



NATURAL DISASTERS AND MAJOR RISKS IN ALGERIA: MANAGEMENT AND PREVENTION MECHANISMS

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EXTENDED ABSTRACT

Le catastrofi e i rischi naturali sono tra le principali cause di morte di milioni di persone in tutto il mondo, così come le malattie, le epidemie letali e le guerre. Molti paesi del mondo hanno registrato un numero molto elevato di vittime, soprattutto nelle zone ad alto rischio. Ciò che caratterizza questi rischi è che si verificano generalmente in modo improvviso e senza preavviso, aumentando il numero di vittime e i danni economici e ambientali. La principale causa dell'aumento del livello dei danni è la mancanza di una completa preparazione ad affrontare la catastrofe prima e durante il suo verificarsi. Inoltre, il livello economico e sociale di alcuni paesi poveri è tra le principali cause dell'aumento del livello dei danni umani o materiali.

L'Algeria è uno dei principali paesi situati nel bacino del Mediterraneo e come alcuni degli altri paesi nel corso della loro storia hanno conosciuto numerose catastrofi naturali, in particolare terremoti e altri disastri naturali come gli incendi boschivi recentemente occorsi. Lo Stato si è trovato impotente di fronte alla vastità delle catastrofi e alla mancanza di mezzi, oltre al basso livello di controllo sulle conseguenze delle stesse, con mancanza di esperienza sufficiente nella gestione dei grandi rischi.

In questa ricerca, abbiamo identificato il quadro spazio-temporale delle catastrofi naturali, che hanno colpito l'Algeria a partire dal secolo scorso e che hanno devastato alcune regioni causando migliaia di vittime (tra morti, feriti e senzatetto) e la completa distruzione delle infrastrutture e delle abitazioni, in particolare i terremoti che hanno colpito la regione settentrionale montuosa dell'Algeria negli ultimi anni. Ciò ha costretto le autorità algerine a riorganizzare seriamente il quadro normativo sulla gestione dei rischi e a ripensare il modo in cui affrontare queste catastrofi per ridurne l'intensità e garantire la protezione dei cittadini e dei loro beni da questi rischi. Lo Stato ha lavorato instancabilmente sin dal terremoto distruttivo di Chlef del 1980, che ha spinto le autorità a ridefinire le procedure necessarie per affrontare tali rischi, la prima delle quali è stata la revisione del quadro giuridico, tra cui l'emanazione di leggi regolamentari che controllano almeno le circostanze prima, durante e dopo la catastrofe.

Abbiamo arricchito questa ricerca con un quadro concettuale in cui ci siamo concentrati sui principali termini, definizioni e concetti direttamente correlati alle catastrofi e ai grandi rischi, come catastrofe, rischio, caratteristiche delle catastrofi naturali e loro tipi. Questo per controllare e distinguere tra i diversi termini, soprattutto quelli che troviamo ripetuti nelle leggi e nei decreti in materia.

Per ovviare alle carenze e agli errori del passato, l'Algeria, dopo il terremoto di Chlef del 1980, ha emanato numerosi regolamenti e testi di legge relativi alla prevenzione e alla protezione dai grandi rischi, imponendo diverse condizioni tra cui: l'adeguamento degli edifici, l'intervento e il primo soccorso, e l'adozione di tutte le misure necessarie per proteggere i cittadini e i loro beni.

E dopo un lungo percorso di emanazione di leggi e completamento di quanto sopra, è stata emanata la legge n. 04-20 del 25 dicembre 2004 relativa alla prevenzione e alla gestione delle catastrofi nel quadro dello sviluppo sostenibile, a seguito del terremoto distruttivo di Boumerdès. Attraverso questa legge, le autorità hanno ovviato agli errori e alle carenze nella gestione delle catastrofi e dei grandi rischi. I suoi vari capitoli definiscono i vari rischi a cui è esposto il nostro paese, come terremoti, inondazioni e incendi. I suoi articoli includono anche alcune regole per la prevenzione dai grandi rischi, principi e sistemi per la gestione delle catastrofi.

Nell'ambito della gestione ottimale dei grandi rischi e della fornitura di meccanismi adeguati per prevenire le conseguenze dei terremoti, abbiamo fornito una scheda tecnica del terremoto di Boumerdès che ha colpito la prefettura nel 2003, causando ingenti danni materiali e umani. Questo terremoto è stato la svolta importante nell'emanazione di leggi e regolamenti per la gestione dei rischi in Algeria. Era necessario aggiornare i progetti antisismici introducendo i progressi tecnologici e le moderne tecniche. La domanda è: cosa succede dopo la catastrofe? Come viene gestita la catastrofe?



ABSTRACT

Natural disasters such as earthquakes and floods cause loss of life, destruction of infrastructure, housing, and facilities, leading to material, moral, and psychological damage that can last for many years. The fear of natural disasters has grown in many countries around the world, as these disasters have become a threat to life no less dangerous than the damage caused by wars, conflicts, and deadly diseases. This has led us to challenge all circumstances in order to find ways to manage natural disasters, crises, and major risks.

Algeria is one of the countries that has been hit by many natural disasters, the most prominent of which are earthquakes. It has relied on temporary and immediate solutions to deal with the aftermath of earthquakes without relying on disaster management mechanisms before and after their occurrence. Algeria, like other countries exposed to these natural hazards, has tried to work to reduce their impact by adopting a legal and strategic system that intervenes during and after disasters. This is done by taking a set of decisions aimed at preventing major hazards and managing them.

The Boumerdès earthquake was one of the most important natural disasters that effectively contributed to the revision of the legal and regulatory framework for major risks in Algeria. The huge losses caused by this earthquake necessitated a complete review by the Algerian legislator to develop a preventive strategy before, during, and after the disaster in order to achieve sustainable environmental and economic development.

KEYWORDS: *natural disaster management, major risks, Boumerdès earthquake*

INTRODUCTION

Algeria, with its vast area of 2381741 km², the largest in Africa, has a diverse topography and a variety of climatic zones. Due to its geographical location (The “Fire line”) and all the natural phenomena it experiences, Algeria is exposed to many types of disasters and major risks. These risks have been increased by rapid urbanization and the growing rate of urbanization, as well as technological and industrial progress. These factors, among others, have led to increased vulnerability of the region. Given its geographical position, Algeria is among the countries most vulnerable to natural disasters. Thus, over the last decade, it has been marked by very large-scale natural disasters such as the floods of Bad El Oued in 2001, Ghardaïa in 2018, Sétif and El Taref in 2012 and the earthquakes of Boumerdes 2003, and Mila in 2020 (RAMOUL *et alii*, 2022).

According to Article 10 of Law No. 04-20 of December 25, 2004, relating to the prevention and management of disasters within the framework of sustainable development, the following hazards constitute the major risks to which our country is

exposed (OFFICIAL GAZETTE OF THE ALGERIAN REPUBLIC, number 84, 2004, page 16):

- Earthquakes and geological hazards
- Floods
- Weather fluctuations
- Wildfires
- Industrial and energy hazards
- Radiation hazards and nuclear hazards
- Hazards related to human health
- Hazards related to animal and plant health
- Environmental, land, marine, or water pollution
- Disaster hazards associated with large human settlements.

Algeria has experienced a series of natural disasters in recent decades, particularly earthquakes that have caused significant loss of life and property damage. The most devastating of these was the Chlef earthquake 1980. In the aftermath of this disaster, it was decided to establish a framework for the prevention and management of natural or industrial disasters. This led the public authorities to issue two decrees in 1985 on disaster prevention and emergency organization (Decrees 85-231 and 85-232).

METHODS AND TOOLS

Conceptual framework definition of disaster

Risk: The combination of the probability of an event and its negative consequences. This definition closely follows the definition of the ISO/IEC Guide 73 standard. The word “risk” has two distinct connotations: in common usage, the emphasis is generally on the notion of chance or possibility, as in “the risk of an accident”, whereas in its technical usage, the emphasis is generally on the consequences, in terms of “potential losses” for certain assets, places, and periods. (UNISDR, 2009).

Historically, risk was considered a direct consequence of a hazard. This is especially evident in the context of natural hazards (TAMER, 2019). The term hazard, or “chance” in English, denotes a physical event with the potential to cause damage (VALY, 2011). Also, hazard is defined “in a narrow sense, by the probability of occurrence of a phenomenon” (DAUPHINÉ, 2003).

DEFOSSEZ (2009) mentions that risk is considered as a combination of several variables and is constructed from experience and representations, becoming a “social object” (VEYRET, 2004). As a result, it evolves according to societies and spatial and temporal scales. There is therefore a plurality of risks that are customarily classified into categories: health risks, technological risks, urban risks, social risks, natural risks, etc.

VALY (2011) offers a simple definition of risk: it is the intersection of a hazard and a vulnerability. Considering the complexity of reality, risk as the intersection of a hazard and a vulnerability does not necessarily account for the interactions between the two entities. When risk is associated with a

simultaneous consideration of frequency and severity, it allows for the definition of three risk domains: individual, medium, and major.

Definition of risk

An incident resulting from inherently hazardous activities due to the use of hazardous materials or unsafe conditions, such as those caused by “natural disasters” (ZROUK & HAMIDA, 2018).

The algerian legislator, on the other hand, has adopted the term “major hazard” for the concept of risk, and it is defined in article 2 of Law 04-20 on the prevention of major hazards and disaster management in the framework of sustainable development:

As any potential threat to humans and the environment that can occur as a result of exceptional natural hazards or human activities. The algerian legislator has described it as a major hazard due to its significant negative impacts on the environment and humans.

The definition of disaster is usually based on the losses caused by a particular phenomenon, whether natural or human-induced, ranging from material losses to the loss of many lives. Disaster is defined as a sudden event, often caused by nature, that threatens the social and economic interests of society, disrupts the natural balance and economic stability of countries on a daily basis. A disaster can disrupt or even paralyze the daily lives of citizens. (AL-KATROUSI, 2017).

A disaster is an incident that results in significant losses and damage to human life and property, as well as the psychological and social consequences that follow.

Disasters can be of natural geological origin, such as earthquakes, volcanoes, landslides, and avalanches; natural climatic origin, such as floods, hurricanes, snowstorms, and the effects of global warming; or human-induced technical origin, such as explosions, emissions, and nuclear interactions. Each of the above sources can lead to social, economic, and environmental humanitarian crises.

All definitions agree that the term “disaster” refers to a “sudden event” that occurs without warning and can generally paralyze the social and economic life of the entire community or part of it.

Characteristics of natural disasters

Natural disasters are typically characterized by their sudden occurrence, leading to several distinct features: (AL-DULAIMI, 2009).

- Speed of occurrence and progression: natural disasters can occur within a matter of seconds or may unfold over several days. This rapid onset can make it challenging to react effectively and provide timely warnings.
- Rapid impact: natural disasters can have a swift and devastating impact on the areas they affect. The destructive force of these events can cause widespread damage and loss of life within a short period.
- Limited control and prevention: natural disasters are

often difficult to control or prevent. While mitigation efforts can reduce vulnerabilities and prepare communities for potential hazards, the inherent unpredictability of these events makes it challenging to fully eliminate the risk they pose. In addition to the following: (AL-KATROUSI, 2017).

- High levels of stress and loss of individual and group control: natural disasters can induce intense stress, anxiety, and a sense of helplessness among individuals and communities. The sudden onset and unpredictable nature of these events can lead to a loss of control and a breakdown of normal social structures.
- Psychological and emotional distress and abnormal behaviors: the trauma experienced during natural disasters can trigger a range of psychological and emotional reactions, including fear, panic, depression, and post-traumatic stress disorder (PTSD). These reactions can manifest in various ways, including abnormal behaviors, difficulty concentrating, and sleep disturbances.
- Disruptions in data and information analysis: the chaotic and overwhelming nature of natural disasters can hinder the effective collection, analysis, and dissemination of critical information. This disruption can lead to delayed or inaccurate decision-making, hampering response and recovery efforts.
- Significant challenges for officials in rapid response and relief coordination: natural disasters pose a significant challenge for authorities in terms of organizing a timely and effective response. The urgency of the situation, coupled with the scale of destruction and the need to coordinate multiple agencies, can make it difficult to mobilize resources, provide aid, and care for the affected population.
- Necessity for innovative and unconventional coping mechanisms and international expertise: the unique challenges posed by natural disasters often demand creative and unconventional approaches to mitigation, response, and recovery. Drawing upon international experiences and best practices can be crucial in developing effective strategies for dealing with these complex events.
- Optimal utilization of available resources and capabilities: effective disaster management requires the efficient allocation and utilization of all available resources, including human capital, financial resources, and technological capabilities. Optimizing the use of these resources is essential for maximizing the impact of response and recovery efforts.
- Requirement for a robust communication system and unified information network: effective communication is paramount in disaster management. A high-level

communication system and a unified information network are essential for disseminating timely and accurate information to the public, raising awareness, providing reassurance, and dispelling rumors.

- Addressing parallel media and false rumors and implementing mitigation strategies: the spread of false information and rumors can exacerbate the chaos and confusion during natural disasters. Counteracting parallel media and addressing the spread of misinformation is crucial for maintaining public trust and ensuring effective communication.

Types of natural disasters

Natural disasters can be classified into various categories based on their origin or triggering event (HASSAN, 2022), the main types of natural disasters are shown in Fig. 1.

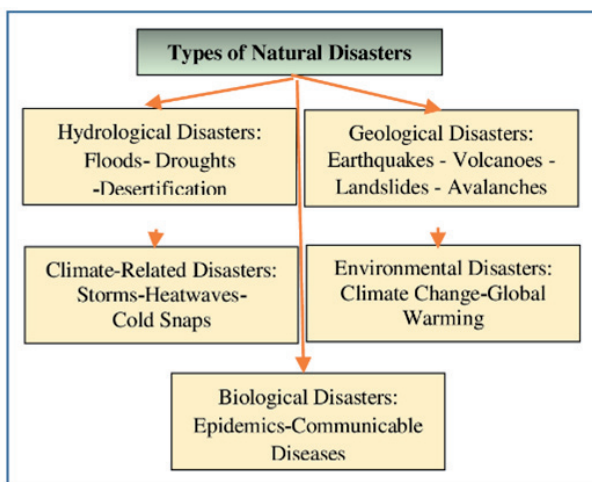


Fig. 1 - Types of natural disasters (Source: HASSAN, 2022+Author's treatment)

Based on the preceding figure, natural disasters have been categorized into five primary groups according to their origin and source. The first category encompasses geological disasters, such as earthquakes, volcanic eruptions, landslides, and avalanches, which are triggered by disruptions in the Earth's crust or other external factors.

The second category is primarily associated with hydrological disasters, including floods, droughts, and desertification. These phenomena are often the result of climatic changes induced by global warming. The third category pertains to meteorological disasters, characterized by events such as storms, heatwaves, and cold snaps. The fourth category encompasses climate-related disasters, which are linked to broader climatic fluctuations and global warming. Finally, the fifth category consists of biological disasters, including epidemics and infectious diseases, which have become a growing global concern.

Major natural disasters: a growing concern for Algeria

Northern Algeria is situated in a geologically unstable zone characterized by a series of faults due to the convergence of the Eurasian and African plates. This convergence results in a northwestward movement at a rate of 4 mm/year (in the west) and 6 mm/year (in the east). Consequently, most earthquakes in northern Algeria are associated with reverse faults, reflecting the compressive movements along the boundary of these two plates (BENOUAR *et alii*, 1994; MEGHRAOUI *et alii*, 1996; HAMANE, *et alii*, 2023).

Algeria has been subjected to violent seismic events that have caused numerous casualties and extensive damage, with massive destruction affecting several regions of the country, such as Chlef in 1980, an event that will forever be etched in the memory of Algerians. In 1996, Algiers experienced an earthquake with a macroseismic radius of 140 km, affecting areas like Ain Bénian, Chéraga, and Staouali. In 1999, Ain Temouchent was struck by an earthquake with a macroseismic radius of 260 km. Most recently, the Boumerdes earthquake served as a stark reminder that heavily populated northern Algeria is not immune to natural disasters. This has heightened the perception of seismic risk, which is the product of seismic hazard and vulnerability. Given Algeria's recognized seismicity, this risk must be taken very seriously (BACHIR & REDJEL, 2009).

Major natural disasters, particularly earthquakes and floods, have become a significant concern for Algeria (Fig. 2). Over the past 50 years, these events have emerged as the primary natural hazards faced by the country. A joint report by the World Bank and the Algerian government highlights the increasing frequency of floods in Algeria (Photo 1), while earthquakes have caused the most significant human and material losses. The report further emphasizes the recurring nature of these crises, which annually claim the lives of 127 people, affect 37000 individuals, and inflict economic losses of \$173.7 million on the nation (<https://aawsat.com/>).

Since 1950, Algeria has experienced 83 natural disasters, resulting in over 8600 fatalities and material losses exceeding \$11 billion. The number of individuals affected by these catastrophes has surpassed 2.5 million, according to the same document circulated by local media outlets.



Photo 1 - The floods in Algeria (<https://lematindalgerie.com/des-images-chocs-des->)

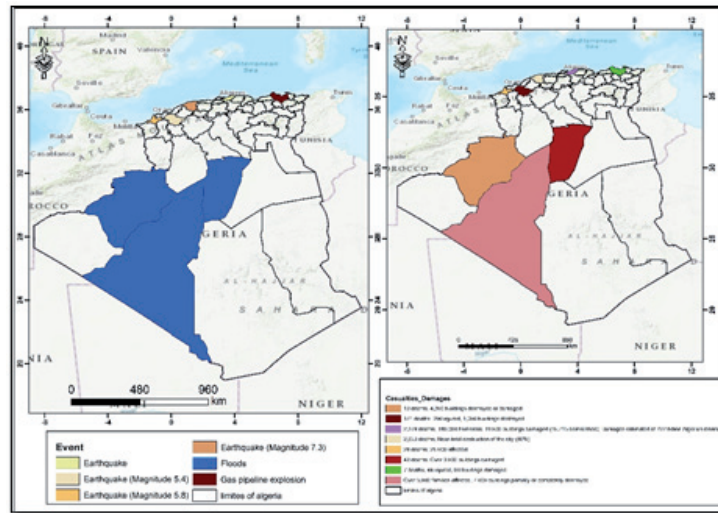


Fig. 2 - Major disasters that struck Algeria (Source: <https://www.interieur.gov.dz/index.php/ar/>)

However, the document highlights that the impact of historical disasters “only partially reflects the risks faced by the country, as potential losses could double to 0.7% of GDP annually on average” (<https://aawsat.com/>).

Since the 1950s, Algeria has experienced a total of 51 major floods (Photo 1), resulting in the tragic loss of 1870 lives and causing economic damage exceeding \$1.5 billion. A World Bank study further revealed that these floods have affected over 800000 individuals (<https://aawsat.com/>).

Algeria has been experiencing an average of 50 earthquakes per month in recent times. However, most of these earthquakes are not strong, with 90% of them being classified as weak and occurring far from urban centers.

Nevertheless, there have been instances of powerful earthquakes. Since 1954, Algeria has witnessed three major earthquakes: 1954 Chlef earthquake: This earthquake, with a magnitude of 6.7 on the Richter scale, struck west of the capital Algiers and resulted in 1243 fatalities. 1980 Chlef earthquake: Another earthquake hit the same city in 1980, this time with a magnitude of 7.1, causing 2360 deaths. 2003 Boumerdès earthquake: This earthquake, with a magnitude of 6.8, struck the Boumerdès region and claimed the lives of 2286 people (Photos 2, 3).

The preceding figure presents two maps. The map on the left depicts a map of natural disasters that have affected Algeria, particularly earthquakes that have struck the northern Tell region with varying intensities, the most severe being those in Chlef and Boumerdès. Additionally, hydrological disasters such as floods are highlighted, with a particular concentration in southern Algeria. The map on the right illustrates the number of casualties and the losses incurred due to natural disasters that have struck Algeria.

In response to these events and concerns over potential natural disasters, the Algerian government launched urgent

measures in September 2023 to enhance disaster preparedness and response capabilities. This included a comprehensive review of the law on major hazards. The plan was implemented in light of the earthquake that struck Morocco and the floods that affected Libya during the same month.



Photo 2 - The Chlef earthquake 1980 (<https://www.algerie360.com/seisme-10-octobre-1980-chlef-sen-souvient-encore/>)



Photo 3 - The Boumerdes earthquake 2003 (<https://www.algerie360.com/seisme-de-boumerdes-de-2003-les-victimes-toujours-dans-nos-memoires/>)

The legal review introduced a “major hazard surveillance and management plan” to be implemented by five ministries. This plan also included the establishment of a digital platform in each

of the country's 58 provinces to monitor climate changes in all regions and notify public authorities of any potential threats to the area and its inhabitants. (<https://aawsat.com/>).

Laws and regulations for protection against major hazards in Algeria

As in most earthquake-prone countries, Algerian seismic building codes have evolved over time to incorporate lessons learned from international and national earthquakes, particularly those in El Asnam and Boumerdes. Historically, the first seismic measures applied to constructions in Algeria were those taken by Dey Ali Chaouch after the 1716 Algiers earthquake, which killed 20000 people and destroyed the city. Based on observations of post-earthquake damage, these preventive measures primarily consisted of recommendations for strengthening masonry structures (the most commonly used construction method at the time), arcade structures (well-known in Muslim architecture), wooden floors, bays, and corbels. More than two centuries later, the 1954 Orléansville earthquake led to the introduction, in May 1955, of french seismic construction recommendations, known as AS 55, which outlined general principles of seismic design and constituted the first seismic regulation applicable in Algeria. The devastating consequences of the 1980 El Asnam earthquake led to the development of the technical document "DTR BC 2-48," known as the Algerian Seismic Regulation (RPA 81), which has evolved over time (modified in 1983, 1989, 1999, 2003, and 2010) to incorporate lessons learned from major earthquakes in

Algeria and advances in seismic risk knowledge. (Lessons learned from past earthquakes: The case of the city of Chlef (Algeria), (BOUTARAA & VERRHIEST-LEBLANC, 2013).

Key measures

- 1984: Establishment of a national committee involving all relevant sectors.
- 1985: Adoption of a national disaster prevention, intervention, and relief plan by the algerian government.
- Executive Decree 85/232 of May 25, 1985: Addressing short- medium-and long-term prevention of major disasters.
- Law 90/29 of December 1, 1990: defining protection zones at the municipal level and setting conditions for land use planning and building construction to prevent natural hazards, within the framework of the Land Use Plan (POS).
- Law 01/20 of December 12, 2001: concerning land use planning and sustainable development. Article 4 states: "The national policy for land use planning and sustainable development aims to develop the entire national territory in a harmonious manner based on the characteristics and potential of each regional space

as well as to protect regions and populations from the hazards associated with natural fluctuations."

- Law 04-20 of 2004: concerning the prevention of major hazards and disaster management in the framework of sustainable development. Article 6 states: "The rules for the prevention of major hazards and disaster management aim to prevent major hazards and deal with their effects on human settlements, activities, and the environment, with the goal of preserving development and the heritage of future generations and ensuring this."
- Law 10-11 of 2011: concerning the municipality, Article 89 states: "The president of the municipal people's assembly shall take all necessary precautions and preventive measures within the framework of the laws and regulations in force to ensure the safety and protection of persons and property in public places where any disaster or accident may occur."
- Law 04-20 on the Prevention of Major Hazards and Disaster Management in the Framework of Sustainable Development, Issued on December 25, 2004, Article 7 states that (OFFICIAL GAZETTE OF THE ALGERIAN REPUBLIC, No. 84, 2004):
 1. Enhance knowledge of hazards and strengthen their monitoring and anticipation.
 2. Take into account hazards in the use of land and construction.
 3. Implement arrangements aimed at coherent, integrated, and adaptable management of any disaster with a natural or technological source.

As outlined in Article 8 of the Law on the Prevention of Major Hazards and Disaster Management (OFFICIAL GAZETTE OF THE ALGERIAN REPUBLIC, No. 84, 2004), the principles of prevention of major hazards and disaster management are as follows:

1. Precautionary principle:

- uncertainty should not be a barrier to taking preventive measures;
- despite the limitations of current scientific and technical knowledge, proactive actions should be taken to avert potential hazards;
- preventive measures should be proportionate to the potential risks and economically feasible.

2. Principle of interdependence:

- the interconnectedness and potential cascading effects of multiple hazards must be considered;
- hazard assessment and vulnerability evaluation should account for the complex interactions and cumulative impacts of various hazards;
- risk management strategies should address the interplay of different hazards and their combined effects.

3. Source-oriented prevention and correction principle:

- preventive measures should prioritize addressing the root causes of vulnerability;
- hazard prevention efforts should focus on eliminating or reducing the susceptibility of people, property, and the environment to potential hazards;
- source-oriented prevention should employ the best available techniques and be economically justifiable;

4. Participation Principle:

- public participation is essential in hazard prevention and disaster management;
- citizens have the right to be informed about potential hazards, vulnerability factors, and risk mitigation strategies;
- open communication and transparency are crucial for building trust and encouraging public engagement.

5. Integration of New Technologies Principle:

- hazard prevention systems should embrace technological advancements;
- continuous monitoring of technological developments in hazard prevention is essential;
- new technologies should be integrated into prevention and mitigation strategies whenever appropriate.

Specific provisions for each hazard

Chapter II of Part II of the Law on the Prevention of Major Hazards and Disaster Management (OFFICIAL GAZETTE OF THE ALGERIAN REPUBLIC, No. 84, 2004) focuses on specific provisions for each hazard category. These provisions outline the legal framework and requirements for preventing and mitigating various types of hazards.

1. Provisions for earthquake and geological hazard prevention;
2. Provisions for flood prevention;
3. Provisions for climate hazard prevention;
4. Provisions for forest fire prevention;
5. Provisions for industrial and energy hazard prevention;
6. Provisions for radiation and nuclear hazard prevention.

Disaster management

Seismic risk management is a challenging task that requires the development of several joint and synchronized actions, the goal of which is to reduce this risk and limit the consequences of an earthquake in the area in question (BOUTARAA, 2013).

Disaster risk management is a systematic process of using policy, strategy and appropriate operational, administrative and financial capacities to implement the necessary measures to reduce the negative effects of natural hazards and related environmental and technological disasters. This term is an extension of the more general term “risk management” to address the specific issue of disaster risks. Disaster risk

management aims to avoid, mitigate or transfer the adverse effects of risks through prevention, mitigation and preparedness activities and measures (UNISDR, 2009).

Disaster management refers to the comprehensive set of phases and processes that encompass the entire disaster cycle, from prediction and preparedness to response and recovery. It entails a holistic system of laws, mechanisms, and strategies aimed at minimizing the adverse impacts of a specific hazard or containing a disaster.

Hazard management encompasses a series of interconnected organizational and assessment measures that a society undertakes to confront potential hazards.

This term allows for the integration of all the findings of human and technological sciences that come together to address major hazards (VEYRET, 2007). The primary objective of disaster and major hazard management is to prevent the occurrence of hazards or mitigate their consequences and impacts.

The disaster management system in Algeria (Fig. 3) is established in accordance with the Law on the Prevention of Major Hazards and Disaster Management (OFFICIAL GAZETTE OF THE ALGERIAN REPUBLIC, No. 84, 2004). The system encompasses the key components shown in Fig. 3.

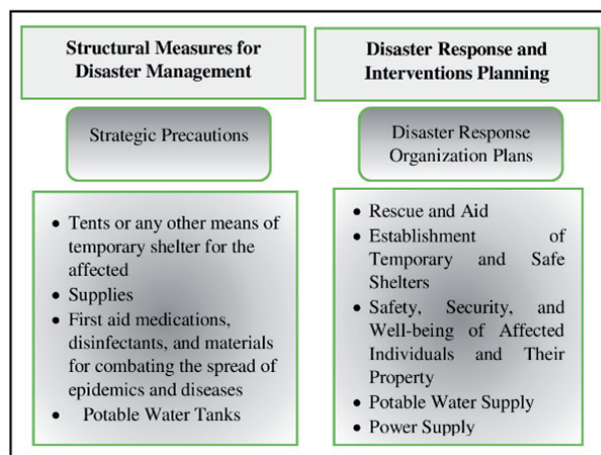


Fig. 3 - Disaster management system in Algeria (Source: OFFICIAL GAZETTE - Number 84, 2004+Author's treatment)

The preceding figure illustrates the disaster management system in Algeria. This system is based on two phases. The first phase concerns the structural measures for disaster management, including strategic precautions such as providing shelter for the affected, as well as supplies of food, water, and medicine. The second phase involves developing a response plan to ensure the safety and security of the victims and to provide a power supply.

System of specialized bodies for disaster and major hazard management in Algeria

In Algeria, there are numerous governmental and civil

institutions tasked with intervening before, during, and after disasters. These institutions play a crucial role in disaster management and include:

Natural disaster and major hazards fund

Established by Decree 402-90, the Natural Disaster and Major Hazards Fund aims to mitigate the impacts of natural disasters and technological hazards. Its revenues come from the contribution to the legal reserve of solidarity established by Law 14-82 of December 30, 1982, relating to the Finance Law for the year 1983. It is noteworthy that this fund plays an important role in major hazard management by spending on studies related to these hazards. It should be noted that this decree was amended in 2017 to replace the term “technological hazards” with “major hazards” in line with the national major hazard management system in force since 2004. However, the fund remains inactive in terms of disaster prevention, being limited to a limited role in managing natural disasters (RADWAN, 2023).

National Delegation for Major Hazards

In order to implement the national policy on major hazard prevention and disaster management, the Ministry of the Interior and Local Authorities has established a national body for this purpose, responsible for dealing with natural phenomena by developing a national strategy to combat the various major hazards to which Algeria may be exposed (RADWAN, 2023).

The National Delegation for Hazards is an institutional body whose tasks and powers are defined in Executive Decree 194-11 of May 22, 2011. The delegation coordinates and evaluates direct activities within the framework of the national major hazard prevention system, and is responsible in particular for the following (Executive Decree, 2011):

- Collecting information on major hazard prevention from the relevant administrations and preparing a database of related operations.
- Promoting and developing the field of major hazard prevention for the benefit of stakeholders and the population.
- Evaluating and coordinating direct activities within the framework of the national major hazard prevention system and making proposals to improve its effectiveness.
- Participating in regional and international cooperation programs related to its missions.
- Contributing to the promotion of scientific and technical knowledge and training in the field of major hazards.

Other stakeholders involved in major hazard prevention

- Local authorities
- Civil protection
- National People’s Army
- Charities
- Civil society

Disasters and major hazards in Algeria: the Boumerdès earthquake as a case study

The Tell region is found to be the most exposed to earthquakes. It is classified as Zone III (high seismicity).

The high plateaus region is classified as Zone II (moderate seismicity). The Saharan Atlas region experiences low seismicity (and is therefore classified as Zone I) (Fig. 4).

As for the Grand Sahara, seismic activity is negligible (Zone 0). Zoning carried out by the DGPC82 services indicates that the regions of El Asnam, Oran, and Algiers are the most threatened given the devastating earthquakes that have occurred there. In general, earthquakes occurring in Algeria are of low to moderate magnitude. Nevertheless, they can reach a magnitude of 6.0. In some cases, they exceed 6.5 and reach a magnitude of 7.5. These earthquakes are generally shallow and do not exceed 15 km in depth.

This makes them more perceptible to the population and therefore more dangerous. Seismic activity in northern Algeria is continuous as it occurs throughout the year.

About thirty micro-shocks are recorded each month, which are not felt by the population. Approximately every two months, an earthquake with a magnitude greater than 3.5 occurs. It is also noted that seismic activity in the last century has been more intense in the western part of the country than in the east and center (TAMER, 2019).

Seismic zoning map: the national territory is divided into five zones: Zone 0: negligible seismicity; Zone I: low seismicity; Zone II: moderate seismicity; Zone III: high seismicity.

This map illustrates the location of Boumerdès province—severely affected by the devastating 2003 earthquake—within Algeria, as well as its position relative to neighboring provinces.

Algeria, a country situated in North Africa, is prone to various natural and technological hazards, including earthquakes, floods, wildfires, and industrial accidents.

Among these hazards, earthquakes pose a significant threat, with the potential to cause widespread destruction and loss of life. The 2003 Boumerdès earthquake stands as a stark reminder of the devastating impact earthquakes can have on communities. The Boumerdès Earthquake: a catastrophic event on May 21, 2003, at 7:44 PM local time, a powerful earthquake of magnitude 6.8 struck the town of Thénia in Boumerdès Province, Algeria (Fig. 5). The earthquake, with its shallow focal depth of only 10 kilometers it caused violent shaking that was felt by residents throughout the region, including the capital Algiers, which is located about 60 kilometers to the east unleashed immense destructive power, causing widespread damage and casualties. The Boumerdès earthquake resulted in a tragic loss of life, with over 2200 people killed and more than 10000 injured.

The quake displaced over 180000 individuals, leaving them homeless and destitute. The physical damage was extensive, with over

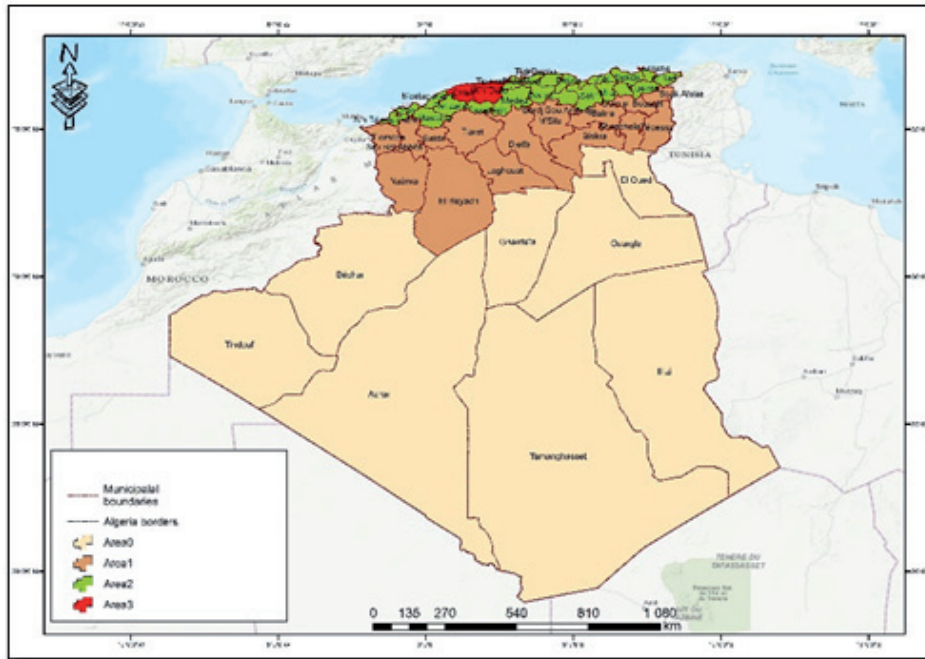


Fig. 4 - Seismic zoning of Algeria (Source: realised by authors, 2024+DGPC)

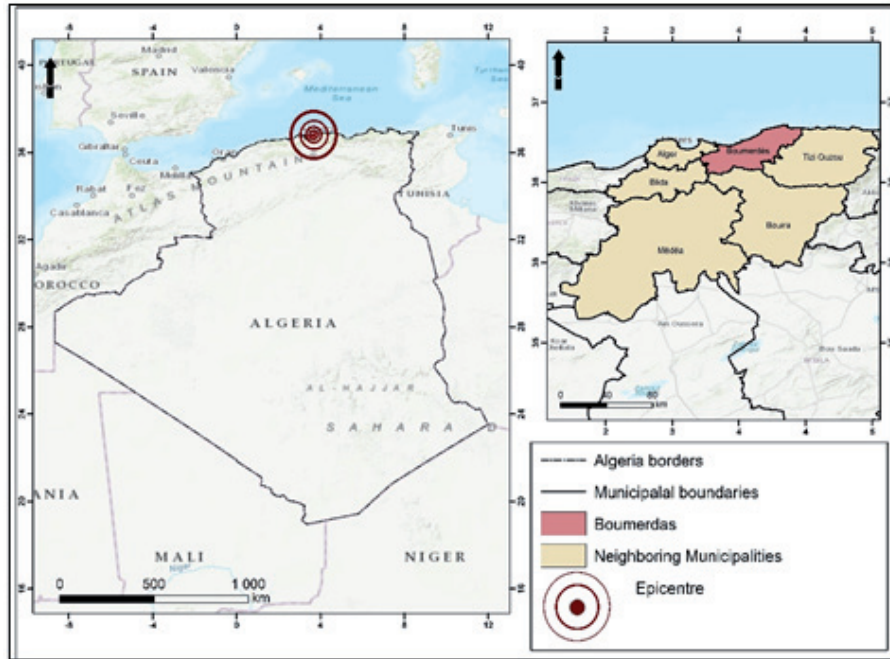


Fig. 5 - Location of the province on Boumerdas and epicentre (Source: realised by authors, 2024)

1243 buildings either severely damaged or completely collapsed. The earthquake also caused significant infrastructure damage, affecting roads, bridges, and other essential services. The economic toll was substantial, with estimated losses exceeding \$500 million.

The Boumerdès earthquake occurred at the boundary between two continental plates, the Eurasian plate and the African plate. Along this segment of the plate convergence zone, the african plate is moving northwestward relative to

the Eurasian plate at a rate of 6 millimeters per year. These movements lead to tectonic compressions, causing earthquakes through collision and collapse. Algeria has previously experienced several destructive earthquakes, including: the 1980 Chlef earthquake, a previous earthquake in the same area in 1954, and a 1989 earthquake that killed at least 30 people.

Tsunami following the earthquake

A shallow earthquake on May 21, 2003, triggered a tsunami that was observed by numerous witnesses and recorded by tide gauges in the western Mediterranean. However, the Algerian coast was apparently not affected by the earthquake-generated waves that caused the tsunami.

While these waves caused significant damage 300 km north of the earthquake epicenter in the Balearic Islands east of Spain and the northern Mediterranean, according to news reports, a port on the island of Menorca suffered extensive damage. Experiencing devastating earthquakes, with several notable events leaving a trail of destruction and loss of life.

Impact of these earthquakes

These earthquakes, along with the 2003 Boumerdès earthquake, highlight the seismic vulnerability of Algeria and the need for robust disaster preparedness measures. The destructive power of these events underscores the importance of enforcing strict building codes, investing in early warning systems, and promoting public awareness campaigns to minimize the impact of future earthquakes.

The recent devastating earthquakes that struck Syria and Turkey on February 6, 2023, leaving a trail of immense destruction and loss of life (exceeding 50,000 deaths), have underscored the significance of the 20th anniversary of the Boumerdès earthquake for Algerian authorities. In response, the Ministry of Housing, Habitat, and Urbanism organized an international conference under the theme "Earthquake Hazard Mitigation: Governance and Foresight." The conference brought together ministers from neighboring countries, including Turkey, Syria, and Libya, along with researchers from Algeria and abroad.

Perhaps the most important points discussed at the conference revolved around:

- updating the seismic building codes: this involves revising the existing regulations to ensure that buildings are better equipped to withstand earthquakes. The updated codes may include stricter requirements for structural design, materials, and construction methods;
- launching the National Major Risk Management Plan: this plan aims to establish a comprehensive framework for identifying, assessing, and mitigating major risks, such as earthquakes, floods, and wildfires. The plan may include measures such as early warning systems, disaster preparedness training, and infrastructure resilience projects. The Ministry of Interior is currently

finalizing the National Major Risk Management Plan before submitting it to the Council of Government for approval. Once approved, the plan will provide a roadmap for enhancing Algeria's resilience to major disasters. As for the current Algerian seismic codes, which were last updated in 2003 (after the earthquake), their development will be an absolute necessity. The map of earthquake-prone areas in Algeria should be updated, as well as the earthquake-resistant design philosophy, which should take into account the tremendous technological progress in building materials and methods, as well as in techniques for reducing the impact of earthquakes, such as base isolation and dampers. In addition, updating the seismic codes should be done regularly and continuously, and should be subject to global studies and research, as well as observations made after earthquakes around the world, and not just in Algeria, as is the case in other earthquake-prone countries which, for example, update their codes every 3 or 5 years. (RAHMANI ABDULLAH, 2023).

What after the earthquake?

Perhaps the most frequently asked question in recent times is: what about after the earthquake? Once the ground tremors subside, the displaced and survivors will face the most difficult circumstances. Some will spend long periods in camps, while others will live in ruins or fragile buildings that could put their lives at risk. Even if some people's homes withstand the earthquake and remain standing, they will not be able to live in them due to power, water, and gas outages, which the earthquake may have damaged.

Numerous questions will arise at that time: How will these people get their salaries? How will their children go to school? What is the state of the roads and bridges they will use to get around? How long will they have to stay in this situation? These are all questions that are being studied and researched. New Zealand, which has a sophisticated performance-based design philosophy, was able to significantly reduce the number of deaths and direct physical losses when an earthquake struck the Christchurch area in 2011. However, it failed to manage life after the earthquake and the reconstruction effort, which cost it more indirect losses than expected. This is precisely where the importance of comprehensive risk management plans lies, as they can mitigate both direct and indirect losses caused by earthquakes. Ultimately, Algeria and all earthquake-prone countries will be compelled to adopt a philosophy that goes beyond earthquake-resistant structures that save lives to resilient structures that ensure the continuity of life after a disaster. (RAHMANI ABDULLAH, 2023).

The aftermath of an earthquake: challenges and resilience

In the aftermath of an earthquake, when the tremors

subside and the dust settles, a new set of challenges emerges for survivors and displaced individuals. These challenges extend beyond the immediate physical destruction and encompass the complexities of rebuilding lives and communities.

The plight of survivors and displaced persons

Many survivors find themselves facing prolonged periods in shelters or camps, grappling with disruptions to necessities like water, electricity, and gas. The disruption of transportation networks further complicates daily life making it difficult to access essential services and livelihoods.

RESULTS AND DISCUSSION

Earthquake awareness is an ongoing process that requires the concerted efforts of all stakeholders to achieve a level of safety and protect lives and property. To this end, some countries at risk of earthquakes have developed roadmaps to mitigate the impacts of these hazards. Given that Algeria, as a country in the Mediterranean basin, is located in an earthquake-prone zone, we have chosen to present a scenario for “dealing with earthquake hazards and mitigating their severe consequences.” In this scenario, we will present the key experiences of Japan and Turkey in dealing with this disaster and, based on these experiences, we will propose a scenario for Algeria to address this crisis:

As Table 1 indicates, Japan and Turkey are among the countries that have prioritized public awareness as a primary preventive measure, following structural measures. This is achieved through educating the community and the population about the necessity of responding appropriately to disasters. The awareness strategy is centered on the importance of the population understanding the risk and how to deal with it through preparedness and organization courses, whether before, during, or after a disaster. These courses are provided by non-governmental organizations and associations at the

local level, especially at the neighborhood level. This is what is known as neighborhood-level preventive measures, which have been adopted in Japan, Turkey, and many other countries exposed to natural hazards such as earthquakes.

Earthquake response and mitigation scenario for Algeria

We have divided this scenario into two main phases (Fig. 6). The first phase is the pre-earthquake period, where actions focus on developing plans and strategies to confront the crisis and mitigate its impacts, especially the human and material losses caused by the earthquake’s force. This phase revolves around crisis management through the local emergency intervention plan, effective laws and strategies, particularly those related to construction and design standards, international agreements with countries and organizations experienced in crisis management, and finally, awareness-raising as an important factor in informing the public about the severity of the situation.

The second phase occurs post-earthquake and involves assessing and quantifying the damage. This involves implementing a national strategy primarily based on a comprehensive assessment of infrastructure, including buildings, bridges, dams, and more. Workshops will be organized to evaluate the results, and intervention methods will be updated to address earthquake victims through the development of technological tools such as maps and geographic surveys of affected areas. Collaboration with research centers will promote the application of more preventive measures, and educational programs will be updated to include safety guidelines before, during, and after earthquakes. Ultimately, awareness and sensitization remain key elements alongside structural interventions, and effective governance remains the solution.

Prevention in Japan	Prevention in Turkey
Adoption of structural preventive measures.	Comprehensive urban planning to mitigate these risks.
Significant focus on public awareness and citizen engagement in the prevention process.	Amendments to laws related to building inspections and mandatory earthquake insurance.
Fostering a genuine culture of risk management among the population from a young age.	Mandating municipalities to undertake reconstruction projects in accordance with standards to replace weak buildings.
Adoption of an urban preventive strategy.	Training, awareness-raising, and community-level self-organization among citizens.
Extensive and effective organization of first aid.	Development of an earthquake preparedness plan titled "Jehangir Emergency Guide," summarized in a booklet (available in Turkish and English) and widely distributed in the neighborhood.
Programming of alerts to encourage citizens to remain disciplined, avoid panic, cooperate, and monitor themselves and others.	
The success of its disaster risk management policy is attributed to a comprehensive view of risks through all non-structural preventive measures: training, public awareness, and especially the active role of civil society, particularly associations, most notably the Rokomi Association.	

Tab. 1 - Experiences of some countries in managing earthquake disasters (Source: realised by authors, 2024)

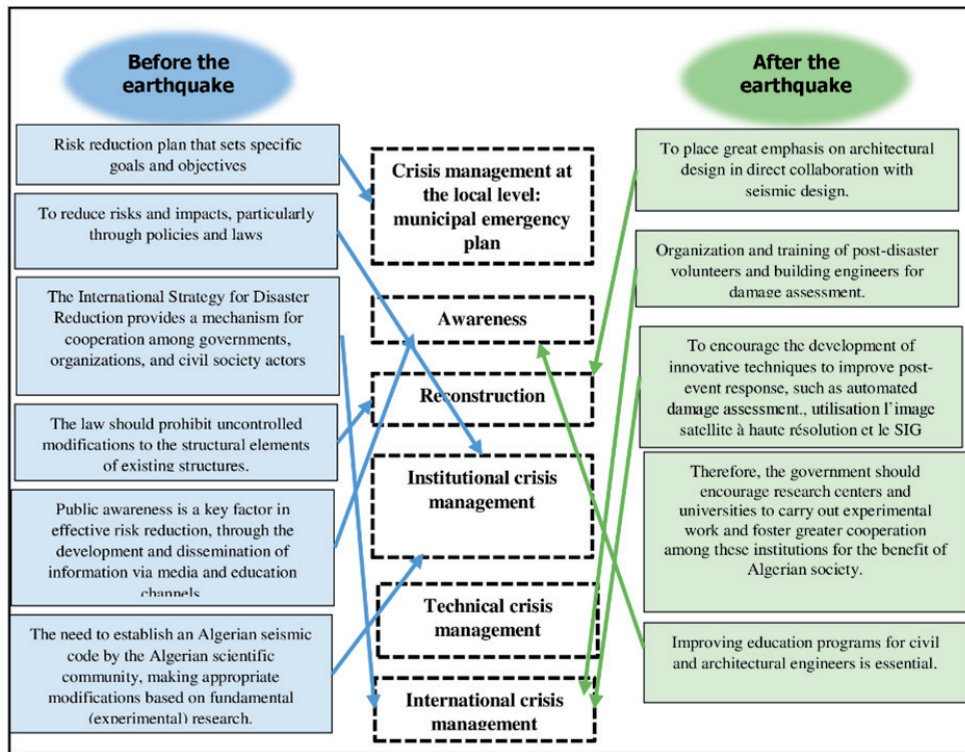


Fig. 6 - Earthquake response and mitigation scenario for Algeria (Source: realised by authors, 2024)

CONCLUSION

Major risks, especially those occurring in areas with economic and human activities, pose a significant challenge to state authorities in view of the negative impacts on the environment and the changes that arise from them and their impact on the lives of individuals.

Algeria has sought to avoid the disastrous consequences of major risks as it is one of the countries exposed to them, especially earthquakes and floods. Making it mandatory to be prepared for these phenomena is an absolute necessity to reduce their destructive effects and thus reduce the extent of damage and losses.

Algeria has suffered from numerous floods and earthquakes for decades, the most violent of which was the 1980 Chlef earthquake and the 2003 Boumerdès earthquake. These risks have constituted a major turning point in the risk management policy in our country by updating laws, regulations, methods and techniques, especially in the field of prevention.

The devastating earthquake that struck Boumerdès in 2003 was the starting point for a forward-looking vision for Algeria in terms of dealing with and preparing for earthquakes in particular and major risks in general, and thus providing a strategy to absorb the resulting damage and take care of everything related to post-disaster.

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