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ANALYSIS AND MAPPING OF THE VULNERABILITY OF TERRITORIES WITH MAJOR INDUSTRIAL RISKS AND THEIR IMPACTS ON URBAN MANAGEMENT IN THE WILAYA OF ALGIERS PRESENTED

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Abstract: Urban expansion in areas adjacent to industrial areas presents serious safety challenges, especially in fast developing areas. Nearly between residential and industrial activities increases the risk of accidents, environmental pollution and massive disasters. In response, industrial countries have adopted advanced management systems to reduce these risks. Of these, the Geographical Information System (GIS) provides a powerful tool for analyzing and mapping the areas coming in contact with industrial threats. The purpose of this study is to assess the role of GI in reducing industrial risks and focusing a specific focus on the Algerian context, reducing industrial risks and supporting permanent urban planning. Research adopts a spatial analysis approach using topological maps, geographical datasets and GIS software. Industrial areas and surrounding urban settlements were studied through layered spatial modeling. Supplementary area observation and case studies were included to validate the accuracy of GIS output. The analysis focused on identifying weak areas, assessing industrial threats and assessing the effectiveness of existing land-use and reaction strategies. Conclusions highlight the important weaknesses in current urban risk management systems, especially in terms of preparations and integration with spatial plan. The GIS proved to be effective in detecting high-risk areas, imagining dangerous areas and providing strategic support for the decisions of land-use. The device also featured landscape simulation, which improved the understanding of potential industrial accidents and their impact on nearby communities. The interpretation of these results suggests that GI increases urban flexibility, reduces exposure to industrial threa.

Keywords: urban risk, industrial hazards, GIS mapping, land-use planning, Algeria

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INTRODUCTION

1. Background of industrial development in Algiers

The commercial improvement in Algiers is closely connected to the city's increase and urban structure. With over 5.3 million citizens within the metropolitan vicinity, Algiers stands as the valuable hub for monetary activities in Algeria, website hosting each large agencies and the relevant government. This prominence underscores the pressing need for more desirable public services and green catastrophe hazard control systems (Boughedir, 2015). As urbanization transforms the cityscape, it's miles vital to address the results of business risks on city governance. Areas with big commercial dangers face important challenges that necessitate cautious scrutiny. Construction policies in these high-threat zones are vital for minimizing ability disasters, but existing risk management frameworks monitor tremendous weaknesses that require pressing reform. Industries play a key position in Algiers' economic panorama, however balancing their benefits towards the risks of industrial-associated disasters is critical. While industries can force financial growth, screw ups threaten to erode trust of the public, businesses, and policymakers, highlighting the significance of a shared obligation method to danger management (Saidi et al., 2023). In this context, Geographic Information Systems (GIS) function as powerful gear for figuring out prone areas and assisting sustainable city making plans via technology-based totally answers.

By making use of GIS, stakeholders can higher apprehend areas at danger because of commercial activities and increase strategies for sustainable urban development. Overall, understanding the dynamics of business boom in Algiers is important for comprehending the complicated courting among commercial operations and concrete governance. As vulnerabilities persist in areas exposed to giant industrial risks, collaboration among numerous stakeholders is critical for imposing effective risk control and promoting sustainable city making plans and projects (Sefouhi & Bahmed, 2023).

2. Importance of analyzing vulnerability of territories with major industrial risks

Assessing vulnerabilities associated with business risks in Algiers is crucial because of fast populace increase and concentrated monetary sports, with the metropolitan location housing over five.3 million residents. This awareness makes

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the town prone to capacity industrial hazards in spite of existing preventive measures. There is an urgent want for stronger public facilities and disaster chance control systems to deal with the increasing susceptibility of Greater Algiers (Boughedir, 2015). The effect of industrial risks on city control is sizable, necessitating stricter guidelines on construction in excessive-danger zones. The life of hazardous centers like refineries, energy flowers, and fuel pipelines poses threats now not only to the nearby populace but additionally to the surroundings. Recent commercial injuries in other cities, along with Skikda, highlight the dire results of those dangers, reinforcing the significance of complete risk assessment and mitigation techniques Bouzouaid & Benabbas (2020). Understanding city dangers involves spotting both normal and awesome dangers linked to human sports, natural activities, and technological advancements.

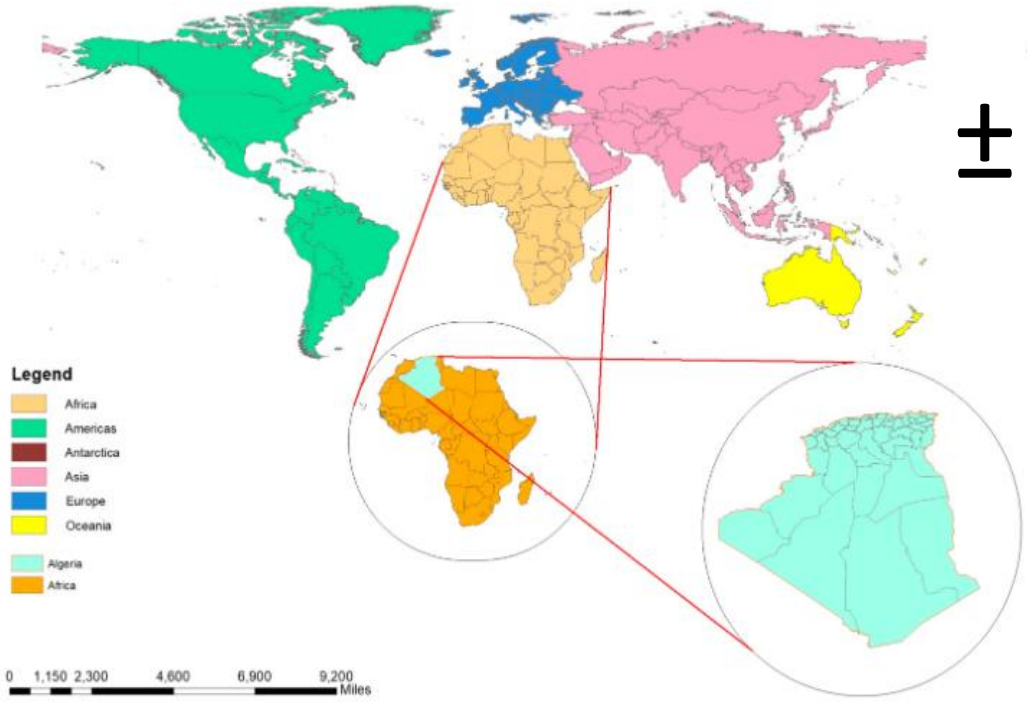

Figure 1. Location of the study area (Saidi et al., 2023)

Geographical location of the study area in Algiers is shown in Figure 1 that presents a spatial framework necessary to analyze the risk of industrial hazards (Saidi et al., 2023). Table 1 summarizes the broader demographic and regional background of the Algerian context by presenting the population distribution in the northern, highlands and southern regions, which reveals that most of the population is concentrated in the northern region in spite of the fact that this region has a relatively limited land area. The institutional and legal organization of the urban system is briefly described in Table 2, in which urban settlements are differentiated according to national planning laws, and hence, indicating a hierarchical territorial structure from metropolitan areas down to a smaller urban concentration. This hierarchy is a key factor in understanding the differential exposure to technical and industrial risks among settlement categories.

Table 1. Population distribution along the three major zones of Algeria (Source: general censuses (1998 and 2008) (Saidi et al., 2023)

Region	Population Share (%)	Land Area (km²)	Area Share (%)	Population Density (inhabitants/km²)
	1998	2008		
Northern	64.72	63.14	102,781.3	4.36
Highlands	26.57	27.39	303,231.7	12.78
Southern	8.71	9.47	1,975,729.8	82.86
Total	100.00	100.00	2,381,741.8	100.00

Table 2. Classification of urban settlements according to Acts 01-20 (2001) and 06-06 (2006)
(Law No. 01-20 of 12 December 2001 relating to the planning and sustainable development of the territory 2001;
Law No. 06-06 of 20 February 2006 relating to the urban orientation law 2006) (Source: Saidi et al., 2023)

Law	Typology	Definition
2001-20	Metropole	Urban area with at least 300,000 residents, playing roles at the regional, national, and international levels.
–	Large city	Urban zone with a minimum population of 100,000 inhabitants.
2006-06	Medium-sized city	Urban area where the population ranges between 50,000 and 100,000.
–	Small town	Urban settlement with a population between 20,000 and 50,000.
–	Urban concentration	Settlement classified as urban, with a minimum of 5,000 inhabitants living in close proximity.

Regional dynamics of urban growth is expressed in Table 3, which reveals a substantial variation in urban population growth from 1987 to 1998 among regions for spatial development. In addition, Table 4 illustrates the proportionate share of each region in national urban growth, thus highlighting the predominant role that the northern regions play in the

overall pattern of urbanization. Major technological risks arising from industrial complexes can generate serious consequences for populations, infrastructure and ecosystems (United Nations Office for Disaster Risk Reduction, 2013). Tackling such challenges requires strong coordination among stakeholders to support sustainable urban planning and effective risk management. In this regard, geographic information systems (GIS) provide important tools to identify vulnerable areas and guide resilience-oriented planning strategies Boubakeur (2022). In end, studying vulnerability to commercial risks in Algiers is important for sustainable improvement and resident properly-being. By organizing proactive threat control structures and engaging all applicable parties in choice-making approaches, Algiers can mitigate capability failures and enhance its resilience against commercial threats (Gheitasi et al., 2024).

Table 3. Presents regional urban population growth (1987–1998) as a percentage change from 1987 levels, based on census data adapted by the authors (Source: Saidi et al., 2023)

Spatial Development Regions	Number of Urban Settlements	Total Urban Population	Urban population in settlements ranging from 5,000 to 19,999 residents	Population of Small Towns	Population of Medium-Sized Towns	Population of Large Cities	Population of Metropoles	Population of Primary City
North Centre	+60	+50	+106	+56	+36	+64	+23	+23
North East	+63	+52	+79	+65	−22	+209	+9	+9
North West	+68	+53	+59	+68	+123	+43	+22	+22
Highland Centre	+72	+93	+117	−26	+65	/	0	+88
Highland East	+102	+71	+107	+62	+21	+85	0	+36
Highland West	+57	+77	+114	−14	+26	/	0	+55
South East	+40	+68	+45	+123	−56	+202	0	+38
South West	+56	+51	+55	+137	0	+25	0	+25
Hoggar Tassili	0	+142	−9	0	/	0	0	+72
Total	+65	+58	+85	+54	+34	+127	+19	+26

Table 4. Shows the regional share of urban population growth (1987–1998) as a percentage of the national total, adapted by the authors from census data (Source: Saidi et al., 2023)

Spatial Development Regions	Number of Urban Settlements	Total Urban Population	Urban population in settlements ranging from 5,000 to 19,999 residents	Population of Small Towns	Population of Medium-Sized Towns	Population of Large Cities	Population of Metropoles	Population of Primary City
North Centre	31	34	36	38	40	11	68	46
North East	16	14	17	15	0	18	11	4
North West	17	16	14	15	23	9	21	15
Highland Centre	6	9	7	0	18	13	0	8
Highland East	17	14	14	11	8	20	0	8
Highland West	5	5	6	0	5	13	0	8
South East	6	7	5	20	0	13	0	4
South West	2	2	1	2	0	2	0	4
Hoggar Tassili	0	0	0	0	8	0	0	4
Total	100	100	100	100	100	100	100	100

3. Purpose of the report

The control of industrial risks in Algiers is critically examined, with a focus on areas at risk of significant industrial hazards. Developing countries like Algeria face extraordinary demanding situations in handling and putting off industrial waste due to limited assets and insufficient practices. This evaluation highlights how the wrong storage and control of unsafe substances from groups, such as NCWW, can adversely have an effect on human fitness and the surroundings. By comparing those risks, selection-makers can create sustainable management structures that correctly mitigate capacity dangers (Rezvani et al., 2023). The file explores the role of Geographic Information Systems (GIS) in figuring out urban areas susceptible to business dangers. GIS technology allows stakeholders to enforce sustainable city making plans techniques, thereby minimizing the effect of commercial hazards on urban environments in Algiers (Boughedir, 2015).

Additionally, it proposes a collaborative method to deal with the cutting-edge shortcomings in threat control systems, enhancing standard techniques for risk mitigation (Sefouhi & Bahmed, 2023). Economic advantages from industries in Algiers are recounted along public distrust as a consequence of failures connected to business risks. Understanding these dynamics permits for higher pointers for sustainable urban making plans aimed toward mitigating dangers while fostering collaboration among stakeholders to enhance hazard control consequences (Khenoussi & Medjden, 2020). In the end, this complete evaluation pursuits to provide precious insights into business risk control in Algiers via vulnerability mapping strategies, nice practice exploration from other urban contexts, and actionable hints for sustainable risk mitigation techniques (Boughaba et al., 2014). The closing goal is to make a contribution to more resilient and steady surroundings for all concerned stakeholders by addressing the complexities of industrial dangers and their effect on city control structures in Algiers (Saadia, 2023).

INDUSTRIAL RISKS AND URBAN MANAGEMENT

1. Impact of industrial risks on urban management in Algiers

Industrial hazards are a major challenge that urban governance has to deal with in Algeria. This is especially true for the rapidly expanding cities where, due to uncontrolled urbanization, there has been a spread of vulnerable buildings around pipelines, high, voltage power lines, and hydrocarbon infrastructures. Besides, this type of spatial disorder not only changes

the face of the city and its architectural heritage but also increases the levels of environmental and technological vulnerability. With the case of Hassi, Messaoud, the mixture of residential neighborhoods with oil wells, pumping stations, and petrochemical facilities makes the risk extremely high to the extent that, without the strict enforcement of safety regulations, the areas concerned could become a human and ecological disaster (Bouzouaid & Benabbas, 2020).

The spatial layout of urban areas and hydrocarbon exploitation is presented in Figure 2, which demonstrates the closeness of residential areas to extraction facilities. Besides, Figure 3 points out the territorial scope of the areas exposed to industrial hazard risk. It reveals that the zones where people live, services, and infrastructures are among the areas impacted by hazardous influence zones. These spatial distributions are a clear indication of the urban system's extreme vulnerability and the critical need for implementation of integrated land, use control.

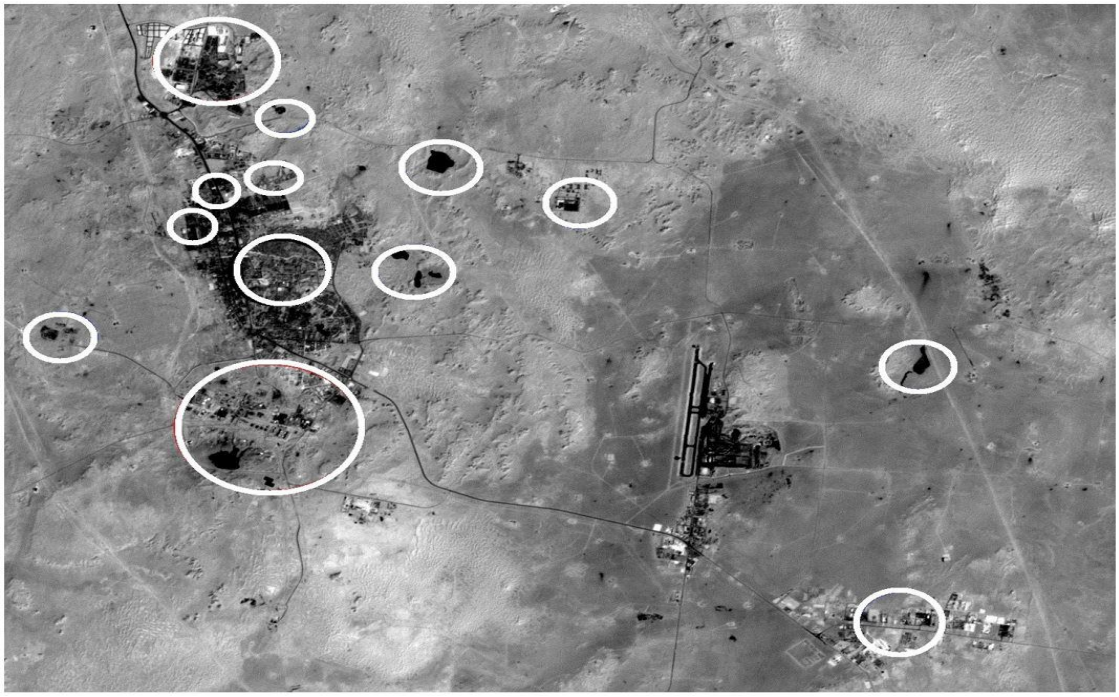

Figure 2. Agglomeration of Hassi-Messaoud, Location of oil exploitation sites
(Source: Land-SAT modified image, authors, 2018; Bouzouaid & Benabbas, 2020)

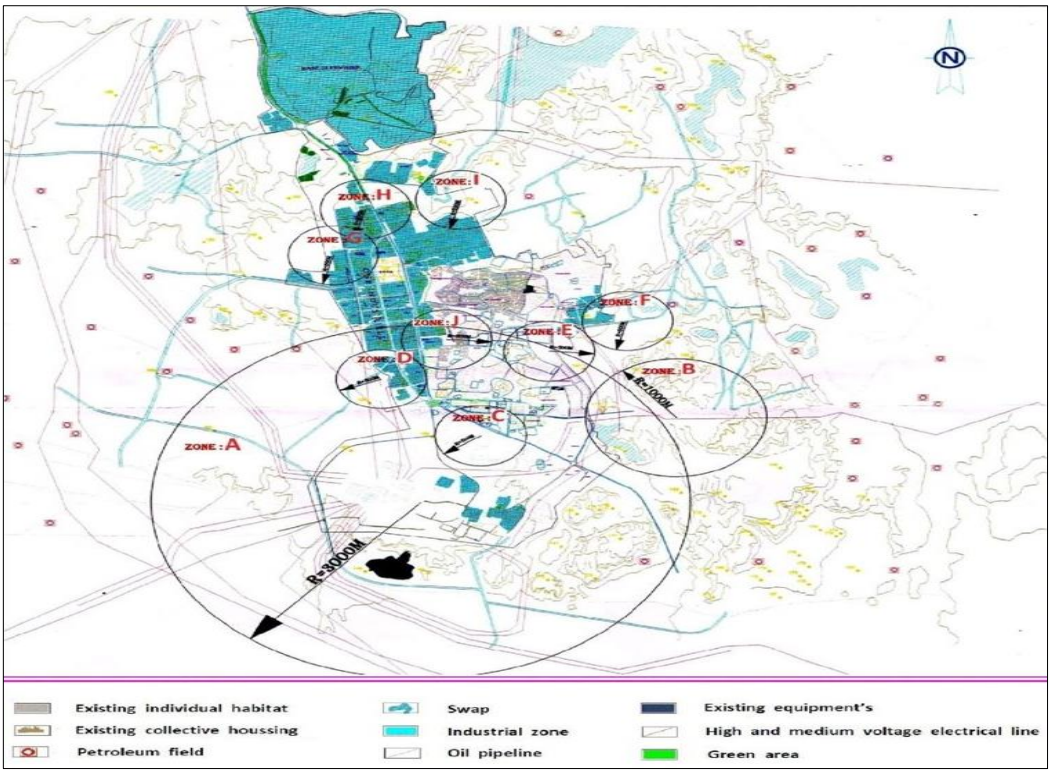

Figure 3. Agglomeration of Hassi, Space concerned by the risk
(Source: PDAU, First Phase, URBASE-Setif, modified by authors, 2018; Bouzouaid & Benabbas, 2020)

A comprehensive classification of hazards is presented in Table 5, where the risks are divided by different criteria such as operational zones, infrastructure networks, and land, use functions. Besides, the table points out the predominance of the risks from explosion, fire, pollution, electrification, and flooding, especially in those areas, where pipelines, electrical networks, storage facilities, and railway infrastructures are crossing one another. The multidimensional risk structure, thus, is an embodiment of the complex interrelations of industrial systems, on the one hand, and urban occupation, on the other.

Apart from the hazard typology, Table 6 outlines the spatial, demographic, and functional attributes of the exposed areas. It shows a considerable concentration of dwellings, population groups, and public or industrial facilities, within the boundaries of the risk, prone areas. These data are a clear indication that technological risk in Hassi, Messaoud is, in a large measure, a territorial and social phenomenon rather than a mere infrastructural one. Thus, technological risks affect not only daily life, access to services, and time but also urban sustainability in the long run. In terms of governance, it is still very important to develop industrial safety culture as a way of reducing vulnerability to technological hazards. Amongst others, this implies the presence of strong safety regulations, clearly understood operational procedures, well, functioning training systems, open communication, and the engagement of both the workers and the safety managers in the activities. Improving these aspects in an urban, industrial environment can lead to a major enhancement of risk prevention (Bouzouaid & Benabbas, 2020).

Therefore, effective mitigation of industrial hazards in Algiers and similar urban environments has to be based on a comprehensive and integrated planning strategy that is able to address issues related to uncontrolled urban expansion, close proximity of hazardous installations, and safety, related institutional weaknesses. Adopting a proactive risk, management approach and ensuring close collaboration among various stakeholders can lead to a significant decrease in the likelihood of disasters, at the same time paving the way for sustainable and resilient urban development (Boughaba et al., 2014).

Table 5. Distribution of types of risk according to the area and type of land use (Source: Bouzouaid & Benabbas, 2020)

Areas	Occupation	Type of risk
ZONE/A (POS: 1, 2, 3, 4, 5, 8, 10, 12, 13, 14): 3000 m	Main Networks	Risks of explosion, fire, and pollution
Electricity HT & MT	Electrical hazards	Danger of explosion and electrification
Gas, Oil, HP, Water Pipes	Pipelines	Explosion, fire, and pollution threats
ZEA, ZET, AEP Equipment	Equipment	Risks related to electrification and flooding
ZONE/B (POS: 3, 13, 14): 1000 m	Distribution networks	Pollution and contamination risks
Sewerage networks	Sewer systems	Same contamination risks
ZONE/C (POS: 1, 2, 12): 500 m	Lines	Explosion, fire, and pollution from railway incidents
Tanks	Storage units	Similar risks
ZONE/D (POS: 4, 10): 500 m	Lines	Explosion, fire, pollution due to railway accidents
Center	Central area	Related hazards
Wells	Water wells	Associated risks
ZONE/E (POS: 4, 5, 10): 500 m	Station	Threats of explosion, fire, and flooding
Facilities	Infrastructure	Same risks
Tanks	Storage tanks	Same risks
ZONE/F (POS: 7, 8): 500 m	Pipes	Fire, pollution, and flooding risks
Networks	Network systems	Related hazards
Wells	Wells	Associated threats
ZONE/G (POS: --): 500 m	Lines	Explosion, fire, and flood hazards
ZONE/H (POS: 11): 500 m	Lines	Explosion, electrification, fire, and railway accident risks
Fuel storage	Storage	Related explosion and fire risks
ZONE/I (POS: 11): 500 m	Lines	Risks from explosion, electrification, fire, and railway accidents
Industry	Industrial sector	Same hazards
ZONE/J (POS: 0): 500 m	AGIP	Fire and explosion hazards
Sonatrach	Company	Same fire and explosion risks

Table 6. Spatial characteristics of risk-prone areas according to the type of occupation (Source: Bouzouaid & Benabbas, 2020)

Areas	Surface (ha)	Built area (ha)	Housing units	Population	EQUIPMENT
ZONE/A	2826	367.38	3,670	18,350	Activity area, Administrative annex, Hotel, Complex, Defense zone, SNTV, Base ZELACI, REBO, Daira SEAT, ECO, APC Center, Games area, Nursery, Technicom, Station, CTC Sud, School, SONELGAZ
ZONE/B	340	1.5	42	366	Arab Bahir
ZONE/C	78.5	21.98	732	3,663	Activity area, CFPA, SONELGAZ, Barrack, High School, Customs, SubHydrau
ZONE/D	78.5	14.13	235	1,413	SNTV
ZONE/E	78.5	40.82	833	4,166	Technicom, NAFTAL, School, HESP, NPHS, KANALGAZ, CEAU, Sports room, ENAFOR, Private base
ZONE/F	78.5	29.83	586	4,102	Hotel, Camp, Station, Center
ZONE/G	78.5	5.79	115	805	ENECO, NAFTAL, GTP, SONELEC, Center, Ouarlissi, Fezz Souad, SAERB
ZONE/H	78.5	39.59	266	1,333	Ouarlissi, NAFTAL, SONELEC, ENAGEO, Center, GTP
ZONE/I	78.5	40.79	375	1,875	Military, ENTP, Center, NAFTOGAZ, Society, Industrial
ZONE/J	78.5	10.03	166	833	AGIP, SONATRACH, ENTP, Society

2.2. Regulations regarding building in high-risk zones

Regulations concerning production in high-chance areas in Algiers are critical for shielding residents ensuring sustainable urban development. The implementation of Risk Prevention Plans (PPR) is fundamental in lowering

vulnerability through powerful land use regulation (Tang et al., 2024). Governed by regulation 04-20, these plans purpose is to control injuries, lessen consequences, and reduce harm to individuals, the environment, and houses. The status quo of these plans changed into brought on by large beyond incidents, along with the 2004 Skikda disaster, the 2003 Boumerdes earthquake, and the 2001 floods in Bab El-Oued see table 7 (Gregg Lemos et al., 2024). Algeria has proven sturdy dedication to disaster resilience through the enactment of a regulation centered on most important risk prevention and catastrophe management. Updated in 2010, this regulation includes hazard concerns into land use and concrete development policies, the evaluation shows gaps in storing and controlling unsafe substances, especially regarding production regulations set by the United Nations Office for Disaster Risk Reduction. (2013).

The US has additionally taken political steps to embed disaster danger discount into its country wide planning techniques Bouzouaid & Benabbas (2020). The know-how of experts in first-class, health, protection, environment (QHSE), and commercial threat management is important in assessing dangers and enforcing environmental safety measures. These experts ensure that buildings in high-danger regions adhere to protection standards and comply with applicable rules Boubakeur (2022). Precisely, building regulations in excessive-hazard zones play an essential role in mitigating business risks in urban environments like Algiers. By imposing laws which includes Risk Prevention Plans and incorporating DRR into country wide strategies, Algeria can bolster its disaster resistance and shield its residents from capacity threats. Effective collaboration among stakeholders is crucial to ensure the a success implementation of complete danger control practices of the United Nations Office for Disaster Risk Reduction (2013).

Table 7. Competitive Rating Scale Based on Weighted Average Score Range (Source: Gregg Lemos el al., 2024)

Weighted Average Score Range	Initial Competitive Rating	Weighted Average Score Range	Initial Competitive Rating
1.00 to 1.50	1	Above 3.00 to 3.75	4
Above 1.50 to 2.25	2	Above 3.75 to 4.50	5
Above 2.25 to 3.00	3	Above 4.50 to 5.00	6

Challenges in Risk Management Systems

1. Inadequacies in current risk management systems

Deficiencies in present chance management systems prevent the protection and resilience of urban areas, in particular in business regions like Algiers. The complexity of interconnected systems and new vulnerabilities from infrastructure interdependencies necessitate sturdy chance control strategies. Historically, towns have shown resilience to failures; however, emerging novel hazards present unique challenges that require proactive and collaborative procedures Bouzouaid & Benabbas (2020). A loss of preparedness for unexpected dangers, referred to as 'gray rhinos' and 'black swans,' highlights the desire for stepped forward chance identification and foresight in decision-making approaches. Integrating asset control with disaster threat management can streamline recuperation efforts in city settings, emphasizing the importance of aligning these strategies to beautify average urban resilience United Nations Office for Disaster Risk Reduction (2013).

In Algiers, the petrochemical region poses sizable commercial dangers, jeopardizing human settlements via pollution and potential screw ups. Incidents in Hassi-Messaoud illustrate the urgency for effective danger mitigation measures and emergency preparedness to defend both enterprise and surrounding communities. Algeria has shown dedication to catastrophe chance discount through legal frameworks and institutional skills, extensively illustrated through the 2004 Law on Prevention of Major Risks, which reflects political will to reinforce catastrophe control practices (Rezvani et al., 2023).

To deal with the shortcomings in current danger management structures, a complete method is important, merging asset control concepts with strong catastrophe hazard discount strategies. By employing foresight gear, enhancing conversation among stakeholders, and enforcing effective schooling tasks, city regions like Algiers can bolster their resilience towards business risks and mitigate potential failures correctly (Saadia, 2023).

2. Need for a collective responsibility approach

In the historical past of urban resilience and adversity threat management, a collaborative approach is essential for enhancing the effectiveness of risk control systems. Urban areas like Algiers, characterized by means of interconnected systems, require a shift towards decentralized cooperation regarding affected additives to attain results that cater to local wishes. Traditional top-down management strategies are inadequate for optimizing actual-time connectivity among crucial infrastructures. Therefore, adopting a participatory approach that makes use of local resources is crucial for efficient risk control and resilience building (Rezvani et al., 2023). The Sendai Framework for Disaster Risk Reduction emphasizes the desire to significantly reduce disaster risks via integrated and inclusive measures that mitigate exposure to hazards even as boosting readiness for response and recuperation. This highlights the importance of grassroots network involvement, which could result in stronger tasks geared toward constructing resilience tailored to precise dangers and developmental necessities. Cities inside the Arab location face increasing herbal disaster risks but also have opportunities for sustainable recuperation primarily based at the precept of "rebuilding better." Engaging multiple stakeholders—consisting of governments, town officials, communities, private sectors, civil society groups, NGOs, and academic establishments—can create an extra comprehensive method to urban resilience. To successfully address business risks in Algiers, it's far crucial to adopt a collective obligation technique that entails all applicable stakeholders. This strategy needs to emphasize network engagement on the neighborhood stage, sell decentralized cooperation among vital infrastructures, and contain inclusive measures for chance reduction and resilience enhancement. By implementing such a technique, Algiers can give a boost to its industrial threat control structures and make sure sustainable city development amid the developing challenges posed by using climate change and urbanization United Nations Office for Disaster Risk Reduction. (2022).

Economic Benefits vs Disasters

1. Economic benefits provided by industries

Algiers' financial prosperity is closely depending on its industrial activities, specially inside the oil and gas region, which significantly contributes to process advent and sales technology. However, those industries also pose great risks through incidents such as explosions, fires, and pollution, that could adversely have an effect on each the populace and the environment. The town's business infrastructure, along with refineries, strength stations, and gas pipelines, is important for energy supply and helps various financial projects. Nonetheless, past injuries, like the Skikda incident, spotlight the capability for excessive monetary loss and human casualties because of industrial mishaps. To protect citizens and maintain financial balance, it's far important to put in force robust threat management structures Bouzouaid & Benabbas (2020).

Rapid urbanization in Algiers has exacerbated inequality and poverty, growing prone surroundings vulnerable to herbal disasters and business hazards. This situation underscores the necessity for sustainable city making plans that integrates effective chance mitigation techniques. By promoting inclusive and sustainable commercial practices, cities can stabilize economic advancement with catastrophe resilience (Rezvani et al., 2023). So, whilst business activities drive substantial financial increase in Algiers, they also introduce challenges that require effective management of related risks.

A collaborative method related to all stakeholders is vital for addressing these demanding situations efficaciously. Moreover, employing sustainable city planning methods, superior by Geographic Information Systems (GIS) era, can help perceive prone regions and tell choice-making for a resilient destiny Corporates Gregg Lemos, el al (2024).

2. Erosion of trust among the public, industries, and policymakers due to disasters

Industrial catastrophes bring about on the spot loss of life and assets, however their effect extends a long way beyond those preliminary outcomes. They disrupt city landscapes, economic activities, and societal well-being, cause skepticism about the reliability of industries, policymakers, and safety protocols. Failures to prevent such disasters can erode trust among stakeholders, further complicating recuperation efforts. The significance of early statistics collection to become aware of capability risks is underscored with the aid of beyond industrial incidents that serve as crucial studying possibilities. These events highlight the need for industries and regulatory bodies to research from preceding mistakes to save destiny occurrences.

However, insufficient threat management can also result in persistent disasters, fostering a growing mistrust of the public toward each industry and government Bouzouaid & Benabbas (2020).Improper dealing with of commercial waste poses enormous threats now not only to human health but additionally to the environment. Hazardous waste mishandling can contaminate air, water, soil, and natural world, contributing to a decline in public self-assurance in the ones chargeable for coping with such substances. This loss of accountability can similarly exacerbate emotions of mistrust in the direction of commercial entities United Nations Office for Disaster Risk Reduction (2013). Moreover, limited involvement from civil society, frequently because of aid constraints, hampers Disaster Risk Reduction (DRR) tasks and powerful threat verbal exchange. This disengagement diminishes public self assurance in catastrophe preparedness measures enacted with the aid of government. Additionally, the low disaster coverage for commercial and business homes well-knownshows a preferred lack of understanding regarding danger prevention techniques. In summary, the repercussions of industrial failures attain a long way beyond on the spot damage, influencing public trust in industries and policymakers alike.

To repair this, believe and ensure sustainable urban development—mainly in areas with excessive commercial risks, like Algiers—implementing robust danger management techniques is crucial. Collaborative efforts among all stakeholders are essential in addressing vulnerabilities and constructing resilience against destiny screw ups (Sefouhi & Bahmed, 2023).

MATERIALS AND METHODS

Utilization of Geographic Information Systems (GIS)

1. Role of GIS in identifying vulnerable areas

The use of Geographic Information Systems (GIS) is crucial for figuring out areas in Algiers that are prone to commercial dangers. A research initiative conducted by the Algerian Ministry of Regional Development and Environment hired GIS to assess vulnerabilities associated with weather trade and herbal disasters. This worried amassing information from numerous resources, together with beyond catastrophe tests, aerial imagery, satellite tv for pc photographs, and digital elevation models to analyze danger factors affecting the metropolis (Boughedir, 2015). Additionally, the significance of GIS mapping in dealing with catastrophe risks is vast, as illustrated by using a UNDP task centered on studying vulnerabilities across one-of-a-kind wilayas in Algeria. The assignment covered education nearby committee individuals in natural chance management and growing a geodatabase for updating chance maps, thereby demonstrating the realistic benefits of GIS in enhancing nearby preparedness for failures United Nations Office for Disaster Risk Reduction (2013). Moreover, the mixing of GIS into urban planning efforts in Algeria is emphasized through a collaboration between the Ministry of Land-Use Planning and Environment and UNDP. This partnership aimed to incorporate Disaster Risk Reduction (DRR) standards into urban improvement plans through GIS mapping, striving to create danger-conscious strategies that protect infrastructure and enhance network resilience in opposition to various risks. Overall, GIS proves to be a useful device for figuring out inclined zones in Algiers exposed to business threats. By making use of spatial statistics analysis and visualization, GIS allows stakeholders to make informed choices approximately sustainable urban planning practices, helping to mitigate ability failures and support average threat management strategies. United Nations Office for Disaster Risk Reduction (2013).

2. Guiding sustainable urban planning through GIS technology

GIS technology is vital for selling sustainable urban planning, mainly in excessive-chance commercial areas like Algiers. The metropolis faces increasing vulnerability to herbal screw ups due to climate alternate, highlighting the urgent

need for resilient techniques. By leveraging Geographic Information Systems (GIS), urban planners can become aware of at-threat zones, investigate dangers, and formulate plans for sustainable development (Rezvani et al., 2023).

In collaboration with the Algerian Ministry of Regional Development and Environment, Egis EAU accomplished studies using GIS era to examine past failures. The analysis was based on aerial imagery, satellite tv for pc records, and virtual terrain modeling. This technique furnished a thorough assessment of Algiers's vulnerabilities projected up to 2030. Tailoring GIS methodologies to neighborhood conditions lets in urban planners to recognize particular commercial risks affecting the metropolis (Ghennam et al., 2021). Environmental health research is another area, which emphasizing the strategic use of GIS. Figure 4 shows the statistical associations between air pollution exposure and respiratory diseases that result from a GLM (generalized linear model) quantifying the impact of indoor air pollution on the increase of respiratory diseases. Besides that, Figure 5 shows a redundancy analysis (RDA) that discloses the combined effects of environmental factors throughout Algiers Wilaya on the pattern of respiratory diseases. These two pictures are the sourced of strong factual evidence on how environmental deterioration is linked to the vulnerability of public, health.

In summary, GIS serves as a powerful device for steering sustainable urban planning in industrially challenged areas like Algiers. With spatial facts analysis and mapping strategies, stakeholders can efficaciously cope with environmental troubles, reduce disaster dangers, and beautify resilience in opposition to changing weather situations (Boughedir, 2015).

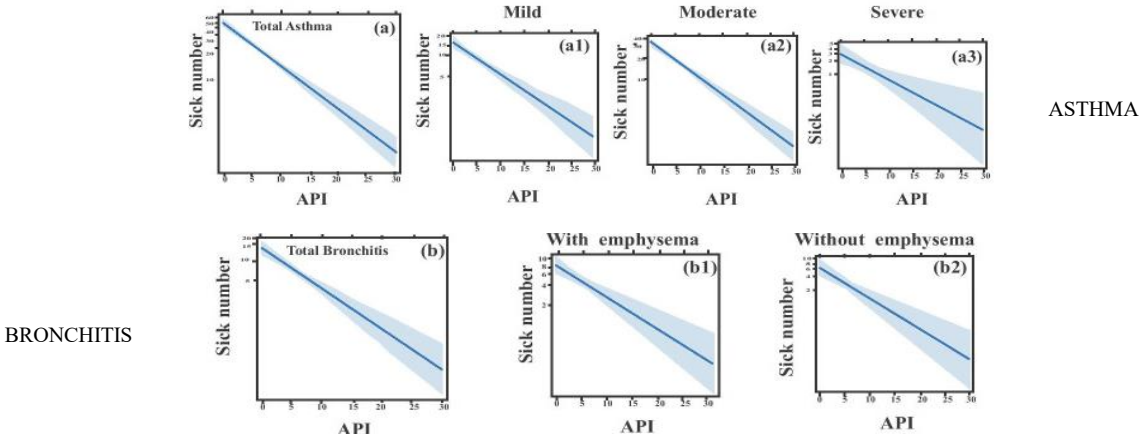

Figure 4. Generalized linear model (GLM) showing the effect of IAP on respiratory diseases (Source: Ghennam et al., 2021)

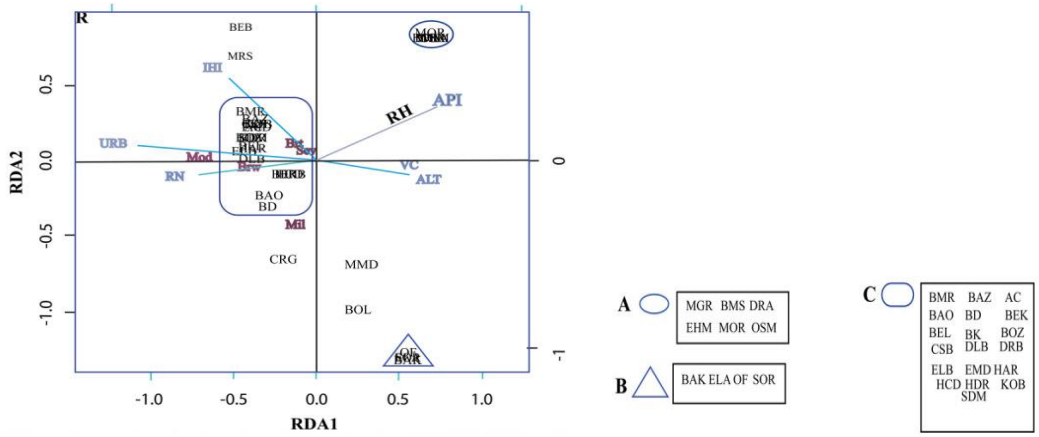

Figure 5. Redundancy analysis (RDA) showing the influence of the environmental parameters of Algiers Wilaya (department) on respiratory diseases (Source: Ghennam et al., 2021)

RESULTS AND DISCUSSION

Vulnerability Mapping in Algiers

1. Methodology for analyzing vulnerability of territories with major industrial risks

Analyzing the vulnerability of industrial hazard regions in Algiers requires a complete method, ordinarily utilizing Geographic Information Systems (GIS). This generation facilitates the identification at-threat zones and various types of hazards. By using GIS-primarily based threat index evaluation, it's miles possible to highlight inclined areas including urban regions without municipal sewage systems, landfills, and agricultural zones. Vulnerability may be categorized into high, slight, low, and really low degrees across different aquifer zones (Gheitasi et al., 2024). Risk checks in commercial waste management are also vital for identifying ability dangers and implementing preventative measures to lessen the chance of injuries associated with business operations. This includes evaluating risks with the aid of their severity and using chance evaluation matrices to determine appropriate responses (Mokhtari et al., 2023). Flood susceptibility analysis is also improved by the Analytical Hierarchy Process (AHP), which mixes demographic density, drainage efficiency, and land, use structure to create a model of the spatial exposure to flooding. High, resolution susceptibility maps can be produced by calculating

the weighted contribution of these factors and normalizing the vulnerability grids, thus allowing for a very precise territorial diagnosis of the flood, prone areas (Boulabeiz et al., 2018). The spatial layout of these hazards is given in Figure 6, which, in turn, shows a representation of vulnerability patterns in the whole study area. Table 8 provides quantitative data supporting the statement that moderate vulnerability covers most of the total area while the very high susceptibility is thus kept geographically minimal. This pattern verifies the dominance of the moderate, risk environments but at the same time signals that there are local critical hotspots requiring the targeted intervention. Collaboration among stakeholders is crucial for fostering sustainable urban planning and enforcing efficient hazard control techniques. Important issues consist of demographic engagement, technological critiques of risks, and the mental affects on panorama values. A holistic perspective can for this reason be advanced to mitigate bad outcomes on both landscape notion and human well-being. Consistent tracking and periodic reassessments are important for addressing dynamic modifications in neighborhood human activities, ultimately enhancing chance control effects and ensuring network safety (Sefouhi & Bahmed, 2023).

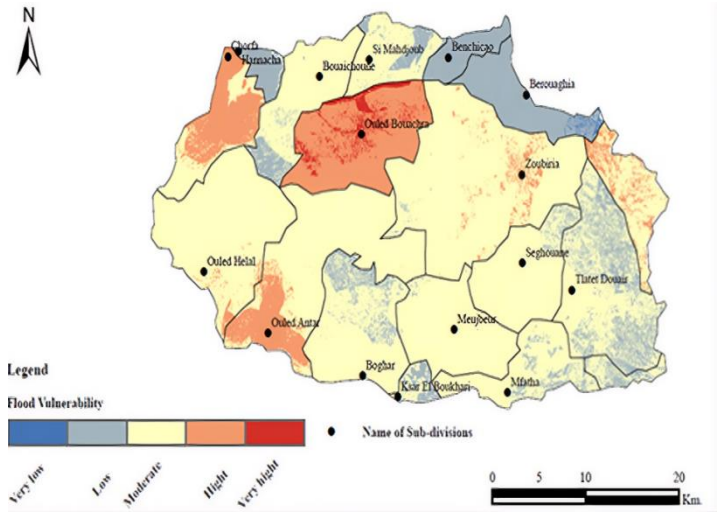

Figure 6. View large Download slide (Source: Mokhtari et al., 2023)

Table 8. Area coverage of the flood susceptibility zones
(Source: Mokhtari et al., 2023)

Vulnerability	Area (km^2)	Percentage
Very low	1.87	0.14
Low	187.63	13.61
Moderate	985.42	71.48
High	187.69	13.61
Very high	16.06	1.16
Total	1,378.67	100.00

6.2. Findings from vulnerability mapping process

The vulnerability evaluation system in Algiers has revealed crucial insights into areas at excessive chance for industrial incidents and herbal failures. The storage of business waste poses widespread risks because of the absence of clear disposal pointers. Utilizing Rausand's Risk Assessment Matrix, the assessment of risky substances such as used batteries, oils, and transformers showed that wrong management should lead to intense environmental and health effects (Mokhtari et al., 2023). Additionally, flood vulnerability assessments highlighted the susceptibility of diverse areas to herbal calamities via the utility of the Flood Vulnerability Index (FVI). This index ranked regions primarily based on demographic and socio-monetary elements, revealing vulnerability ranges starting from slight to very high in certain components of Algiers. These findings emphasize the need for robust threat mitigation strategies to relieve the affects of floods on urban populations. The significance of catastrophe risk control in Algeria become further underscored, specially concerning forest fire prevention. With an annual average of almost 3,000 fires affecting over 30,000 hectares, weather exchange has been diagnosed as a key thing exacerbating hearth dangers. This scenario underscores the need for preventive measures and improved land use making plans to beautify resilience towards such screw ups Virtual (2021). Overall, the mapping of vulnerabilities in Algiers presents important records for pinpointing excessive-chance areas liable to both industrial accidents and natural failures. By integrating insights from numerous research, sustainable urban planning processes can be evolved, strengthening risk management structures to sell safety and resilience in regions dealing with massive commercial dangers (Sefouhi & Bahmed, 2023).

7. Recommendations for Sustainable Urban Planning

7.1. Strategies for mitigating industrial risks in urban areas

Reducing business risks in city environments requires a complete technique that includes various stakeholders, emphasizing the importance of urban resilience to address complicated commercial dangers. Effective urban resilience strategies necessitate collaboration amongst national and neighborhood governments, private sectors, non-governmental groups, and worldwide our bodies. These entities are important in developing catastrophe hazard control plans, enforcing mitigation measures, and improving community resilience (Rezvani et al., 2023). Strong city governance is essential for constructing resilience and coping with emerging dangers. Decentralizing governance can empower nearby authorities to attention on catastrophe danger discount (DRR) and combine resilience into their development priorities. The UNDRR has identified thirteen DRR moves tailor-made to nearby governments' abilities, which include growing monetary plans for resilience, revising constructing codes, and enhancing societal preparedness. By incorporating these movements into their governance frameworks, cities can better identify, determine, and cope with commercial risks whilst organizing vital shielding measures *United Nations Office for Disaster Risk Reduction*. (2022). Integrating asset control with hazard control practices also enhances selection-making related to urban resilience. Aligning those techniques allows cities to enhance their preparedness for herbal screw ups and climate trade consequences. This integration combines technical aspects,

inclusive of model and information analysis, with social elements like bias, hesitation, and commentary. In an international increasing push via technology like Big Data and synthetic intelligence, acknowledging the effect of human elements is important for making informed selections that bolster urban resilience. Precisely, successfully mitigating commercial dangers in city settings is predicated on collaborative efforts from diverse stakeholders facilitated by using robust city governance. By merging asset management with threat management techniques and prioritizing local DRR tasks, towns can decorate their resilience and readiness for capability screw ups. These processes not best deal with commercial dangers but additionally guide sustainable urban making plans tasks *United Nations Office for Disaster Risk Reduction*. (2022).

7.2. Collaborative efforts between stakeholders for effective risk management

Effective risk control in urban regions like Algiers relies on collaboration amongst various stakeholders. Governance of urban dangers entails awesome roles for exceptional actors in mitigating risks. The government holds an imperative duty in shaping country wide disaster rules, applying danger reduction measures, and organizing emergency reaction structures. At the local level, government help those efforts via land-use planning, enforcement of production requirements, and preparedness and evacuation packages. The non-public sector also performs a vital position via ensuring resilient infrastructure and homes. Meanwhile, civil society contributes to danger discount with the aid of undertaking community-targeted making plans and advocacy. International businesses, like the United Nations, provide precious help—particularly to useful resource-confined international locations—by using supplying investment and technical support (Rezvani et al., 2023). Addressing the challenges faced by Arab towns requires the involvement of a couple of stakeholders. Promoting inclusive participation and duty in choice-making techniques permits local projects to efficiently decorate community resilience whilst catering to specific dangers and improvement wishes. This collaborative method aligns with the human security ideas outlined in the Sendai Framework (Kennedy et al., 2023). Furthermore, integrating Indigenous Peoples' stewardship into risk management can improve resilience. Recognizing the rights, illustration, and resource vulnerabilities of Indigenous communities permits for the implementation of effective techniques to mitigate risks related to business activities on their lands (Linda & Lylia, 2023).

So, sustainable city planning and green hazard control in Algiers rely on the collective efforts of numerous stakeholders throughout sectors. By harnessing the understanding and assets of governmental companies, private entities, civil society companies, global companions, and Indigenous groups, a comprehensive strategy can be developed to cope with commercial risks and beautify resilience in city settings *United Nations Office for Disaster Risk Reduction*. (2022).

Case Studies and Best Practices

1. Examples of successful risk management initiatives in other urban areas

Successful danger control practices in city environments emphasize the essential position of Geographic Information Systems (GIS) in planning and choice-making. GIS generation complements diverse duties together with website choice, undertaking visualization, resource management, danger assessment, environmental impact analysis, and undertaking monitoring. By using GIS equipment, cities can become more aware of vulnerable areas, check risks related to terrain and natural disasters, and track undertaking development in actual-time (Gheitasi et al., 2024).

Public participation GIS (PPGIS) has proven precious in knowing the impact of industrial zones on threat perception and landscape values, particularly in Tehran. This approach highlights the significance of incorporating public opinions within the layout of business areas, aiming to balance capability with environmental and aesthetic concerns. Engaging stakeholders through PPGIS surveys and modified photos permits for the improvement of strategic action plans that mitigate danger perception and promote emotional well-being (Boughedir, 2015). In Algiers, a vulnerability mapping exercise discovered the metropolis's susceptibility to disaster risks including coastal erosion, underscoring the need for concrete additional measures to lessen the monetary, social, and human impacts of herbal screw ups.

Overall, effective danger control projects across urban contexts illustrate the importance of integrating GIS technology, thinking about public input, and acting vulnerability checks. Learning from these examples and adopting collaborative techniques among stakeholders can make stronger hazard control frameworks, as seen in Algiers' efforts in the direction of sustainable urban improvement. To correctly mitigate commercial dangers, it's far vital to foster shared obligation and proactive techniques driven by means of comprehensive information evaluation supported by using GIS technology Virtual (2021).

2. Lessons learned from past industrial accidents

Learning from past commercial failures can notably enhance danger management systems in urban regions like Algiers. Rapid urbanization has led to the improvement of business centers in excessive-risk locations, exemplified through the 1998 fuel pipeline explosion that caused lack of life and significant harm. This highlights the urgent need for strict policies governing production in inclined areas to prevent such tragedies. Proper waste disposal is also vital in industrial operations to shield human fitness and the environment. Poorly managed hazardous waste may additionally bring about soil pollutants, groundwater contamination, and diverse fitness issues, including respiratory disorders troubles and cancer. To mitigate these dangers, imposing strict controls and ensuring normal preservation of system are important Bouzouaid & Benabbas (2020). The Tunisian example of Ain Draham, which among other things was supported by the United Nations Development Program (UNDP), demonstrates that vulnerability assessment, stakeholder engagement, land, use regulation, and community awareness programs can together enhance flood, risk preparedness and urban resilience. The project emphasizes the importance of collaboration between different actors in achieving effective and sustainable urban risk governance.On an organizational level, the safety culture of the industry is a critical factor for the prevention of technological disasters. A comparative illustration of the safety, management can be found in Figure 7, which shows the safety culture profiles of Company A and Company B according to the main safety parameters. The differences found

highlight how the level of institution, communication/safety awareness, and preventive measures significantly influence the capability of industrial systems to reduce risks. A a success case Tunisia illustrates effective hazard control practices. With guide from the UNDP, the town of Ain Draham advanced its disaster hazard control capabilities, focusing on flood prevention. This initiative concerned undertaking vulnerability exams, enticing neighborhood stakeholders, enforcing land use policies, and promoting community consciousness efforts. The example underscores the importance of collaborative moves among diverse stakeholders for effective threat management in city settings (Sefouhi & Bahmed, 2023).

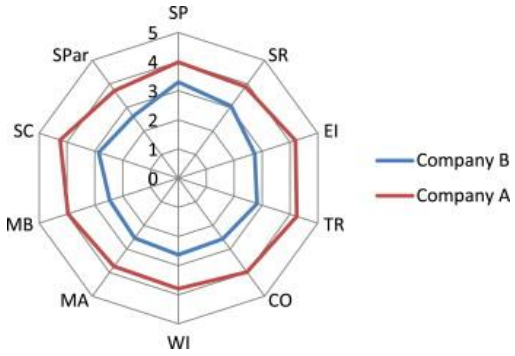

Figure 7. Safety Culture Profiles of Company A and Company B Across Key Safety Dimensions (Source: Boughaba et al., 2014)

Precisely, through drawing training from beyond commercial accidents and a successful threat control strategy, Algiers can formulate comprehensive plans for managing industrial dangers through sustainable urban improvement. Essential components consist of fostering collaborative partnerships, organizing stringent guidelines, training accountable waste control, and inspiring network involvement. These measures are vital for addressing vulnerabilities and growing more secure surroundings for all citizens *United Nations Office for Disaster Risk Reduction*. (2022).

At the organizational level, the industrial risk prevention measure's impact is forecasted to be greatly dependent on the safety managerial, behavioral, and relational factors within the firm. Table 9 presents a comparative study of these factors, which evaluates ten major safety facets in two oil companies. It is revealed that Company A, in general, has higher average scores in strategic planning, emotional intelligence, team relations, communication, managerial skills, and strategic control that are indicative of a more advanced and cohesive safety culture. On the other hand, Company B shows comparatively lower results in the majority of the markers, thus it may have some loopholes in its governance, motivational, and stakeholder engagement mechanisms that might lead to an increased technological risk exposure (Luting et al., 2025).

Table 9. Analysis of the ten safety-related factors observed in the two oil companies included in the study (Source: Boughaba et al., 2014)

Variable	Company A Mean (SD)	Company B Mean (SD)	Total Sample Mean (SD)
SP (Strategic Planning)	3.978 (.8435)	3.298 (.8985)	3.699 (.9281)
SR (Social Responsibility)	3.884 (.9165)	3.060 (1.0111)	3.546 (1.0379)
EI (Emotional Intelligence)	4.200 (.5264)	2.734 (.7067)	3.599 (.9422)
TR (Team Relations)	4.244 (.5488)	2.824 (.6994)	3.663 (.9308)
CO (Communication)	3.978 (.6542)	2.572 (.9879)	3.402 (1.0631)
WI (Workplace Integrity)	3.791 (.5389)	2.629 (.7951)	3.315 (.8697)
MA (Managerial Aptitude)	3.741 (.6445)	2.537 (.6703)	3.248 (.8831)
MB (Motivational Behavior)	3.961 (.4831)	2.461 (.7145)	3.347 (.9439)
SC (Strategic Control)	4.248 (.5833)	2.857 (1.0990)	3.678 (1.0783)
SPar (Stakeholder Participation)	3.712 (.6148)	2.627 (1.1188)	3.268 (1.0095)

CONCLUSION

Managing industrial dangers in Algiers is critical for ensuring local protection and stability. Urban areas like Algiers are increasingly more liable to dangers from business development and herbal screw ups. It is essential to include catastrophe chance discount measures into urban planning, as validated by using projects following the 2001 flooding and the 2003 earthquake. This approach targets to beautify the resilience of city infrastructure.

Geographic Information Systems (GIS) play a vital position in figuring out susceptible zones and helping sustainable city making plans efforts. Through vulnerability mapping with GIS era, stakeholders can better understand the risks connected to industrial regions and develop effective risk mitigation strategies. Additionally, training from past business accidents underscore the importance of proactive danger control systems to prevent disasters and protect public protection.

Collaboration among stakeholders is key to effective threat management in urban environments. The involvement of government groups, personal zone corporations, and local groups is important for developing comprehensive strategies to mitigate commercial risks. A collective responsibility approach encourages all events to work collectively to cope with shortcomings in present hazard management structures at the same time as prioritizing sustainable answers that beautify city resilience. Precisely, the complex challenges of managing industrial dangers in Algiers require a holistic strategy that mixes danger assessment, urban planning, and stakeholder collaboration.

By adopting guidelines for sustainable city making plans and mastering from a success risk control practices in other cities, Algiers can improve its preparedness for potential crises and construct a greater resilient destiny.

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