectively respond to various threats. Understanding this interaction is essential to designing resilient and sustainable urban strategies.

3.1. Governance as a Framework for Urban Risk Management

Urban risk management cannot be separated from the broader framework of urban governance, which defines decision-making processes, the actors involved, and the coordination and accountability mechanisms (Pelling, 2003). Governance provides the institutional framework needed to plan, finance, and implement risk reduction policies. For example, integrated urban planning, under the leadership of local authorities, helps reduce vulnerability by controlling land use and preserving sensitive areas (Birkmann et al., 2010).

3.2. Participatory Governance and Risk Management

Integrating citizen participation into governance strengthens risk management by incorporating local knowledge and the needs of vulnerable populations (Wamsler, 2014). Participatory governance improves the legitimacy of policies and encourages better ownership of prevention measures by citizens, which is crucial for their effectiveness. For instance, community involvement in risk mapping and disaster preparedness exercises has shown positive effects on urban resilience (Cutter et al., 2008).

3.3. Multi-actor and Multi-level Coordination

The complexity of urban risks often combining natural, technological, and social factorsrequires effective multi-level and multi-actor governance. Coordination between various government agencies, private actors, NGOs, and local communities is a key success factor in risk management (Solecki et al., 2017). Without such coordination, efforts may be redundant, contradictory, or ineffective, increasing urban vulnerability.

3.4. Adaptive Governance and Risk Management in the Face of Uncertainty

Urban governance must be adaptive to respond to the dynamic and uncertain nature of urban risks, particularly in the context of climate change and rapid urban transformations (Folke et al., 2005). This adaptability implies the ability to learn from past experiences, to adjust policies according to new challenges, and to innovate in responses. Adaptive governance thus promotes urban resilience by enabling proactive and flexible risk management.

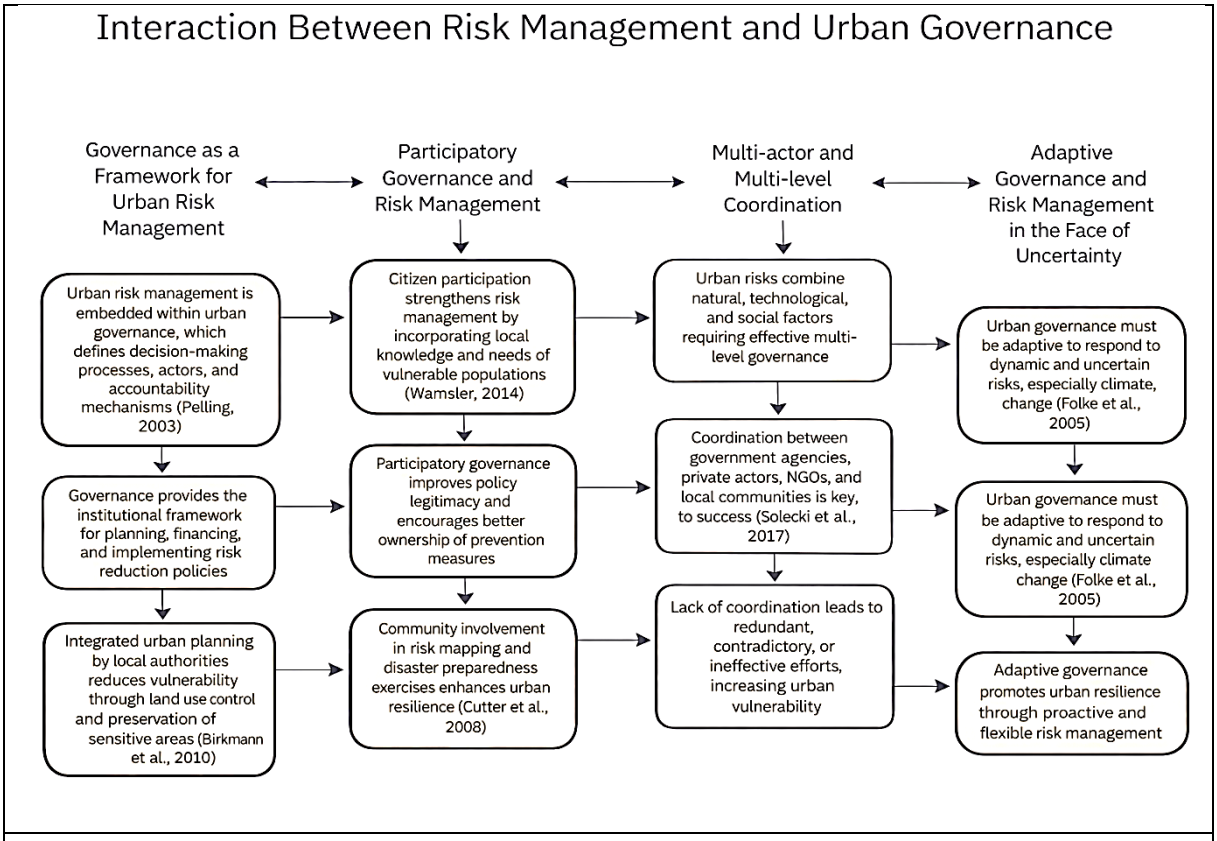

Figure 41: Interaction Between Risk Management and Urban Governance

Source: Author,2026

4. Governance Mechanisms and Tools for Urban Risk Management

4.1.Integrated Public Policies and Spatial Planning

Effective risk management requires integrated public policies that consider interactions between urban planning, the environment, economic development, and social cohesion (Healey, 2006). Spatial planning plays a central role in defining risk zones, regulating land use, and directing investments towards resilient infrastructure (Birkmann et al., 2010). These integrated policies help anticipate risks and reduce population vulnerability.

4.2.Early Warning Systems and Information Management

Early warning systems are key tools for reducing the impacts of urban disasters. They rely on the rapid collection, analysis, and dissemination of information on imminent threats, enabling quick mobilization of relevant actors and public preparedness (Basher, 2006). Effective information management, with communication channels accessible to all, is a core element of these systems.

4.3.Public-Private Partnerships and Collaborative Governance

Collaborative governance, particularly through public-private partnerships, is increasingly used to mobilize the resources, expertise, and innovations necessary for urban risk management (Healey, 2006). These partnerships combine private sector investment capacity with public service missions, while fostering shared responsibility. They may concern the construction of resilient infrastructure, emergency management, or public awareness campaigns.

4.4.Role of Digital Technologies and Participatory Platforms

Digital technologies offer new ways to improve risk governance in urban areas. Online participatory platforms facilitate citizen engagement in data collection (crowdsourcing), real-time information reporting, and decision-making (Meijer & Bolívar, 2016). They also contribute to more effective and transparent communication between authorities and the public, thereby reinforcing trust and coordination.

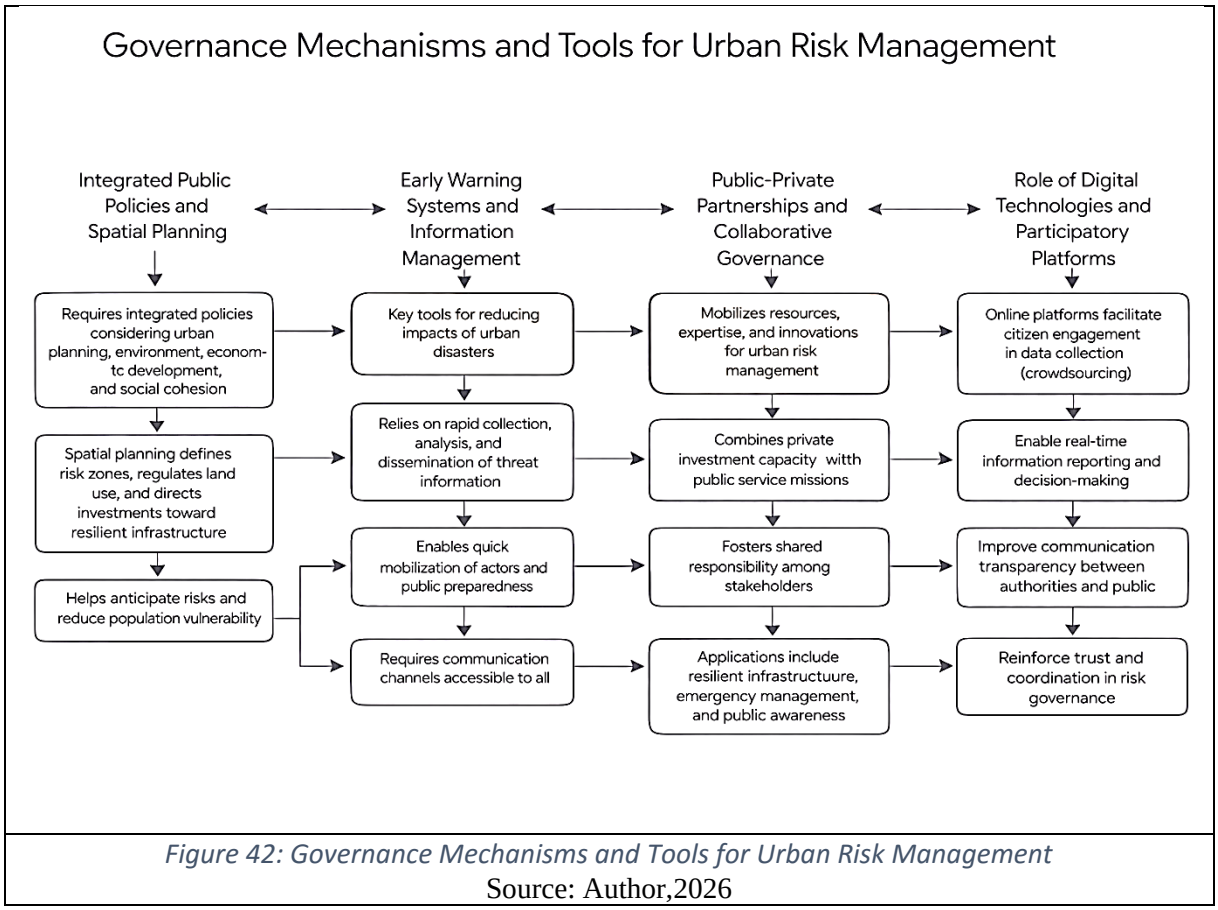

Figure 42: Governance Mechanisms and Tools for Urban Risk Management
Source: Author,2026

Global Perspectives on Governance

USA (NIMS - National Incident Management System): Uses a standardized "Incident Command System" (ICS). Regardless of the disaster size, the command structure is always the same (Operations, Planning, Logistics, Finance). This allows for rapid scalability.

Canada (FPT Coordination): Emphasizes "Federal-Provincial-Territorial" collaboration, where the local level is the first responder, and higher levels only intervene when local capacity is overwhelmed.

Comparison with **Algeria**: Algeria utilizes the **ORSEC Plan**, which is a hierarchical, state-driven command structure similar to the French model, effective for large mobilization but sometimes less flexible than the modular US system.

5. Case Studies and Good Practices: International and Algerian Experiences

5.1. International Examples of Effective Governance in the Face of Urban Risks

At the international level, several cities illustrate exemplary urban governance models for managing major risks. Singapore, for instance, is frequently cited for its integrated climate risk management strategy, combining rigorous urban planning, sophisticated early warning systems, and strong citizen involvement (Koh et al., 2019). Similarly, Tokyo, facing major seismic risks, has developed an effective multi-actor governance system, combining strict regulations, regular simulations, and transparent communication with the population (Saito & Sakurai, 2016). These examples demonstrate that the success of urban governance in risk management relies on effective institutional coordination, active citizen participation, and the capacity to adapt to new challenges. They also highlight the importance of resilient infrastructure supported by integrated public policies.

5.2. Governance and Risk Management in Algeria: Context, Challenges, and Initiatives

In Algeria, urban governance in the face of risks is marked by several structural challenges, including rapid urban growth, informal urbanization, and institutional fragmentation (Khelfaoui, 2018). Recurrent natural disasters such as floods and earthquakes reveal the weaknesses of the current system in terms of prevention and crisis management (Bensaid et al., 2020).

However, recent initiatives show a willingness to strengthen risk governance. The implementation of municipal risk prevention plans and the establishment of specialized units in certain wilayas represent a positive evolution (Medjahed, 2019). Furthermore, Algeria has adhered to several international conventions on risk management and urban resilience, encouraging the adoption of global best practices (UNDRR, 2021).

6. Toward Resilient Urban Governance

6.1.Guiding Principles for Effective Governance

In a context of increasing complexity of urban risks linked both to natural hazards, climate change, social vulnerabilities, and demographic pressure urban resilience becomes a central requirement of governance policies. To address these challenges, several guiding principles must structure risk governance at the scale of cities.

1-Coherence of Public Policies

Coherence consists in articulating planning policies, crisis management, social and environmental development within a logic of complementarity. This horizontal and vertical integration allows avoiding contradictions or administrative duplications (Pahl-Wostl, 2009). Coherent governance must also harmonize local, regional, and national levels, respecting the competences of the different actors (Hooghe & Marks, 2003).

2-Anticipation

Resilient governance is based on a prospective logic, placing risk anticipation at the heart of urban planning. This implies preventive analysis of vulnerabilities, investment in adaptive infrastructures, and establishment of alert and response scenarios. The Sendai Framework (UNDRR, 2015) emphasizes the crucial role of risk knowledge to strengthen cities' response capacity.

3-Flexibility

Flexibility refers to the capacity of institutions to adapt to uncertainties and crises. It relies on open governance mechanisms, capable of revising their modes of functioning, priorities, or tools according to evolving contexts (Folke et al., 2005). This dimension presupposes a "learning" governance, that is, capable of benefiting from feedback and weak signals.

4-Equity

Equity aims to ensure that governance mechanisms take into account social, territorial, and generational disparities. Resilient governance cannot ignore inequalities of access to information, infrastructure, or participation (Arnstein, 1969; Anguelovski et al., 2016). Equity also requires special attention to vulnerable groups often the most exposed to risks.

2. Strategic Elements for Urban Resilience

Urban resilience strategies rely on operational tools and an inclusive institutional architecture. The effectiveness of these strategies depends as much on their content as on the process of their implementation.

-Integrated Approaches and Territorial Planning

Resilient governance demands integrated urban policies, articulating territorial planning, environmental management, economic development, and security. Integrating risk management into territorial planning documents, such as master urban plans or regional schemes, is indispensable (UN-Habitat, 2016). These approaches limit exposure to risks (flood zones, collapses, etc.) while promoting more sustainable urbanism.

-Multi-Actor Steering

Shared steering between public institutions, private sector, civil society, and local communities fosters more reactive and inclusive governance (Ansell & Gash, 2008). Such an approach presupposes clear coordination mechanisms, based on deliberation, trust, and recognition of non-institutional knowledge (Healey, 2006). Public-private partnerships, intermunicipal arrangements, and collaborative platforms are key tools of this hybrid governance.

-Evaluation, Learning, and Continuous Innovation

Resilience is not a fixed state but a dynamic process. Hence the importance of regular policy evaluation, capitalization of feedback, and organizational innovation. Resilient cities implement territorial information systems, risk observatories, and encourage experimental approaches and social or digital innovations (Meijer & Bolívar, 2016). Institutional learning fosters adaptive governance, capable of evolving its responses in the face of risk transformations (Djalante, Holley & Thomalla, 2011).

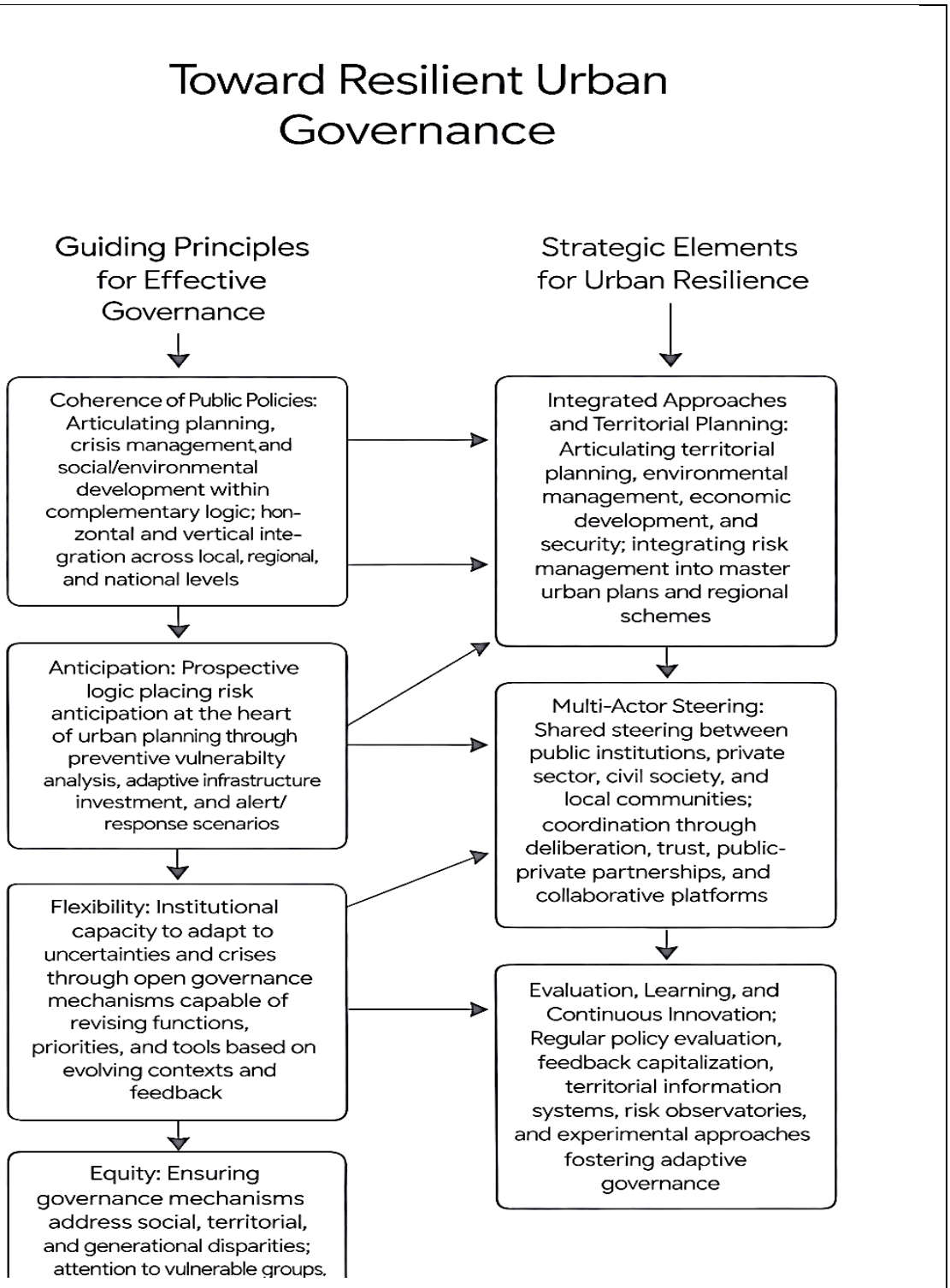

Figure 43: Toward Resilient Urban Governance

Source: Author,2026

Conclusion to Chapter 7

Urban governance in the management of major risks now represents a central pillar for ensuring the resilience of cities to multiple contemporary vulnerabilities. The intensification of natural phenomena, the dynamics of accelerated urbanization, and the complexity of urban systems make an integrated, participatory, and adaptive governance approach indispensable. International experiences show that success in this area is based on coherent planning, effective inter-institutional cooperation, mobilization of digital technologies, and active citizen participation.

From this perspective, governance is not limited to the actions of public institutions but extends to all territorial actors, including the private sector, civil society, and local communities. It also requires transparent communication mechanisms, a clear distribution of responsibilities, and continuous adaptability to risk evolutions.

The use of early warning systems, integrated spatial planning, and collaborative platforms strengthens cities' capacity to anticipate, absorb, and overcome crises.

Thus, urban resilience cannot be envisioned without inclusive, agile, and learning-oriented governance. By placing cooperation, innovation, and social justice at the heart of public action, it becomes possible to transform risks into opportunities to build safer, more sustainable, and more united territories.

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GENERAL CONCLUSION

The management of major urban risks represents a central challenge in the context of contemporary urban development. As cities grow in complexity and vulnerability, the need for integrated, anticipatory, and adaptive risk management strategies has become more urgent than ever. This course has provided a comprehensive overview of the theoretical and practical dimensions of risk prevention, reduction, and resilience-building at the urban scale.

Through the exploration of both natural and technological hazards, students have been introduced to key concepts such as vulnerability, exposure, mitigation, preparedness, and resilience. Special attention was given to institutional and regulatory frameworks, including the development of Risk Prevention Plans (PPRN and PPRT), which serve as operational tools for territorial risk governance. These instruments highlight the critical role of spatial planning, legal regulation, and multi-stakeholder coordination in reducing disaster impacts and promoting sustainable urban environments.

The course also examined the Algerian national policy on disaster risk prevention and reduction, offering insights into the local legal, strategic, and institutional mechanisms aligned with international frameworks such as the Sendai Framework for Disaster Risk Reduction. This case study allowed students to contextualize broader theoretical knowledge within a specific national setting, identifying both strengths and areas for improvement.

Finally, the course concluded with a focus on urban resilience, emphasizing the capacity of urban systems not only infrastructure, but also communities and institutions to absorb, adapt, and recover from major disruptive events. Building resilience is not solely a technical task, but a multidimensional process requiring political will, social engagement, knowledge integration, and long-term vision.

In summary, this course has equipped students with the analytical tools and practical knowledge necessary to engage with urban risk management in a cross-disciplinary and operational manner. Whether as urban planners, engineers, decision-makers, or researchers, students are now better prepared to contribute to safer, more resilient cities capable of facing future challenges.

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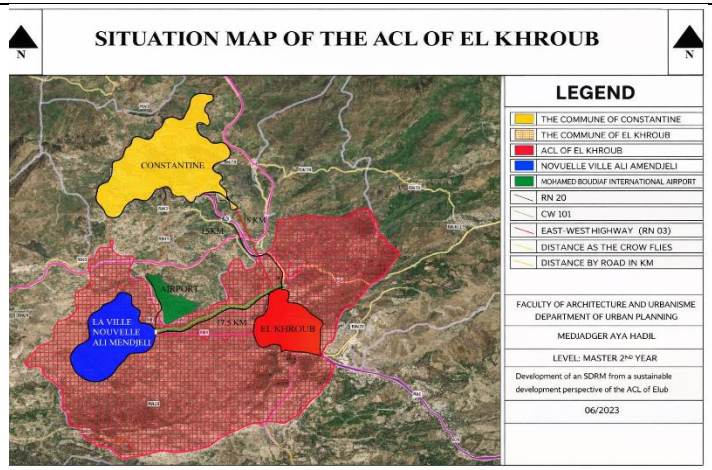
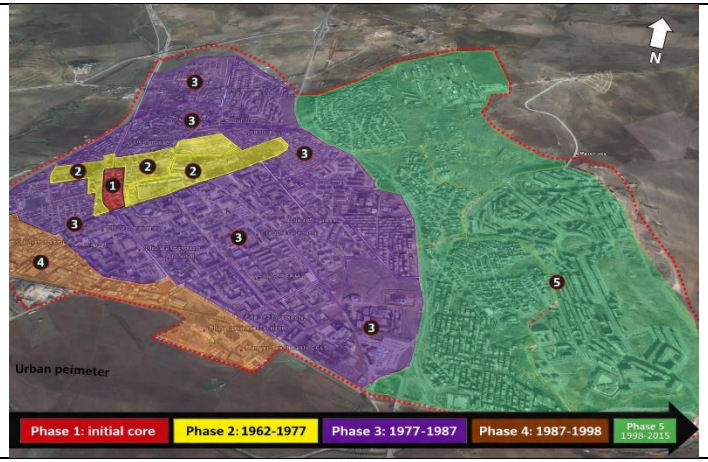
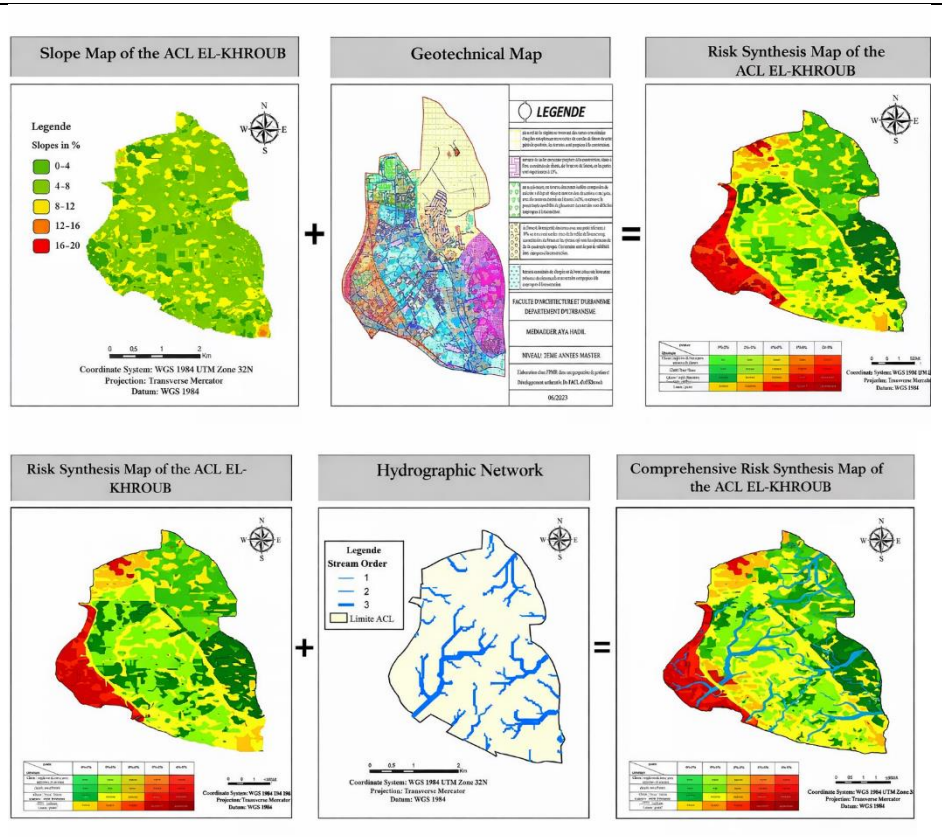
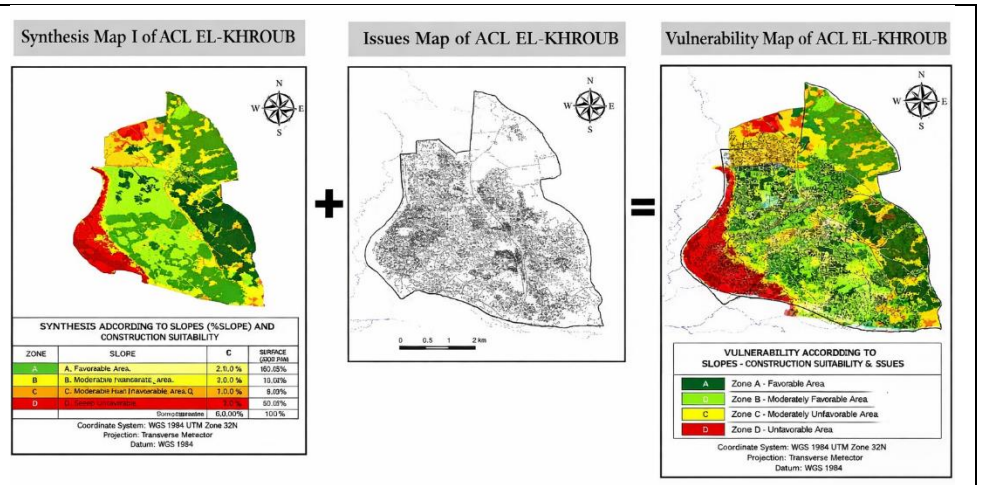
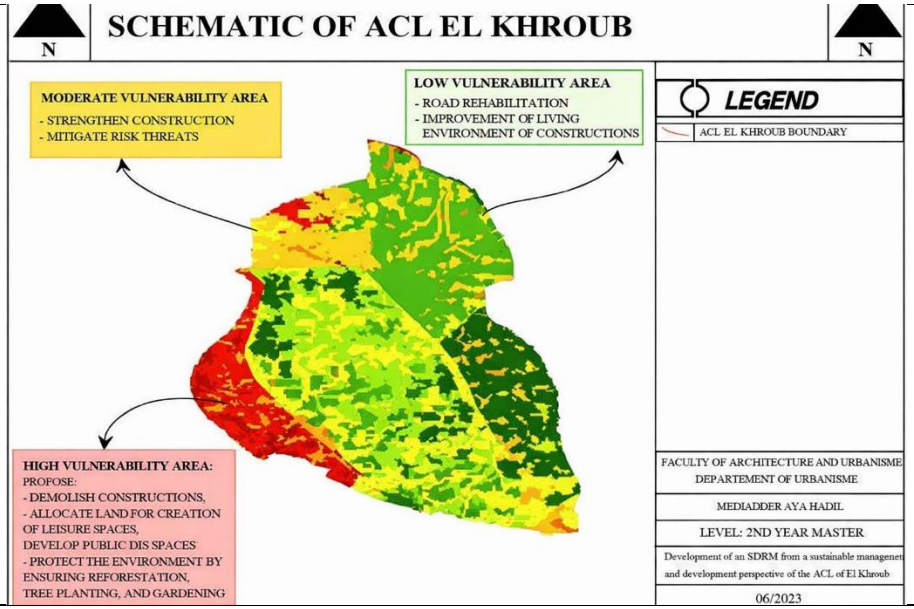
Appendix

SYNTHESIS TABLE

RISK PROFILE OF THE WILAYA OF CONSTANTINE

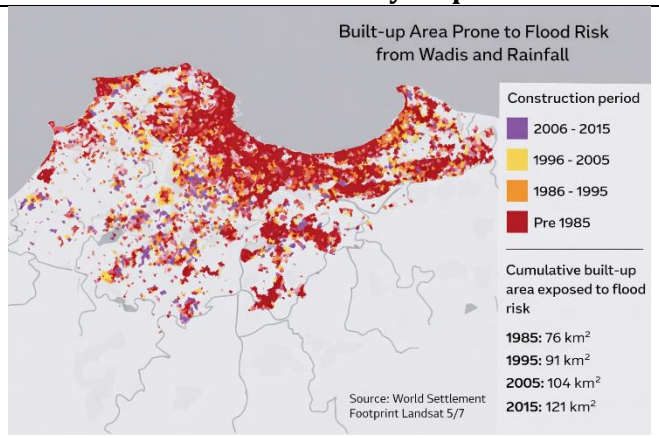
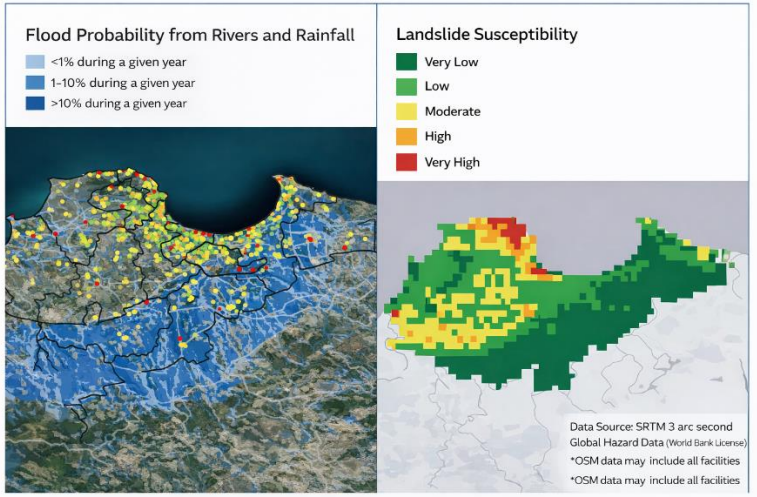
Components	Synthetic Description	Associated Study Maps
Territorial Context	Constantine is the capital of Eastern Algeria and a major regional metropolitan center. Covering an area of 2,297 km^2, the wilaya concentrates significant administrative, economic, and cultural functions. It is characterized by strong physical and geographical constraints, notably its rugged topography and its location on the rocky plateau known as "Le Rocher."	
Urban Dynamics	Rapid but poorly controlled urban development affects all municipalities, including El Khroub. Urban sprawl is marked by a high proportion of informal housing and accelerated land consumption. Unregulated urban expansion has generated zones of increased vulnerability.	

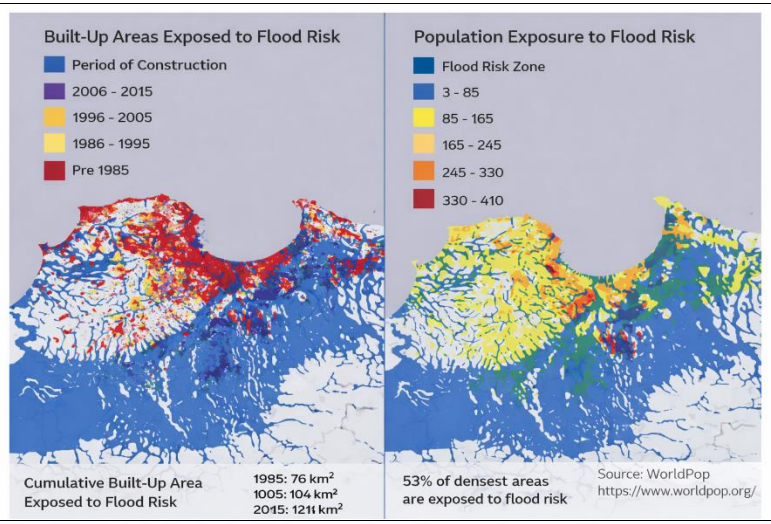
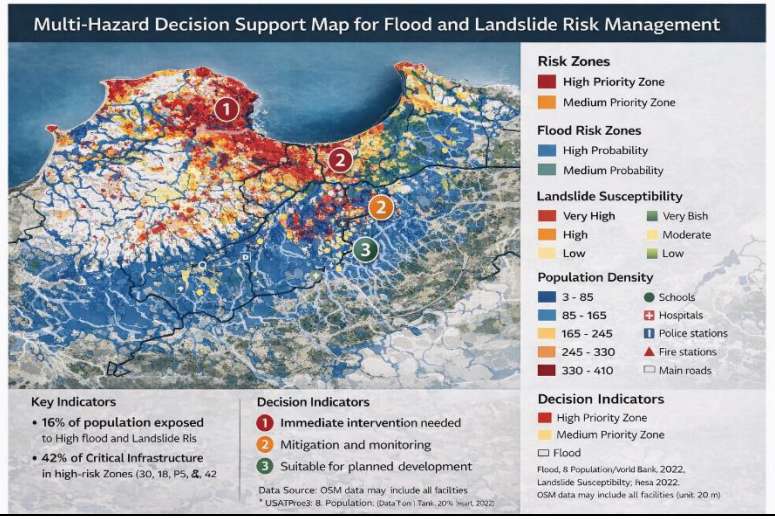
Main Natural Hazards	Flooding represents the predominant natural hazard affecting the wilaya, particularly along wadis such as Boumerzoug, El Berda, El Fantaria, and Hmimime. Seismic risk (classified as seismic zone II-a according to the RPA 1999 seismic regulation) and landslides on unstable slopes constitute additional natural hazards.	
Exposed Stakes	A dense and vulnerable population, widespread informal and substandard housing, industrial zones (notably the Ain Khadjo industrial area), strategic infrastructures, public facilities, and urban heritage are exposed to multiple hazards.	

Major Vulnerabilities	High population density, prevalence of informal settlements, concentration of industrial activities and hazardous materials transport, vulnerability of strategic infrastructures, insufficient sanitation networks, absence of risk prevention instruments, and limited public risk awareness.	
Observed Impacts	Major disaster events include the floods of 1984–1985, 2015, and 2019, as well as the 2009 industrial explosion, illustrating severe human, material, and economic impacts.	
Recommended Strategic Orientations	Development of a Multi-Risk Prevention Plan, reduction of informal housing, seismic retrofitting, integration of risk into spatial planning, improvement of drainage systems, public awareness, and establishment of non-buildable high-risk zones.	

SYNTHESIS TABLE

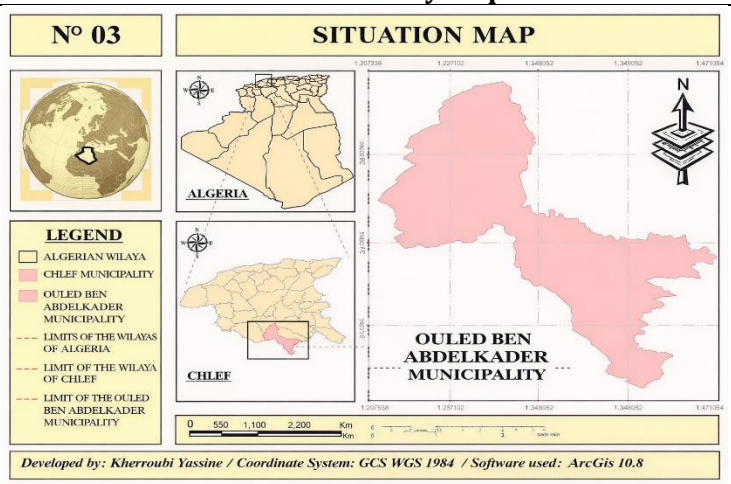
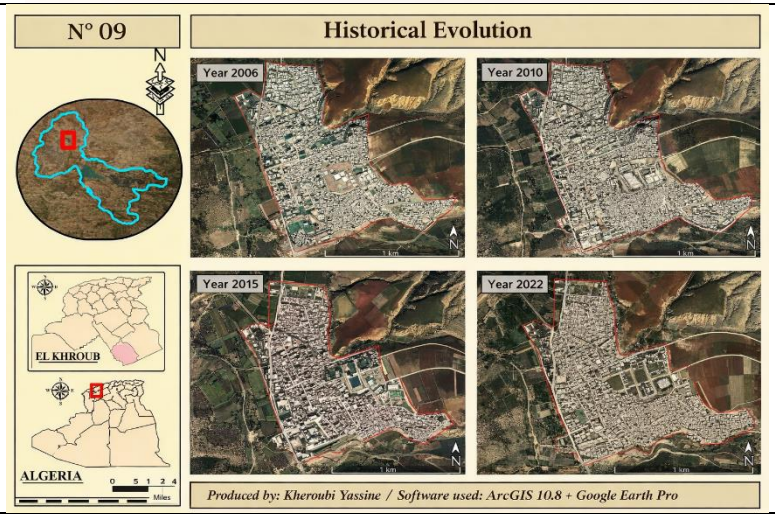
RISK PROFILE OF THE WILAYA OF ALGIERS

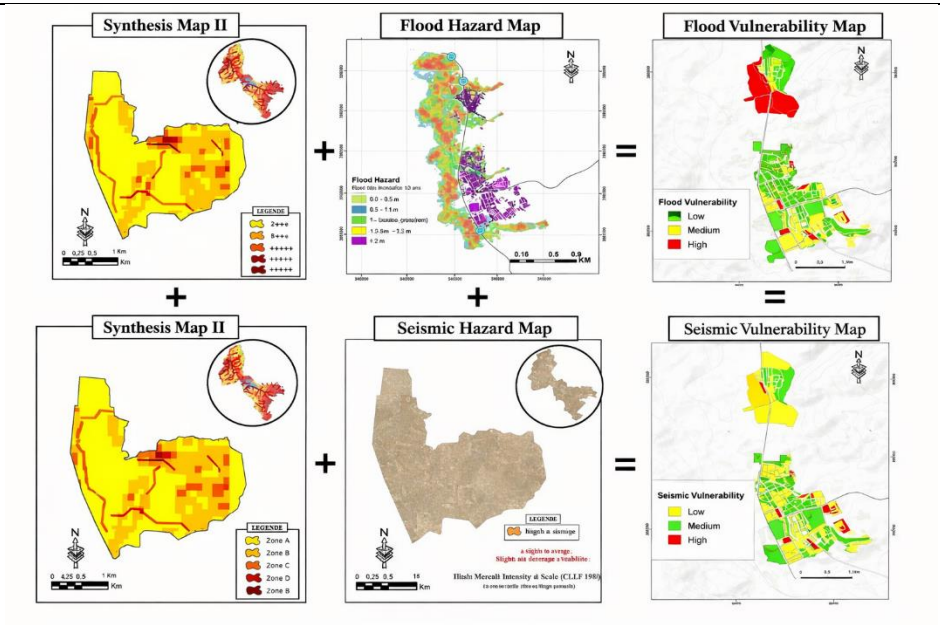
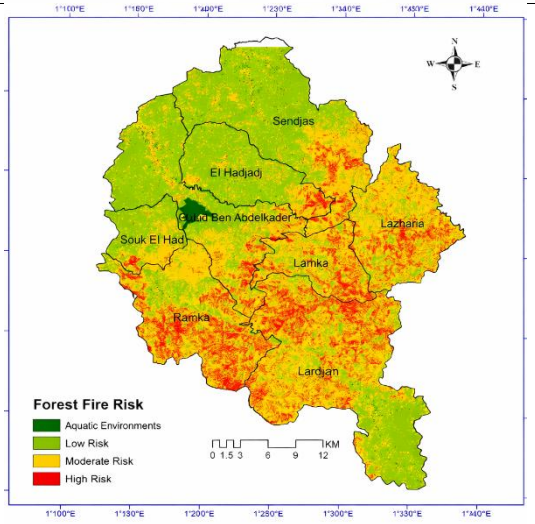
Elements	Summary Description	Associated Study Maps
Territorial Context	Primary economic hub outside the hydrocarbon sector, accounting for 8.3% of the national population and 16.8% of GDP. The Wilaya of Algiers plays a strategic national role with a high concentration of administrative, economic, and service activities.	
Urban Dynamics	Continuous coastal urbanization with expansion toward the Mitidja Plain and the Sahel. Urban development is often dense and informal, increasing pressure on land and infrastructure.	
Main Natural Hazards	Floods and landslides represent the main natural hazards affecting the Wilaya of Algiers, particularly in densely urbanized coastal areas and unstable slopes.	

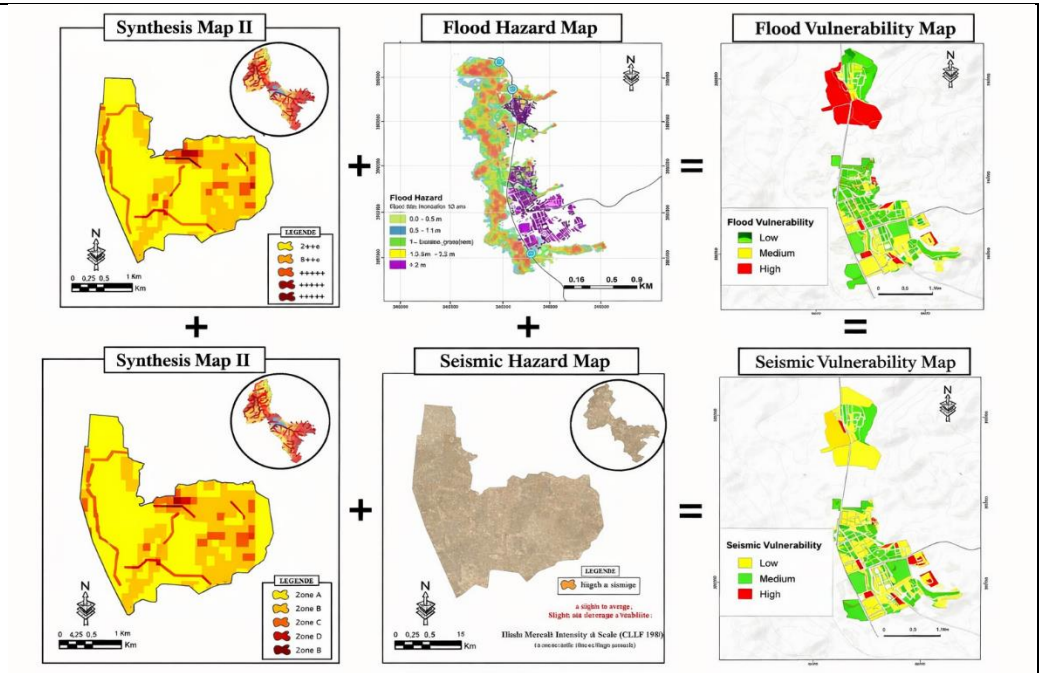
Exposed Assets and Stakes	Dense population, informal housing, industrial zones, strategic infrastructure, as well as significant urban and natural heritage exposed to multiple hazards.	
Major Vulnerabilities	High population density, prevalence of informal settlements, concentration of industrial activities, and the vulnerability of strategic infrastructure and heritage assets increase overall risk levels.	
Observed Impacts	Major disasters, notably the Bab El Oued floods (2001), and a continuous increase in exposed built-up areas, illustrate the severity of potential human, material, and economic impacts.	
Recommended Strategic Directions	Elimination of substandard housing, seismic retrofitting of buildings, and systematic integration of risk considerations into spatial planning and urban development policies.	

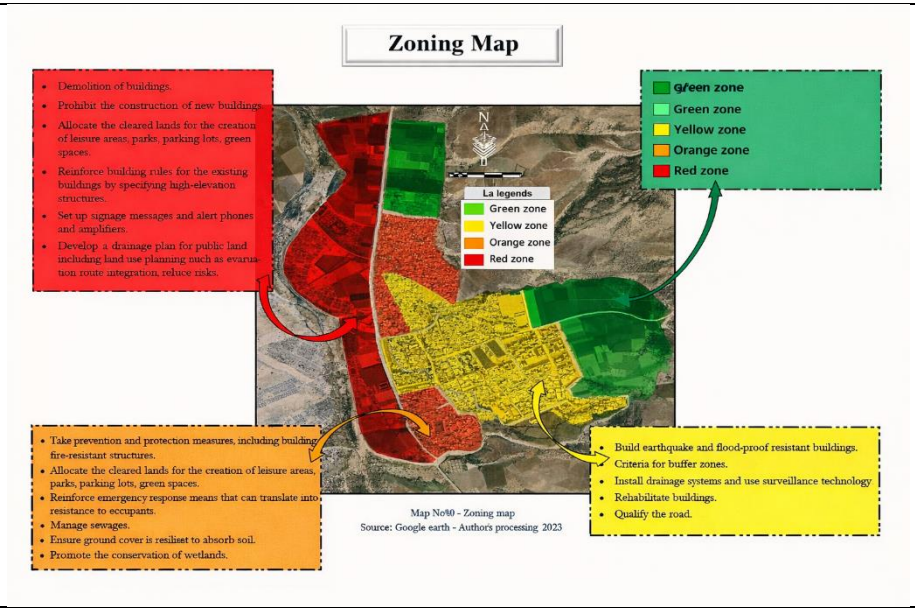
SYNTHESIS TABLE

RISK PROFILE OF THE MUNICIPALITY OF OULED BEN ABDELKADER (WILAYA OF CHLEF) PPMR

Elements	Summary Description	Associated Study Maps
Territorial Context	Municipality located in the Wilaya of Chlef, classified as Seismic Zone III under the Algerian Seismic Code (RPA). Historically strategic area marked by the El Asnam earthquake (1980). Rugged terrain characterized by forested massifs and crossed by several wadis. High population concentration within a limited and vulnerable territory.	
Urban Dynamics	Rapid and uncontrolled urban growth on high-risk sites without compliance with construction standards. Fragmented urban pattern dominated by individual housing, widespread illegal constructions and precarious settlements. Uncontrolled urban expansion toward sensitive peripheral areas.	

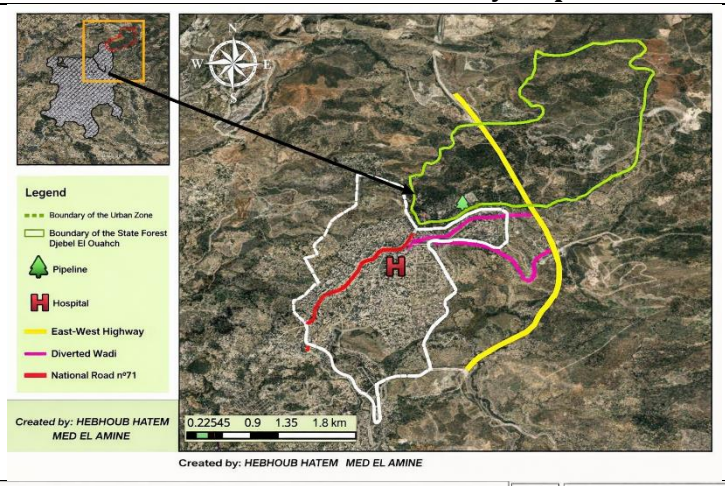
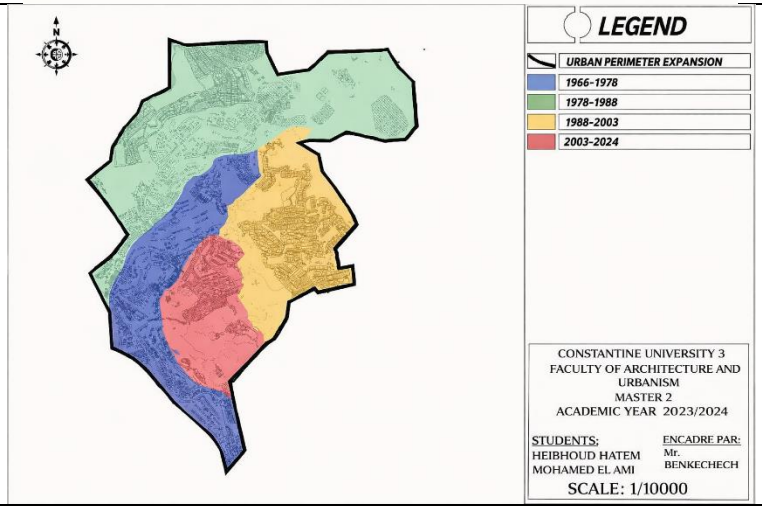
Main Natural and Technological Hazards	Major seismic hazard (Zone III – RPA) with a high probability of destructive earthquakes. Flood risk linked to wadi overflows threatening low-lying areas. Forest fire risk due to extensive forested areas. Technological risks related to the transport of dangerous goods and industrial facilities.	
Exposed Assets and Stakes	Population concentrated in risk-prone areas, vulnerable hydraulic and road infrastructures, exposed strategic public facilities (schools, health, administrative buildings), threatened environmental heritage (forests, agricultural land), and sensitive economic activities (commerce, agriculture).	

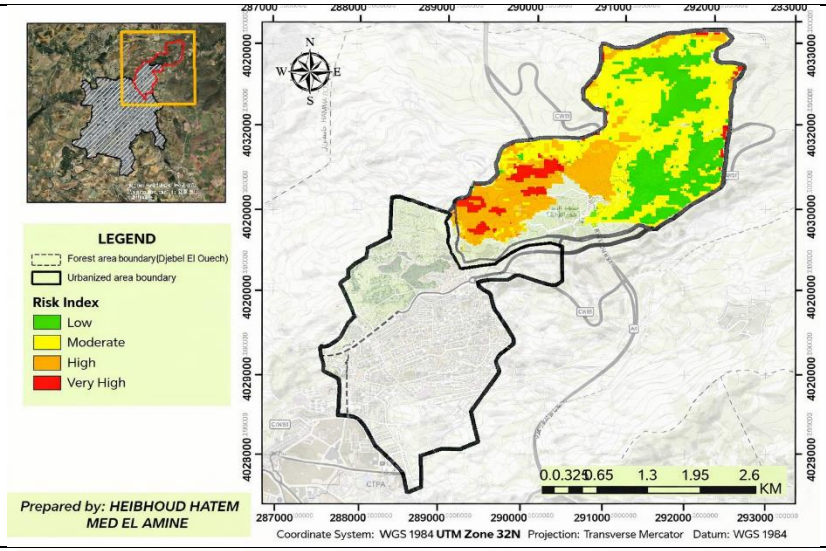
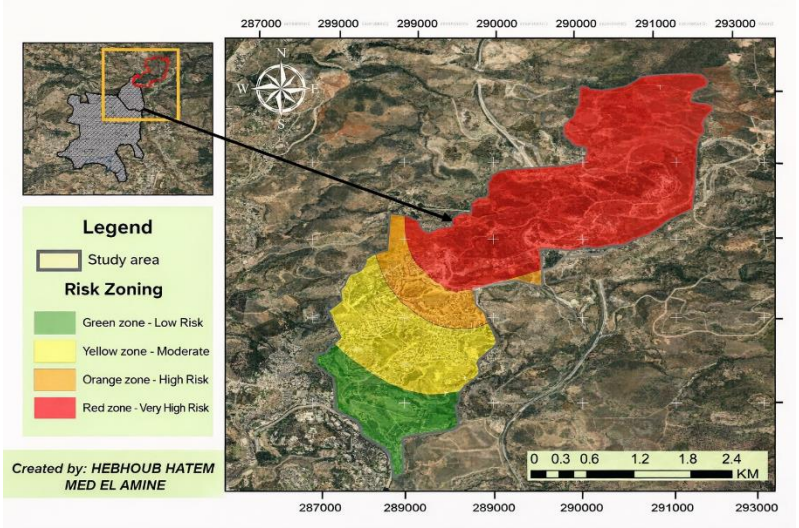
Major Vulnerabilities	Physical vulnerability: non-compliant housing, construction in flood-prone areas, fragile building materials. Social vulnerability: lack of risk awareness among inhabitants and limited access to preventive information. Institutional vulnerability: weak integration of risk into planning instruments and limited coordination among stakeholders. Structural vulnerability: aging infrastructure networks and non-compliant public facilities.	
Observed and Historical Impacts	Traumatic legacy of the El Asnam earthquake (10 October 1980) with massive destruction and significant human losses. Potential impacts of current hazards include building collapse, high casualties, disruption of critical infrastructure, economic losses, and population displacement.	
Recommended Strategic Directions	Development and strict implementation of a Multi-Risk Prevention Plan (PPMR) with regulatory zoning (Red: non-	

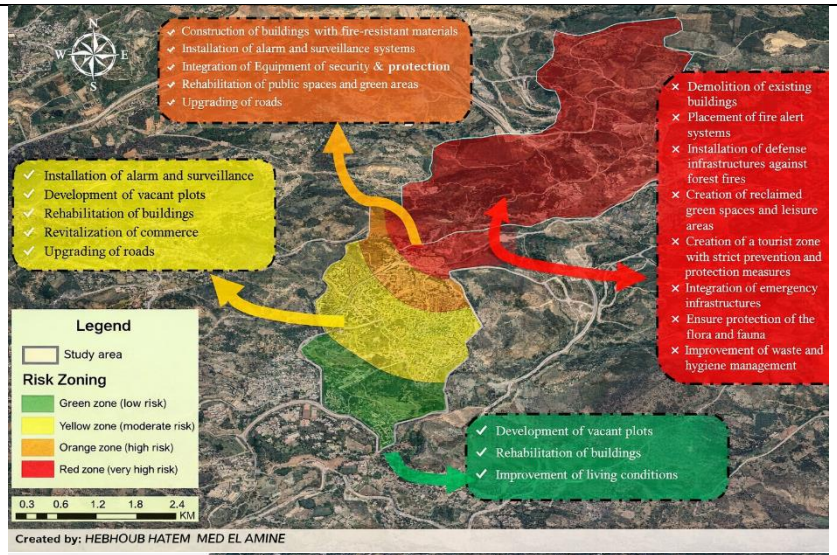
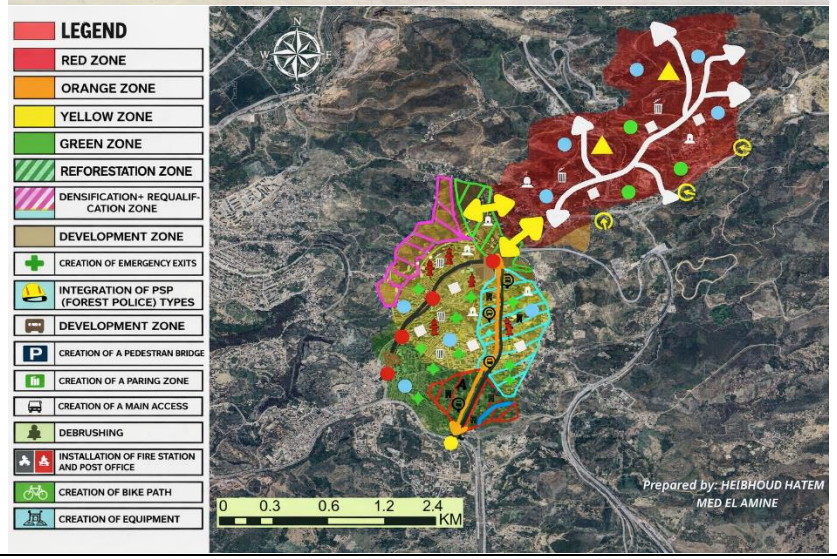
	buildable, Orange: buildable under strict conditions, Green: low exposure). Urban resilience strengthening, risk culture promotion, integration of risk into planning instruments (PDAU, POS), seismic retrofitting of public buildings and existing housing stock.	

SYNTHESIS TABLE

RISK PROFILE OF THE DJEBEL EL OUAHCH AREA (CONSTANTINE)

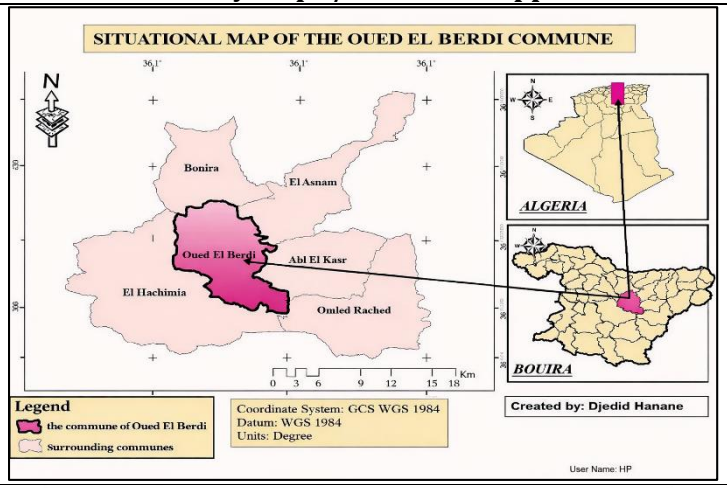
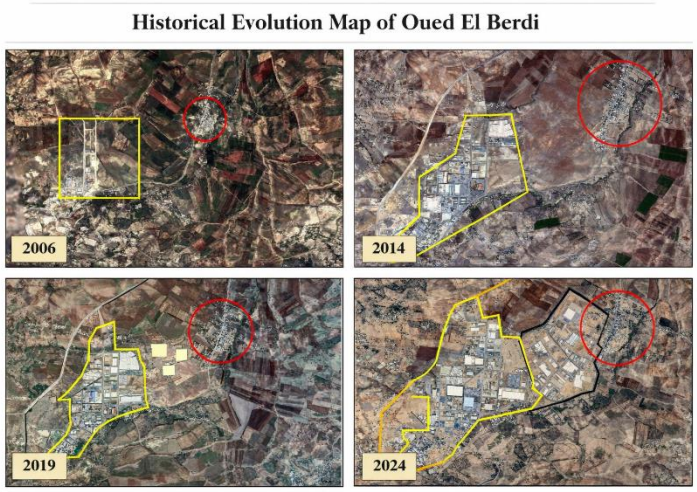
Elements	Summary Description	Associated Thematic Study Maps
Territorial Context	Strategic area located in the north-east of Constantine, covering 1,122 ha and hosting more than 41,000 inhabitants. The urban sector of Ziadia (572 ha) is adjacent to the Djebel El Ouahch forest (550 ha). The area occupies a strategic position at the main access to Constantine via the East–West Highway bypass.	
Urban Dynamics	Progressive urbanization since 1966, expanding toward forested areas. Urban fabric dominated by individual housing distributed across six neighborhoods. The urban–forest interface creates a highly vulnerable contact zone.	

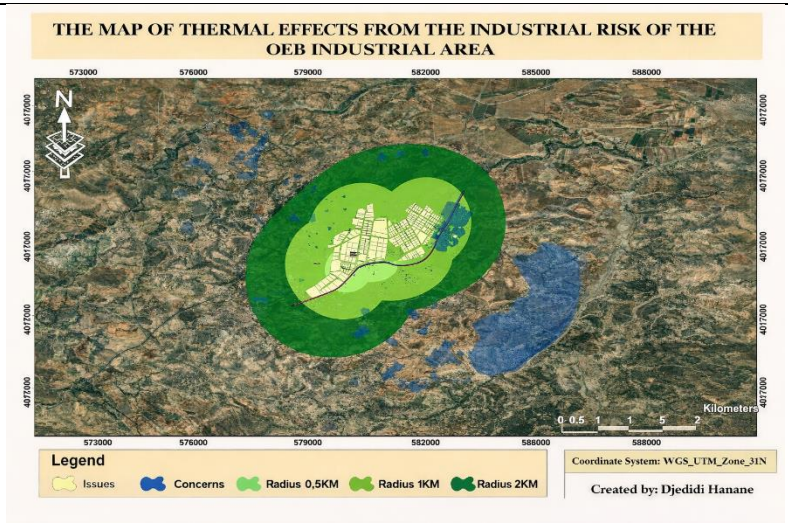
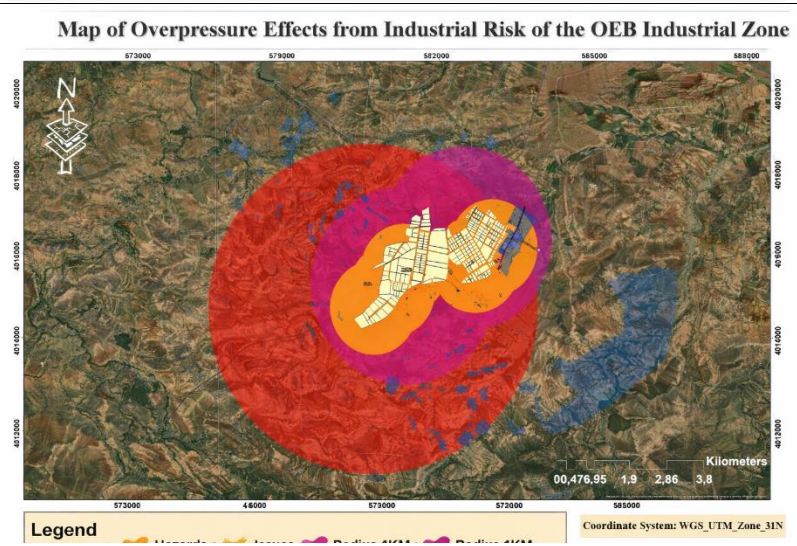
Main Natural Hazards	Recurrent forest fires, with more than 50 fire outbreaks recorded over nine years (2015–2023), affecting over 500 hectares. Critical fire seasons occurred in 2015, 2017, 2019, and 2022. Main causes include visitor negligence (90%), extreme climatic conditions, and high vegetation density.	
Exposed Assets and Stakes	Dense population (estimated 41,190 inhabitants in 2008), housing located less than 50 meters from the forest in northern sectors, strategic infrastructure (psychiatric hospital, 15 schools, sports facilities), recreational assets (amusement park, arboretum, lakes, hill reservoir), and major road infrastructure.	
Major Vulnerabilities	Critical urban–forest interface (distance < 50 m), absence of emergency exits and alarm systems in buildings, limited access points, lack of evacuation routes, insufficient fire hydrants and water points near the forest, frequent traffic congestion, and low public awareness (85% unaware of emergency procedures).	

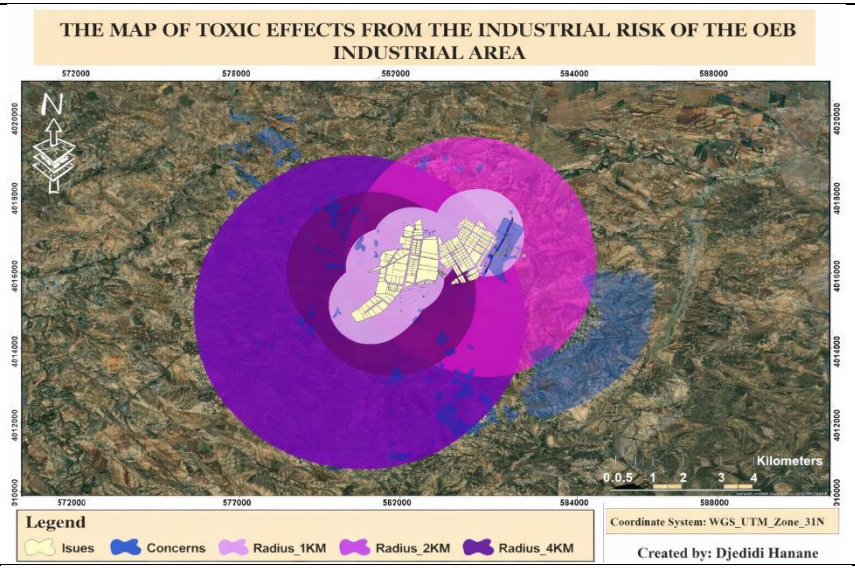
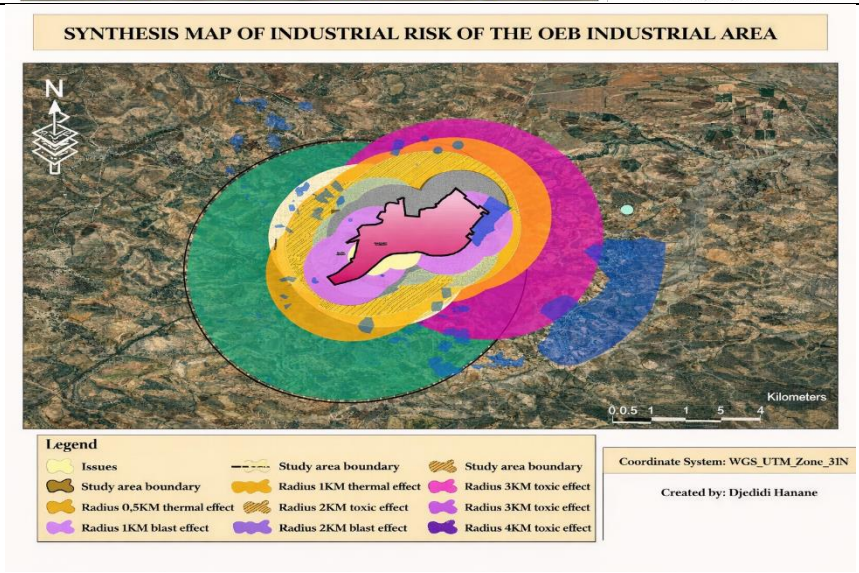
Observed Impacts	More than 500 hectares burned between 2015 and 2023. The 2019 fire season alone destroyed 380 ha, including 310 ha of scrubland. Persistent threat to the Ziadia urban sector, degradation of forest and ecological heritage, and disruption of recreational and tourism activities.	
Recommended Strategic Directions	Short-term priority actions (2024–2029) focusing on social awareness, improvement of the built environment and transport, strengthening of health infrastructure, enhanced information and training, institutional integration of forest fire risk into planning tools (PDAU, POS, ORSEC), expansion of prevention infrastructure, and implementation of regulatory zoning (Red, Orange, Yellow, Green zones).	

SYNTHESIS TABLE

RISK PROFILE OF THE MUNICIPALITY OF OUED EL BERDI (WILAYA OF BOUIRA)

Elements	Summary Description	Associated Thematic Study Maps / Decision-Support Tools
Territorial Context	Municipality located 10 km from the Wilaya capital of Bouira, in the central region of Algeria. Strategically positioned along National Road RN8B. Covers an area of 15,736 ha with an estimated population of 13,511 inhabitants (2022). Predominantly agricultural vocation (90% of the territory), with the presence of a major industrial zone.	
Urban Dynamics	Urban development concentrated in the municipal center and the secondary agglomeration of Fraksa. Linear urbanization along RN8B. Significant expansion driven by the Sidi Khaled industrial zone and its planned extensions. Scattered housing observed across six localities.	

Main Natural and Technological Hazards	Natural hazards include seismic risk, flooding from Oued El Berdi, and landslides related to unstable clay soils. Technological hazards are significant due to the industrial zone hosting 51 classified facilities with major fire, explosion, and toxic emission risks.	
Exposed Assets and Stakes	Concentrated urban population, strategic transport and utility infrastructure (RN8B, East–West access roads, high-voltage power lines, water supply and sanitation networks), productive agricultural land, and close proximity between industrial facilities and residential areas (less than 70 m in some cases).	

		
Major Vulnerabilities	Industrial vulnerability linked to 51 classified facilities, including very high-, high-, and medium-risk plants. Environmental vulnerability due to air, water, soil, and noise pollution. Structural vulnerability associated with unstable soils, degraded road infrastructure, lack of recreational facilities, and inadequate household waste management.	
Observed Impacts	Thermal, overpressure, and toxic effects affecting thousands of inhabitants within radii up to 4 km. Health impacts reported by 66% of the population, including respiratory and eye-related disorders. Environmental impacts include air	

	quality degradation, water pollution of the wadi, soil contamination, and persistent noise nuisance.	
Recommended Strategic Directions	Implementation of industrial risk mitigation measures (emission control technologies, wastewater treatment, solid waste management, emergency planning and drills). Urban risk management through controlled urbanization, relocation of the most exposed housing, integration of risk into planning instruments (PDAU, POS), infrastructure upgrading, and strengthened prevention, information, and emergency preparedness.