International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Scholarly Publisher
RS Global Sp. z O.O.
ISNI: 0000 0004 8495 2390

Dolna 17, Warsaw,
Poland 00-773
+48 226 0 227 03
editorial_office@rsglobal.pl

ARTICLE TITLE	LANDSLIDES IN THE CITY OF MILA BETWEEN THE SENSITIVITY OF THE LOCATION AND URBAN EXPANSION
ARTICLE INFO	Bouguerroudja Nassima, Amirech Hamza. (2024) Landslides in The City of Mila Between The Sensitivity of The Location and Urban Expansion. *International Journal of Innovative Technologies in Social Science*. 4(44). doi: 10.31435/ijitss.4(44).2024.3151
DOI	https://doi.org/10.31435/ijitss.4(44).2024.3151
RECEIVED	19 October 2024
ACCEPTED	21 December 2024
PUBLISHED	30 December 2024
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LANDSLIDES IN THE CITY OF MILA BETWEEN THE SENSITIVITY OF THE LOCATION AND URBAN EXPANSION

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ABSTRACT

Cities are evolving rapidly, exposing them to natural hazards that can cause major human and environmental losses. The Algerian town of Mila is particularly vulnerable due to its complex geological and morphological environment, which favours various risks, such as landslides. The aim of this article is to highlight the risk of landslides in Mila, particularly in the Khirbet region. To analyse these risks, it is essential to define concepts such as natural risks, high risks, Algerian risks, the phenomenon, vulnerability and prevention. High risks are physical phenomena caused by fast- or slow-moving phenomena, while high risks are potential threats caused by exceptional natural or human activities. Vulnerability refers to the ability to withstand losses resulting from exposed areas and the fragility of the situation. Understanding and dealing with natural hazards in urban environments is crucial for sustainable development, preserving the urban environment and protecting citizens. The study revealed that natural factors, such as topography, geology, seismic activity and hydrology, play an important role The report recommends greater coordination between institutions and citizens, better knowledge of landslide risks, early warning systems and increased funding for disaster risk reduction and mitigation. Comprehensive and integrated approaches are needed to tackle climate and disaster challenges in Algeria. ground movements in Mila
The report recommends greater coordination between institutions and citizens, better knowledge of landslide risks, early warning systems and increased funding for disaster risk reduction and mitigation. Comprehensive and integrated approaches needed to tackle climate and disaster challenges in Algeria.

KEYWORDS

Landslides, Mila City, Vulnerable Areas, Al-Kharba, Neighborhood, Algeria

CITATION

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1. Introduction.

Cities are constantly evolving and growing rapidly to become urban centres with millions of inhabitants. With this rapid growth comes increased exposure to natural hazards that may cause severe losses to human life and the environment. In Algeria, the wilaya of Mila is among the regions that are witnessing population growth and urbanisation, which makes it vulnerable to various natural hazards.

The importance of studying natural hazards in the urban environment comes from the need to understand the interaction between the urban environment and natural phenomena on the one hand, and to determine the extent of the impact of these phenomena on the safety of cities and their inhabitants on the other hand. This type of studies also contributes to the development of strategies to mitigate the impact of natural hazards and enhance the resistance of cities to them, which may contribute to achieving sustainable development, preserving the urban environment and protecting citizens and their property. In this paper, we have tried to highlight the risk of slipping in the city of Mila as a The city of Mila was chosen because it is an area frequently

exposed to the risk of landslides, and the Khirbet area is a vivid example that illustrates the instability issues in the study area.

It is located in a complex geological and geomorphological environment that encourages the occurrence of several risks, including the risk of landslides that threaten the majority of the urban fabric of this city. This raises the question:

- What are the factors driving the risk of landslides in the city of Mila?
- What are the consequences of these hazards on the urban fabric?
- What suggestions can be taken to prevent natural hazards in the city of Mila?

In order to analyse natural hazards, it is necessary, first of all, to define in a concise and clear manner the concepts associated or related to the research topic, and the following is a definition of the concepts used in the research paper sample of natural hazards in the urban environment.

2. Conceptual Framework.

2.1. Natural hazards.

These are natural physical phenomena caused by fast or slow-occurring phenomena, which can be geophysical (earthquakes, landslides and volcanoes), hydrological (soil erosion and floods), climatic (high temperatures, droughts and wildfires), weather (hurricanes, storms, tidal waves) or biological (epidemics, insect infections, animal epidemics) (Types of disasters: Definition of hazard, 2021).

2.2. Definition of high risk.

A major hazard is a potential threat to humans and their environment, which can be caused by exceptional natural hazards or human activities.

Haroun Tazarief wrote about a major risk: 'A major risk is a direct threat to humans, their surroundings and facilities, and this threat has an impact on society when it exceeds a disaster'.

Through these definitions, we can say that a high risk is a potential threat to humans and society as a whole, which can lead to major disasters that cause significant material and human losses.

2.3.Definition of risk according to Algerian law.

Mucus: A person who has been exposed to the risk of injury or death, or who has been exposed to the risk of being exposed to the risk of being exposed to the risk of being exposed to the risk of being exposed to the risk of being exposed to the risk of being exposed to the risk of being exposed to the risk of being exposed to the risk of being exposed to the risk of being exposed to the risk of being exposed to the risk of being exposed to the risk of being exposed to the risk of being exposed to the risk of being exposed to the risk Law No. 20- (Law No. 20 of 20 December 2004) 04 dated 25 December 2004).

2.4.Definition of Phenomenon: (Aléa)

It is the set of possible (expected) events in a certain place and associated with the expected probabilities of each of these events, which can occur under certain conditions, and is the source of risk for human beings and their activities (social, economic...).

2.5.Definition of Vulnerability (La vulnérabilité).

Vulnerability is a very difficult term in that it is polysemic because the idea of the likelihood of a hazard (Aléa) is insufficient to understand the occurrence of a disaster. Vulnerability means the ability to withstand the losses resulting from areas exposed to threatening sources, as well as the fragility of the situation. The term refers to a series of conditions caused by natural, social and economic factors that can contribute to a community's vulnerability to the effects of a disaster.

The concept was first proposed in 1993 and refers to the degree of possible losses, whether economic or social:

- Economic Vulnerability (Vulnérabilité-économique) includes physical losses, infrastructure, roads...
- Human vulnerability (Vulnérabilité-humaine).

Prevention: It is the collective or individual endeavour to reduce the probability of the occurrence of a particular hazard or to minimise material and human losses when it occurs, through organisational arrangements, precautionary measures or proactive laws to reduce the likelihood of the occurrence and realisation of the hazard and to guard against it.

3. Introducing the study area: eld of expectations, so it is the 'Prévisions'.

The city of Mila is located in a complex geological and geomorphological environment that encourages several hazards, including the risk of landslides that threaten most of the urban spaces in this city.

A brief history of the origins and naming of the city of Mila: (Ahmed Daasse)

Nature and influential civilisations The city of Mila is one of the ancient cities in eastern Algeria, whose position has not changed with the change of religions and elements

The city was like other neighbouring cities of Cirta, which revolves in its orbit and is at the same time the front line and strategic depth of the city.

The city was founded in 49 BC, the city was called by several names, the first of which was 'Milo' during the Numidian rule in relation to an ancient Numidian queen, while during the Roman era it was called 'Milave', meaning a thousand springs of water, and the city was known during this rule. Progress, prosperity and urban and architectural development

This ancient city was also nicknamed by several names that have their origins in the successive civilisations, the most important of which are: Milium, Meadows, Milovtania, Milaf and Mila, and when the Muslims conquered it, they called it 'Milah' to signify the beauty it enjoyed (Ahmed Daas).

3.1. Location Mila Governorate.

3.1.1 Astronomically.

Mila is located between longitude 5°43' and 6°30' east of the Greenwich line and between latitude 35°45' and 36°34' north of the equator

Geography:

Located in the north-east of Algeria, bordered by

- North-east of Skikda Province
- To the north-west is the wilaya of Jijel.
- To the south it is bordered by the wilaya of Batna
- To the east is the state of Constantine
- To the west is the wilaya of Setif
- To the south-east is the state of Oum El Bouaghi.

It covers a total area of 3480.54 km2, 484 km from Algiers and 50 km from the capital of Eastern Algeria, Constantine.

Municipality of Mila covers an area of 130.60 km2, equivalent to 3.75% of the total area of the state, located in its north-east, bordered to the north by the municipality of Sidi Marouane and the municipality of Qarm, to the south by the municipality of Ahmed Rachidi and Sidi Khalifa, to the west by Zghaya and Wad El Naja, and to the east by Ain El Tine and Messaoud Bouguereau of Constantine Province Figure No. (01)

Most landslides occur as a result of several factors that destabilise the slopes. Slides may occur quickly or slowly, but the most dangerous ones are those that occur quickly and suddenly with the occurrence of earthquakes (as happened in the study area) or after heavy rains.

Slides defined as the movement of the earth and its movement for a few metres, as well as land subsidence, falling rock masses and soil slippage, especially in steep areas, especially in steep areas. The ground represents the danger of using the land and man is interested in these studies because they directly related to his life and stability and have a great impact on the economic aspect, especially if they are in urban areas for these reasons. For these reasons, I will try through this research paper to shed light on landslides in the city of Mila, Algeria, which is a living model for the study of natural hazards in the urban environment to present the most important natural and human causes and the consequences of the Khirbet landslide that occurred in 2000 to provide solutions and suggestions that will reduce them and mitigate their effects in the future.

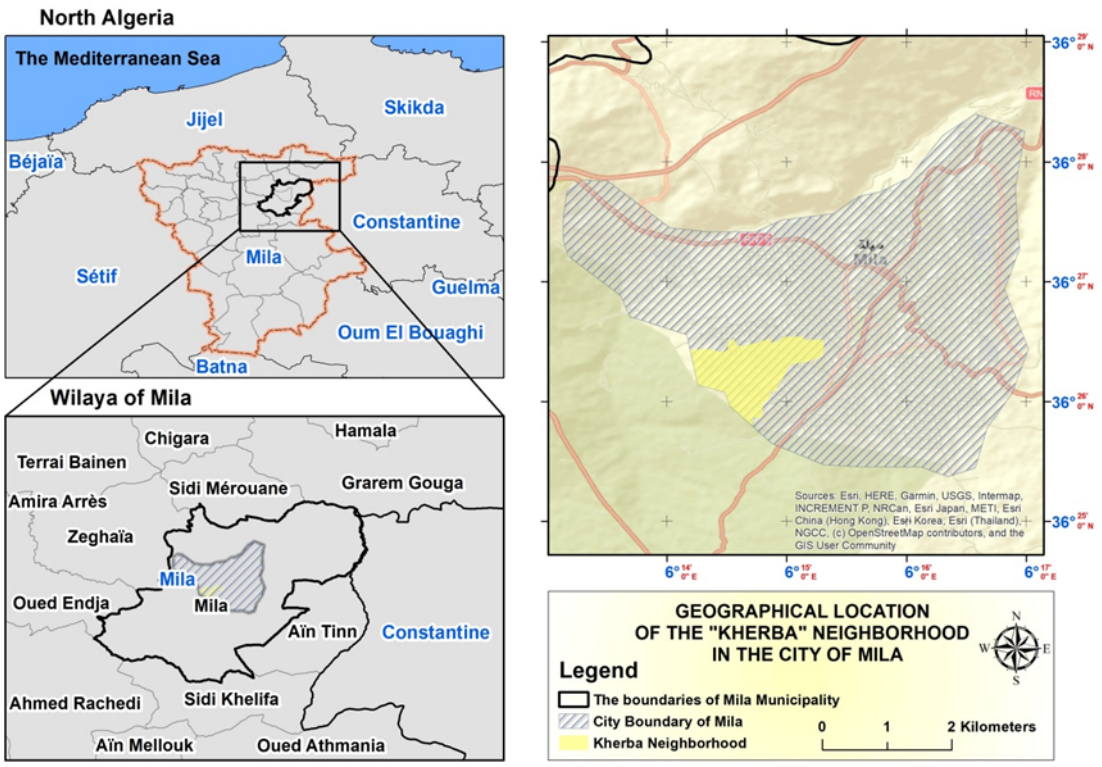

Fig.1. Map (01): The Location of the City of KHERBA in the city of Mila, (Source: Authors (2024)using ArcGIS 10.7.)

4. Geology and tectonics.

The Mila region belongs to the eastern part of the Maghreb Range, the Alpine range of North Africa (M. Durand Delga, 1969).

Mila is located in a long and wide depression filled with Tertiary clays, known as the Basin Miocène de Constantine, which appears as a long corridor between the mountains (Bassin Miocène de Constantine). It has an east-west direction with a length of about 100 kilometres and a width of more than 40 kilometres. It bordered to the north by the hilly massifs of the Numidian range and to the south by the Shattaba mountain range and the upper plains of Constantine. The region offers a rugged terrain consisting of numerous small grey, yellow or reddish clay hills, sometimes deeply cut by valleys. A true topographic slice, in fact; tectonic movements within the clay have caused numerous fractures (deformations) that have displaced very large Miocene clay masses and the overlying limestone (Pliocene limestone) has been loosened and transported. Pliocene) and transported by sliding over very long distances, and we still currently observe deep mudflats within the valleys, which explains the instability and mass movements experienced in the area (Etude géotechnique 'PLAN D'OCCUPATION DES SOLS MILA': le 12. 06.06.2001

4.1.Seismic: The seismicity.

The Mila region is less seismically active than neighbouring regions despite being located on the border between two geologically active provinces, such as Constantine and Babur. The city of Mila is located in a seismic zone classified by Bokel as capable of experiencing tremors of magnitude 6 to 7.The city of Mila is located in a seismic zone classified by Bokel as capable of experiencing tremors of magnitude 6-7. This area bordered to the northwest and southeast by two more seismically active zones with potential intensities greater than 6°. Among the seismic foci located within a radius of 30 kilometres around the city of Mila, the most important earthquakes occurred as follows (J.P.Michel, 2000).

-Earthquake of 23/08/78 in the Sidi Marwan overlap area at a distance of 16 km from the site of the Beni Haroun dam with an undetermined magnitude but probably less than 3.5 mm.

- 20/12/83 earthquake in the Sidi Idriss block about 27 km east of the site with a magnitude of 4.6 mm.

- The earthquake listed as the most important in a radius of 50 km around the city of Mila is the earthquake that occurred on 27/10/85 with a magnitude of 5.9 mm and its epicentre located northeast of Constantine (Chettah Wahid 2008/2009)

- August 2020, a first earthquake in the state of Mila with a magnitude of 4.9 on the Richter scale, the epicentre was located 2 km south-east of Hamala in the same state, and a second earthquake was recorded on the same day at 12:13 pm with a magnitude of 4.5 on the Richter scale, the epicentre was located 3 km south of Hamala).

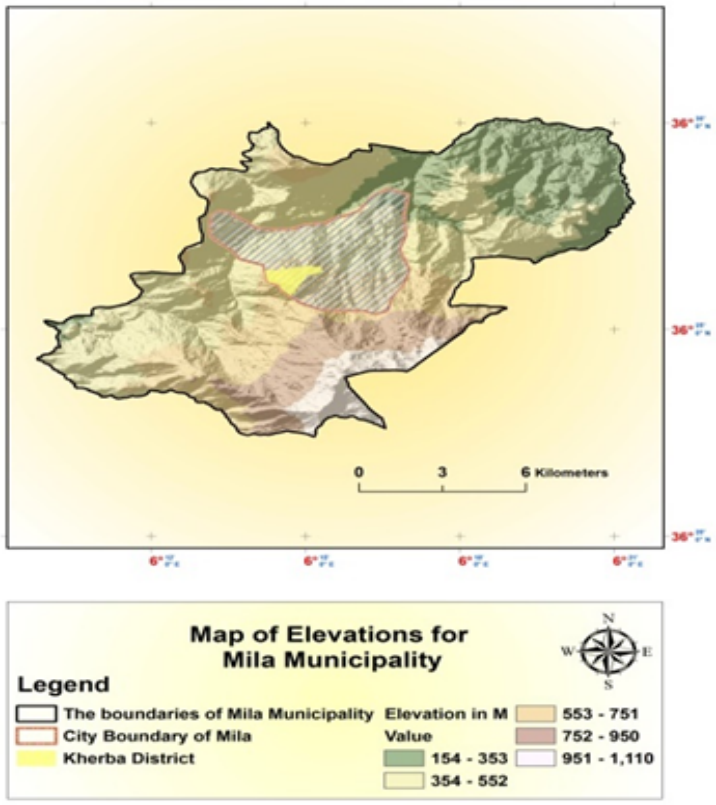

Fig.2. Map (02): Elevation map of Mila, (Source: Authors (2024)using ArcGIS 10.7.)

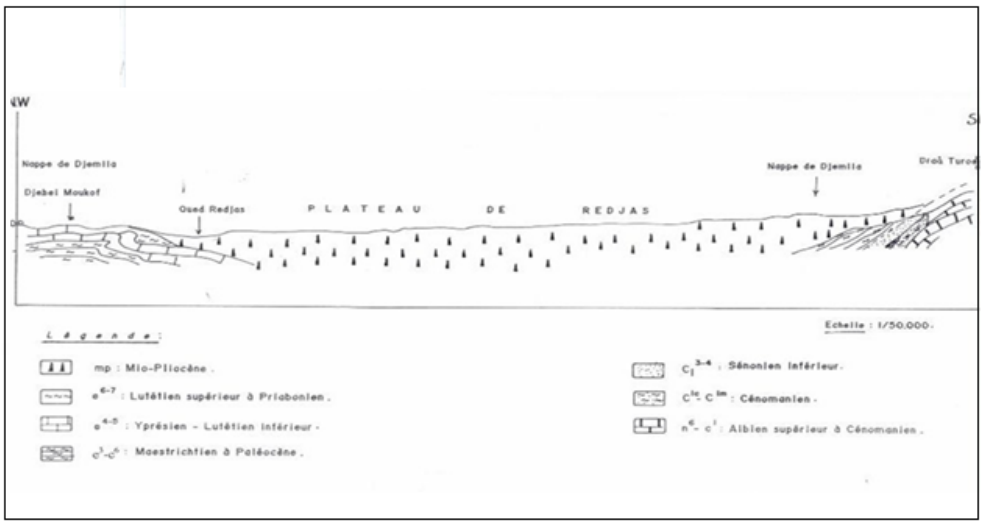

Fig.3. Geological analysis of the Redjes –El farada basin, (Source: OPGI Mila.)

In general, it can be said that the city of Mila is dominated by weak rock formations with a percentage of more than 70% of the total area, in addition to the prevalence of influential formations that have the property of absorption and this is what gives it the property of flow and flow, especially since it is located, as I have already mentioned, above limestone layers, which contributes significantly to the occurrence of landslides and instability.

4.2. Elevations

The municipality of Mila is characterised by a medium to low altitude, the lowest altitude in its northeast, where the Mila valley and the sand valley meet 154 m. The highest altitude is 1110 m. The direction is east-west and south-north, and the flows are mainly directed in a south-north direction.

The highest percentage is the heights between 354 m and 552 m by 43%, followed by the height category confined between 553 m and 751 m by 20%, while the heights above 750 m exceed 18%, which explains the presence of significant slopes in the study area, and the large heights in the region make it vulnerable to wind erosion, which contributes to soil degradation and loss of vegetation cover, which contributes significantly to the weakness of the structure and makes it vulnerable to sliding.

4.3. Regressions

From Figure (04), the regression functions can be categorised into the following categories

1. **Category 1 (0 to 5%):** It covers an area of 19.63 km2 representing 18.05% of the total area. This category is located in the north-east of the city.
2. **Category 2: (5 to 12%**): It covers an area of 82.84 km2, over 63% of the total area. This slope category dominates the majority of the city's area and is located in the centre of the municipality.
3. **Category 3 (12 to 25%)**: It covers an area of 23.89 km2, representing 18% of the total area, and is generally located in the northwest and south

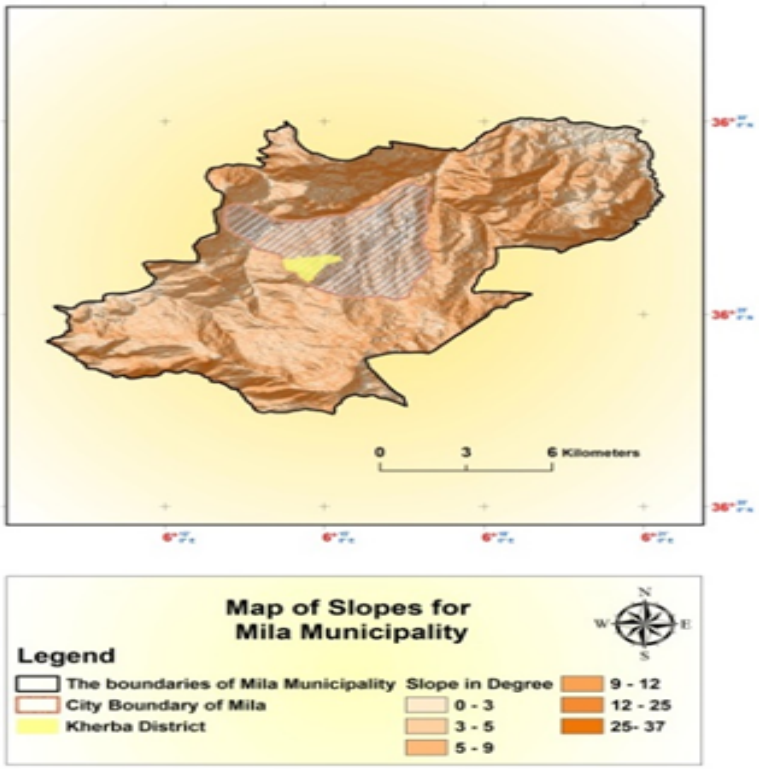

Fig.4. Map (03): Elevation map of Mila, (Source: Authors (2024)using ArcGIS 10.7.)

The topography of the study site consists of different classes of slopes, which fully explains the relationship between slopes and the excitation of ground motions, thus this topographic data is suitable for all gravitational processes that can be found in landslides. The terrain is characterised by a northern slope. It ranges from 10% to 15% across most of the site, with elevation variations of up to 60 metres. The natural boundaries are: To the west and north-west, Wadi Mila; to the west, Wadi El Kharba; to the north-east, the Medeiros Forest and Wadi El Makhawad; to the south, the entire Marasho Plateau.

5. The climate.

The study area is located at the intersection of two different climatic zones a temperate and humid climate in the north characterised by dry and hot summers and mild and humid winters with annual rainfall ranging between 900 and 1200 mm and a semi-arid climate in the south, characterised by a fairly large temperature difference with temperatures above (40°C) in summer that can drop to below 0°C in winter and rainfall of about 400 mm/year.

5.1. Precipitation.

The state of Mila is located in a region where the average rainfall ranges between 600 and 700 mm per year.

In this study, we adopted the Ben Haroun and Ain El-Bay stations in Constantine, based on the data collected from the two stations, we graphed the average monthly rainfall (Figure 05), this data indicates that the month

Based on the data collected from the two stations, we have plotted the average monthly rainfall (Figure 05). These data indicate that the rainiest month is December with an average of 159.87 mm, and the least rainy month is July with an average rainfall of about 0.46 mm. In general, precipitation develops as the weather increases from August to December. Watercourses and aquifers are recharged by rainfall mainly in winter. The average annual rainfall in the Mila region is 612.75 mm (Beni Haroun station)

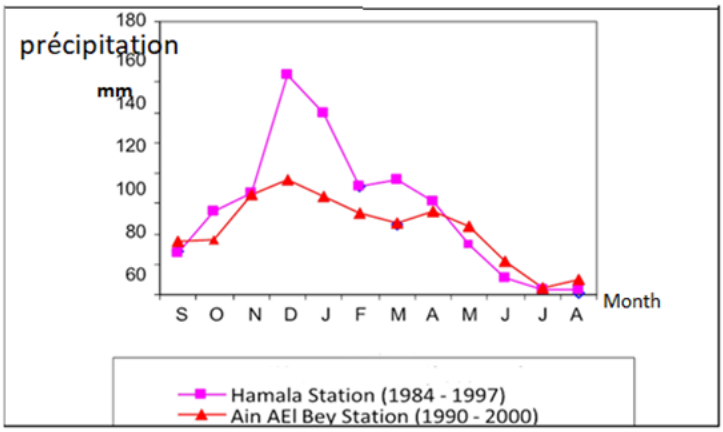

Fig. 5. Annual precipitation averages for Ain El Bey and Ben Haroun stations

5.2.Hydrographic network.

The state possesses an important water wealth as it falls within the Great Sand Basin, which extends from the northern edges of the High Plains and the Sabbakhs in the south to flow into the Mediterranean Sea in the north and consists of three sections.

- **The upper basin**: The sand valley and the Boumerzak valley run until they meet in Constantine.
- **The middle basin**:in the southern foothills, which is the basin to which the study area belongs, the Naja valley and the lower Rimal valley run until their meeting point in Sidi Marwan (Ben Haroun Dam).
- **The lower basin**: In the northern hilly block at the meeting point of Wadi al-Rimal and Wadi al-Najaa up to the mouth.

If we take the criterion of the municipality as a criterion for studying the water network, we find that all waterways that cross the municipality and neighbouring municipalities pour into the Ben Haroun Dam, which is located in the north and passes through the municipality:

Wadi Mila: It has a southwestern to northeastern flow, located in the centre, separating the old city from the countryside and the industrial area adjacent to it, and Wadi Ghazali has a north-south flow.

Wadi Khirba: With a north-south flow, it is located in the centre of the municipality on the western side, separating the Boumerka neighbourhood from the university neighbourhood and the Boualerkayeb neighbourhood.

Wadi Makhoud: It centres the municipality in the eastern part and borders the city of Mila on the western side with a flow.

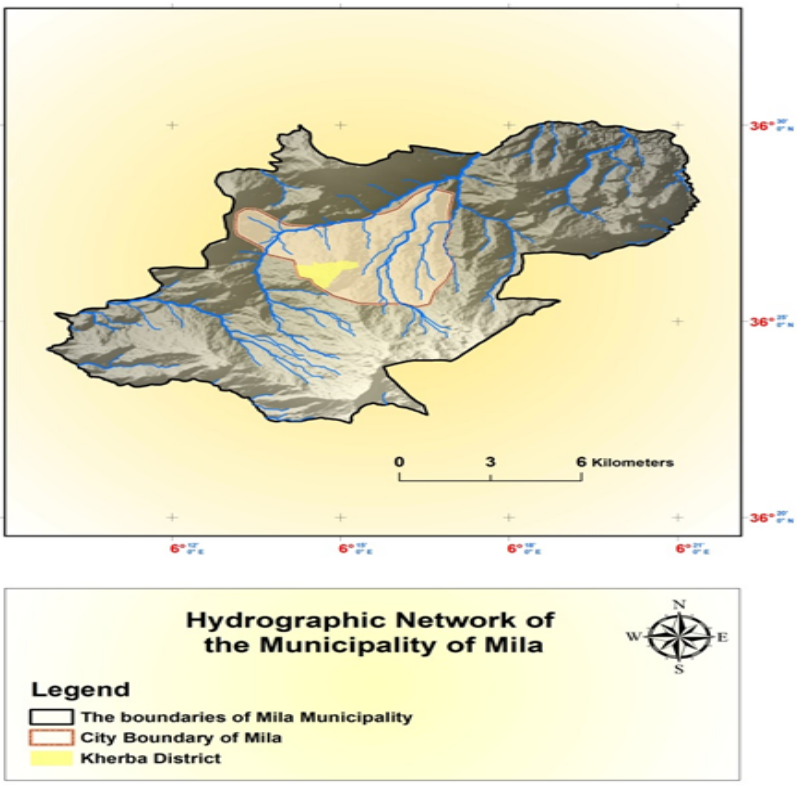

Fig.6. Map (04): Hydrographic network, (Source: Authors (2024)using ArcGIS 10.7.)

6.Conclusion of the study of natural factors.

Through the study of the natural and physical factors of the city of Nile (topography, geology, seismic activity and hydrology), we concluded that natural factors play an important role in the occurrence of ground movements in the city of Mila, where the topography and fragile lithological formations (marl and clay) played a key role in the occurrence of landslides and contributed significantly to soil instability, in addition to the hydrological factor that also plays a significant role in mass movement.

7.Analytical study of the Khirbet area

7.1.Population

The population of Kherba is 12,304 inhabitants, which represents 15% of the total population of the city (Technical Department of the Municipality of Mila, Housing and Population Statistics Section 2023), with Rafm64 ranking first with 1170 inhabitants and the weakest district being 79 with 453 inhabitants.

Table 1. (Distribution of population by district in the Al-Kharba area *Source***:** District*Plan of the Municipality of Mila (RGPH2022) Technical Service of the Municipality of Mila, Housing and Population Statistics Branc*

Destruction	64	65	66	67	74	75	76	77	78	79	80	81	82	The total
Number of fragments	07	09	14	10	07	10	06	14	16	17	09	06	15	140
population	687	1170	1004	1050	983	951	1052	1037	901	453	1029	1008	979	12304

7.2 Study of the built framework.

The Khirbet area is 100% dominated by individual housing, which constitutes 15% of Individual housing in the city of Mila, and facilities are almost non-existent with the Exception of the primary school and the mosque. The Khirbet area is 100 per cent dominated by individual housing, which constitutes 15 per cent of individual housing in Mila city, and facilities are almost non-existent with the exception of the primary school and the mosque.

Table 2. Distribution of the number of buildings and housing units according to each district in the Al-Kharba area.

Destruction	64	65	66	67	74	75	76	77	78	79	80	81	82	The total
Number of fragments	07	09	14	10	07	10	06	14	16	17	09	06	05	140
Number of buildings	95	179	156	109	148	164	134	156	161	159	123	133	109	1826
Number of dwellings	206	285	238	209	239	224	179	221	198	191	200	221	177	2788

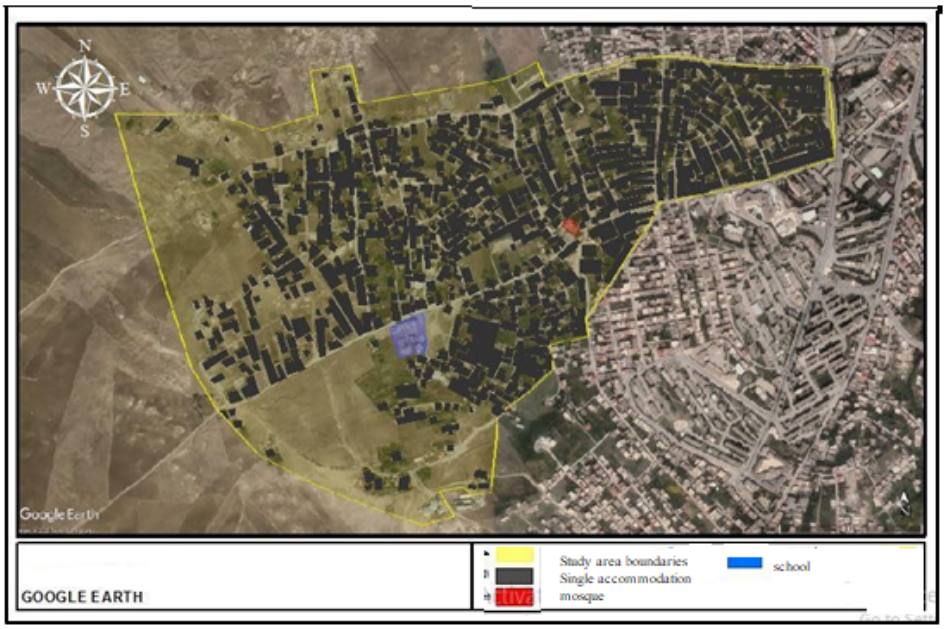

Fig. 7. Map (05) Map of the built framework of the study area (Al-Kharba neighborhood)

By projecting the coordinates of the built structure of the study area on ArcMap, it was found that its percentage is estimated at: 72% of the total area of the area is built-up land compared to 29% vacant land (unbuilt land and road network).

7.3 Assessing the condition of buildings after landslides and earthquakes.

As previously mentioned, 100% of the houses in the Khirbet area are individual (illegal) houses that do not have building permits and have not been subjected to a prior geotechnical study.

After the earthquakes that occurred on 07 August 2000 and the subsequent landslides, the task of assessing the condition of the buildings was entrusted to the National Laboratory for Housing and Construction (LNHC), which carried out a geotechnical study of the area and The National Authority for Technical Control of Construction (CTC) in Mila and the results of the study are shown in Table 03.

Table 3. Classification of the condition of buildings according to the lvel of damage in the Al-Kharba area (Source.: National Technical Control Authority for Construction (CTC) Mila2023)

	Damage level					
	Red	**Orange**		**Green**		
	Level05	Level04	Level03	Level02	Level01	
the total	**Al-Kharba area**					the total
1826	423	341	274	347	347	Single accommodation
100%	23.17	18.67	15.01	19	19	percentage%

Analysing the data in Table 03 leads us to the following results:

• **Very damaged buildings**: These buildings are classified in the red zone and are 423 buildings (23.27%) that are in danger of collapse, as shown in the picture

Photo 1-2 Very damaged buildings

• **Buildings with major damage**: shown in orange 2 341 buildings (18.67%)

Photo 3-4 Buildings with major damage

• Buildings with moderate damage: Shown in orange colour 2, representing 241 buildings or 15% of the total number of buildings

• Lightly Damaged Buildings: Shown in green colour 2, they are lightly damaged, representing 274 buildings, or 19% of the total number of buildings.

• Non-damaged buildings : Shown in green colour 1, 374 buildings (24%

Through the study of the natural elements of the city of Mila and the urban analysis of the slide area, we found that the landslides in the Khirbet area are the result of a combination of natural factors (geological structure, slopes, elevation and climate) and human factors, mainly represented by the construction of unstable buildings over unstable areas.

8.Recommendations and suggestions

In order to conclude this report, we would like to make a number of recommendations, including the need to raise the level of coordination between institutions and citizens, deepen the knowledge of the risks of slides to reduce their risks, strengthen early warning systems, and encourage the financing of disaster risk reduction activities:

- The need to raise the level of coordination between institutions and citizens, deepen the knowledge of slippery slope risks to reduce their risks, strengthen early warning systems, and encourage funding for disaster risk reduction and insurance.
- Learning from past shocks to enhance resilience to natural hazards in Algeria.
- Rigorous enforcement of laws and the adoption of strict deterrent measures against violators of the provisions of construction licences, preventing construction in areas prone to landslides and activating the role of construction plans and land occupation plans.
- Activate natural hazard prediction schemes (PPRI).

Conclusions.

The city of Mila is one of the Algerian cities that witnesses frequent slides, and this is clearly visible to anyone who visits the city due to the large deformations inside and outside the urban environment, as well as the deterioration of roads, various equipment, infrastructure and infrastructure, so landslides have become a real concern that worries citizens, local authorities and academic researchers alike.

Due to the location of the city within the unstable hilly area and its urban expansion on fragile areas, the city is prone to serious landslides and what happened in the Kharia neighbourhood in 2000 is proof of this,

Therefore, as academic researchers, we must shed light on the real causes of slides, whether natural or human, and provide effective solutions to reduce them and minimise their effects,

Enhancing resilience in Algeria is not an impossible task, as it requires concerted efforts from all parties to implement comprehensive and integrated approaches. The lessons learnt from past disasters and the priorities identified to address disaster and climate challenges provide a glimpse of the opportunities for a future where people are safer and better prepared to face natural hazards in Algeria.

Directorats:

– CTC Mila “National Organization for Technical Control of Eastern Construction” Directorate of Town Planning and Construction of Mila
– ANRH Constantine “The National Agency for Hydraulic Resources”
– OPGI Mila “Office for the Promotion of Real Estate Management”
– Mila Hydraulic Station rate of Town Planning and Construction of Mila

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