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The sensitivity of the urban environment to natural hazards using the method of hierarchical analysis and geographic information system: the risk of floods in the city of Oued El Athmania as a model

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Abstract :

Natural phenomena in all their forms are one of the dangers that threaten humanity, and perhaps the danger of floods is one of the most lethal of these dangers due to the material and human losses they cause, a threat that all countries of the world suffer from and have become a frequent occurrence in recent times. Algeria in general and the city of Oued El Athmania, in particular, are considered areas at risk of flooding constantly, due to heavy and sudden precipitation, leaving material and sometimes human losses that accelerate the impact of urban expansion processes at the expense of unorganized agricultural land on the banks of Oued El Athmania in the center of the city. This study aims to identify and map the areas at risk of flooding in the city of Oued el Athmania, five criteria were introduced: slope, distance to valleys, and distance to dam Hammam Garouz, residential density, and land use, which were determined based on relevant available references, using one of the effective methodological approaches Hierarchical Analysis (AHP). This method determines the final weight of each criterion affecting floods based on the opinions of local experts and decision-makers, and then conducts the weighted linear integration of the maps used in the GIS program, to obtain a map suitable for hazard sensitivity so that it can be used in decision-making towards planning flood management in the city of Oued El Athmania. The results of the case demonstrate that the GIS-AHP-based category model is effective in identifying flood risk areas; it confirms that the integration of AHP and GIS technologies provides a powerful tool for decision-making procedures in flood risk mapping, allowing for a coherent and efficient use of spatial data.

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Keywords: flood risk, AHP method, Geographic Information System 'GIS', risk sensitivity, urban center, Oued El Athmania city.

Introduction:

Floods are one of the natural hazards that are considered an intractable and complex problem, because of the danger they pose to human life and the ecosystem in general, as they have become frequent at the level of most countries of the world, whether developed or underdeveloped. The development of severe phenomena associated with climate changes that caused the change of the Earth's climate has become a catalyst for this phenomenon on the one hand, and on the other hand, the factor of irrational human intervention on the natural field by creating an imbalance in the middle through unplanned and random urbanization, which often grows in vulnerable areas, especially cities that have been chosen a location near the places where water is located, whether valleys, rivers or lakes to benefit from it, and on the other hand in certain areas of Planning urbanization is being unknown or not adequately calculated, but with the acceleration of the pace of reconstruction and the resulting satisfaction of the needs of housing, facilities and equipment, expansion has become directed in the risk areas at the level of valleys or rivers, and despite interventions aimed at protecting urban tissues, they have often remained useless in front of the risk of flooding, especially in sudden cases (Hanaziat, 2005, Al-Jamal, 2010, Owaimer, 2020).

With different factors and causes of flooding, it remains one of the most important natural hazards hesitant and sudden, so this phenomenon has received attention and attention from researchers to understand the factors that stimulate it, and therefore effective measures and interventions have been taken to mitigate its impact and reduce the damage it causes, in special schemes (Watfa.2014)

Since rapid urbanization and rapid population growth are among the most prominent factors causing an increase in the volume of losses, the correct and proper management of the risk is of great importance in protecting the urban environment from the negative consequences of dangers in general, even if it cannot remove the danger permanently, through which several disasters that may occur can be avoided and their damage minimized.

The use of GIS in water resources management over the last two decades has achieved significant development and effective answers to various natural and human problems facing the city, actors, and populations to understand the problems they face and help stakeholders make effective decisions in the field. For foresight and anticipation, as well as for the management and careful follow-up of various emergency phenomena in the urban field and feeding it with information to predict the likelihood of flooding using developed models, and thus visualize the expected hazards

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and estimate their size, paths, and losses to identify preventive solutions and provide the necessary elements to mitigate in the event of their occurrence (Brahimi Rayma. 2018, Brahmi et al., 2021).

Through this research, we will address all of the above by taking the city of Oued Athmania as a model, so that we will work to clarify the importance of geographic information systems in identifying areas at risk of flooding with an assessment of the size of the risk and the amount of sensitivity to it on the expansion areas and how to prevent and reduce the size of this disaster, taking into account a set of criteria and factors that may affect the sensitivity of areas to the risk of flooding, relying on the techniques of information systems and the use of the hierarchy process Analytical (AHP), in order to determine the weights of the criteria that were chosen and this through our study to produce a map of the sensitivity of areas to this danger in the city because of its location, which is considered more vulnerable to this risk, as there is a variation in slopes between lands with a weak slope and lands with a steep and strong slope, and the region is characterized by the confluence of Oued Al-Rhumal and Oued Bouyagour, which pose a great danger to the urban fabric of the region, in addition to containing the Oued El Athmania, which makes it more vulnerable to this danger (Al-Qarfi Muhammad, 2006, Khryashi Hammouda, 2021).

2. Objective of the research:

The research aims to identify areas at risk of flooding in urban areas Trying to find out the reasons behind the recurrence of the risk of flooding on the urban perimeter to propose appropriate solutions using the hierarchical analysis method that uses the opinions of expert analysts in determining the weight of the influencing factors, then conducting a linear weighted integration of the maps used classified and representative of the mentioned factors using the GIS program in identifying residential communities exposed to natural hazards in the study area with the identification of areas The most suitable and least harmful to the expansion of the Oued Athmania city.

3. Research materials and methods:

To carry out this study and reach the desired goal of producing a map of the sensitivity of areas at risk of flooding using geographic information systems (GIS) as well as scientific theories whose results are based on a set of sequential and organized steps by hierarchical analysis method (Dehimi et al. 2022) AHP, it is necessary to collect data and standards, which we need to analyze to use several programs and means according to the type of treatment required, starting with extracting the weights of these criteria, To reach the ultimate goal of this part of the study, we have resorted this:

- ✓ The use of satellite images and processing by ARC map and Global Mapper programs so that we can establish a geographic information system.

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- ✓ The geological map at a scale of 1/200000 and the topographic map at 1/50000 extract hydro flow charts with an estimation of relative altitudes and slopes.
- ✓ Map of the annual distribution of rainfall for the study area.

The risk of floods in this research has been addressed through a basic perspective, which is the inundation of the surface waters over the course of the Oued El Athmania and the high water level in the Bouigour Valley and the extent of its impact on the urban fabric of the city.

To assess the risk of flooding by flooding the surface waters of the valley course, we have relied on the following variables: population density, slope, proximity and distance from the valley stream, the nature of land occupancy, the intensity of rain, and previous levels of water inundation, the quality of housing and proximity to the Oued El Athmania Dam, and the use of all these variables as factors through which we extract the risk matrix to determine the sensitivity of the city to this risk.

4. Some concepts and terms for the study of the phenomenon:

4.1. Definition of risk:

The word danger was defined as a natural geological condition or event made by man or as a phenomenon that result in the emergence of potential risks to human life and property. The management of disasters within the framework of sustainable development is as follows: "It is described as a great danger within the meaning of this law, any potential threat to man and his environment that can be caused by exceptional natural hazards or by human activities."

4.2. Risk assessment:

There are many statistical methods by which the risk score can be assessed, but the simplest and most effective is to describe the risk score as very high, high, medium, low, and very low. The assessment of the degree of risk depends on two characteristics: the effect of the risk and the probability of the occurrence of the risk (Thomas Sa'ani, 2000).

4.3. Definition of the flood:

The risk of flood is defined as a hydroclimatic phenomenon that occurs mainly due to rainfall, which in turn leads to a sudden rise in the water level in the watercourse to flood the larger flooded and neighboring areas, in large quantities that exceed its ability to discharge it and lead to the inundation of neighboring areas, and therefore the flood is the rise in the water level in the valley from the scarcity bed to the flood bed. G. Remeniras defines a flood as the largest flood of the year and this expression remains acceptable in the event of a single flood during the year when several floods of different sizes can occur."

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Floods are considered one of the most frequent risks in the world and affect human life, property, and facilities, so the lack of awareness or lack of awareness of the population of the risks of floods and their settlement in floodplains and slopes and their construction of buildings away from technical control, excessive use of land even in places that are not amenable to construction, the collapse of barriers and dams, the lack of information and data related to the occurrence of floods and the lack of early warning systems are among the most important factors of vulnerability to floods and the increase in the size of material and human losses.

4.4. The importance of GIS in the management of hazards:

Its importance is to transform, store, link, analyze, and display information related to the earth's surface, above and below it and what are the uses of the earth, natural resources, and population gatherings facilities to reach a successful GIS application (Belkhirad. A, and al, 2019, Boulaghmen. F and al,2019) The three basic rules must be provided:

- A geodetic grid to provide an accurate coordinate reference.
- A topographic database to which other geographic information can be linked.
- The Land Survey Database is a reference for land use and land ownership with much demographic information.

4.5. The objective of building a geographic information system to support the decision:

This is done by determining the general structure required for the database of the final system, which must contain all the necessary information to deal with the disaster at various levels while working to identify the basic spatial elements (maps) to be linked with the database and with the basic application of the geographic information system. Information related to disaster management at the country level is computerized (Khryashi Riad 2021).

5. Study area:

The city of Oued El Athmania is located between the hill and the upper plains, so the northern part of the region belongs to the Constantine mountain range, while the southern part belongs to the eastern upper plains, characterized by flat land with a height not exceeding 700 m (Map N°. 1). The city of Oued El Athmania is one of the oldest municipalities in the Algerian field, reconstruction began in 1837 AD, it belonged to the field of the Greater Constantine State in 1956 AD, and after its organization, its area shrank, but it remained affiliated with it while retaining its area and the department of Chalghoum Al-Eid, after the administrative division of 1984 AD, Mila was promoted to the center of the state and the city of Oued El Athmania became affiliated with it (review of the directive plan for preparation and reconstruction PDAU for the municipality of Oued El Athmania, 2021).

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Aerial photo N° (1) of the city of Oued El Athmania (taken in 2023-04-23 by the researcher).

The city of Oued Athmania is the seat of the municipality located 35 km from the southeast of the headquarters of the state of Mila and 15 km from the western side of the municipality of Chalghoum El Eid and 35 km from the state of Constantine, bordered to the northwest by the municipality of Sidi Khalifa, northeast by the municipality of Ibn Ziad in the state of Constantine, to the east by the municipality of Ain Smara in the state of Constantine, the municipality of Oued Saqqan from the southeast, the municipality of Chalghoum El Eid southwest, to the west by the municipality of Ain El Melouk. The main community of the municipality and the focus of services, the municipality consists of 04 secondary communities: Jabal Aqab grouping, Bilad Youssef, Boumalek grouping, and Dambar community (Ouled Kaseh), the total area of the municipality is 27,150 hectares, or 7.80 percent of the total area of the state (Map N°. (1)) (review of the PDAU master plan for the municipality of Oued Al Athmania, 2021).

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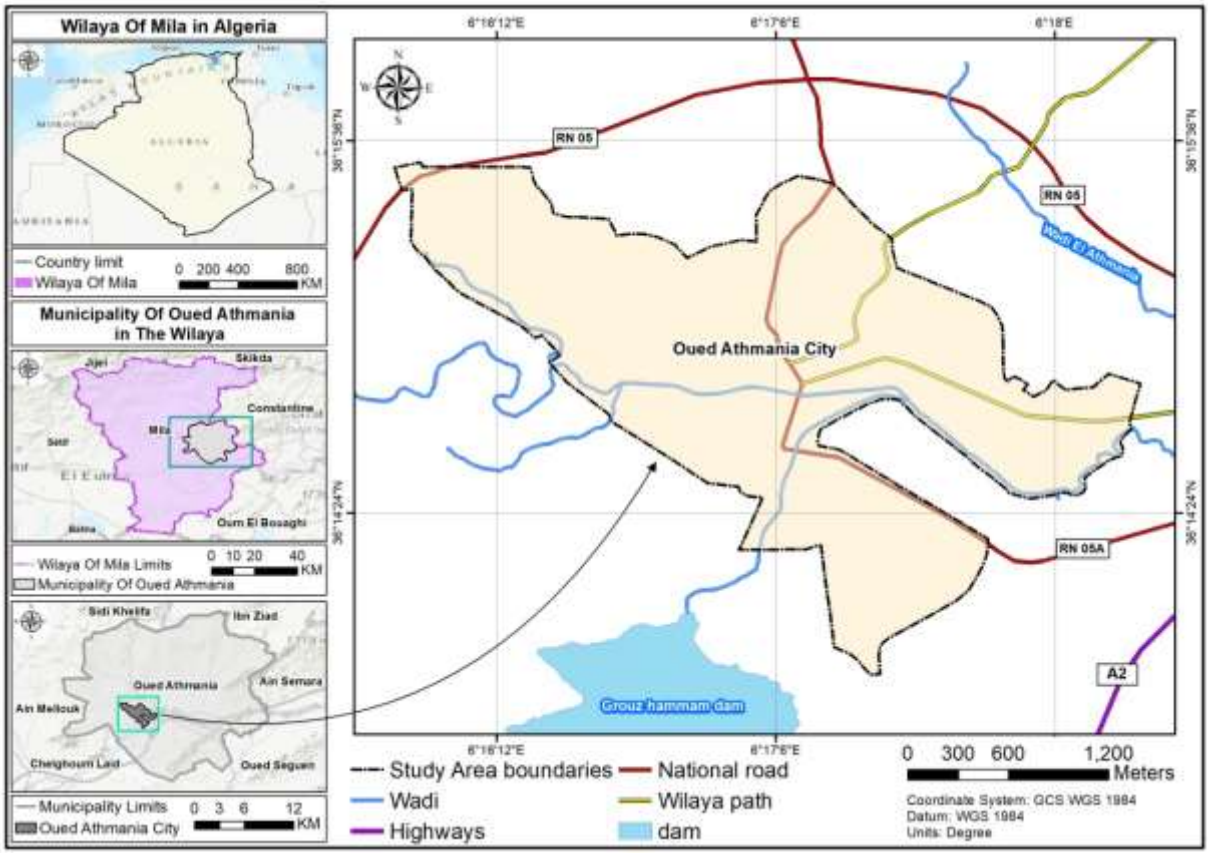

Map n°(1): The geographical location of the Oued El Athmania cit

(Done in 2023-04-23 by the researcher).

6. Determine the criteria that affect the study of the sensitivity of areas at risk of flooding.

There are many factors whose interaction together causes floods, but there are no fixed factors to study this type of hazard, as the latter differ from one study area to another, and through our analytical survey of the city of Oued El Athmania and reviewing the previous studies of this topic, we have identified five main criteria that we considered to directly affect the occurrence of this type of danger, some of which are natural and some of which are artificial and human (Khryashi Riad, 2021).

6.1. Natural factors:

6.1.1. Topographies of the region:

One of the most important factors that contribute to raising sensitivity and increasing the risk is the topography of the region in which the levels of elevation vary; the city of Oued El Athmania is located between the hill and the upper plains, which makes it characterized by the variation of its topographic unity from the north and south. The plains of the city territory is a basin that extends from east to west in the form of a portico that widens as we head west, its height is about 680 m, in which the sand valley runs, while the south is interspersed with some reefs, but they are not dense,

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and this is due to the complete flatness that hinders the movement of gonorrhea. Al-Jial constitutes 13% of the total area of the city from high mountain masses devoid of vegetation, the highest peak of which is Djabal Aquab by 1200 m and Djabal garouz by 1187 m with limestone masses (revision of the PDAU master plan for the municipality of Oued El Athmania, 2021).

6.1.2. Slope:

The slope affects the direction and amount of runoff or groundwater drainage that reaches the site. In this course, the slope map was prepared using the Digital Elevation Model (DEM) and the slope creation tools in Arc GIS The slope categories with lower values were assigned higher due to flat terrain, while the category with the maximum value was classified as lower due to relatively high flow. For the case header, the results of the original and reclassified elevation and detractor layers are displayed. The field of study is characterized by relatively weak slopes amounting to 48.9% of the total area and includes the areas located in the north, and southwest of the municipality, and very weak slopes amounted to 24.5% located in the flat plain lands located near the valley) (Map N°. 2), and by 19% of the medium slopes, which are represented in the feet of the mountains, the valleys, and the very steep slopes that include mountainous areas such as Djabal Aquab and Djabal Garouz by more than 24%. (Revision of the PDAU Directive Plan for the Municipality of Oued Al Athmania, 2021)

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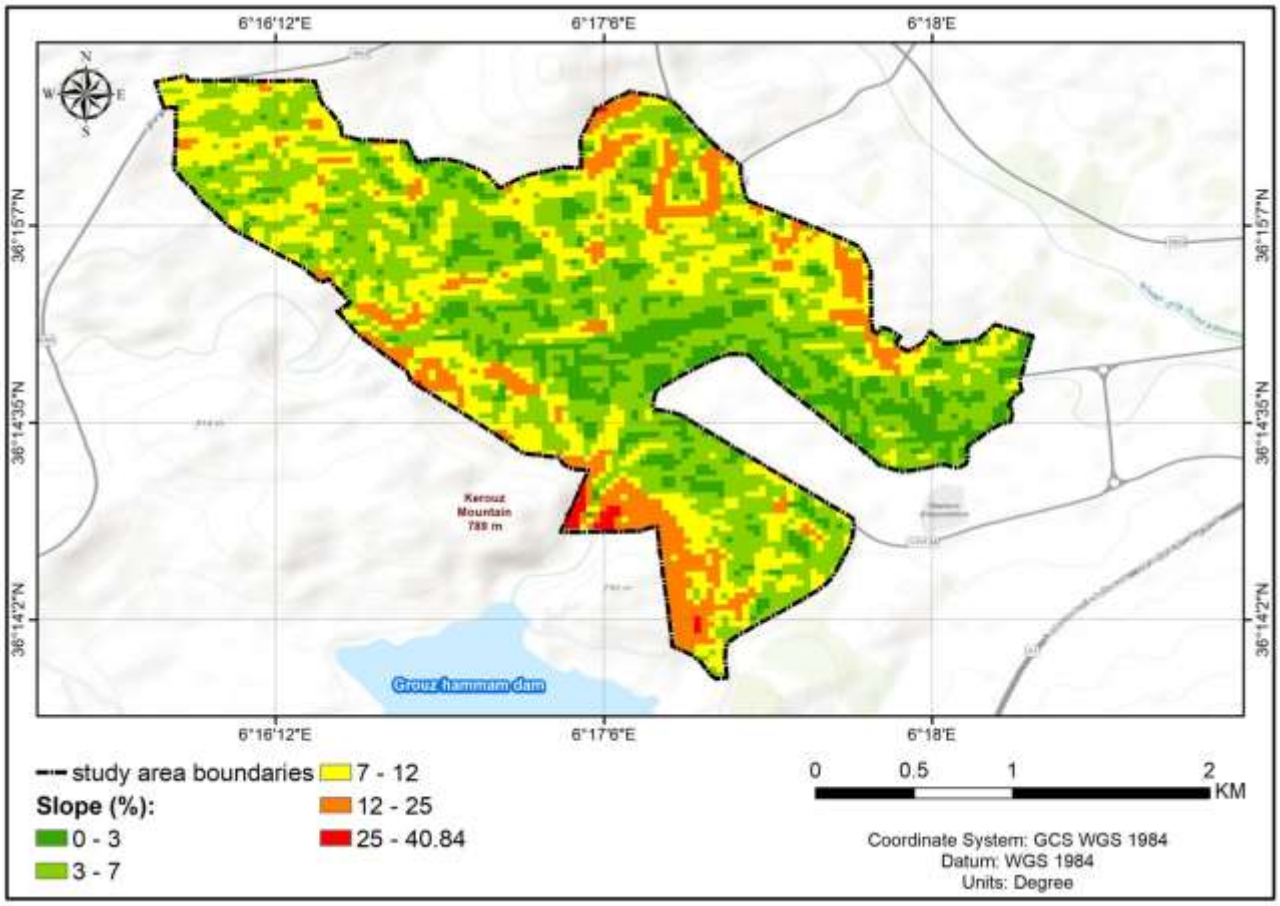

Map n° (2): Cliffs in the Oued El Athmania (Done in 2023-04-23 by the researcher).

6.1.3. Hydrography and water resources:

The city of Oued El Athmania is located in the large casting basin of sand covering an area of 8811 m bordered by the coastal basin of Constantine from the north, the bass of the high plateaus of Constantinople from the south, from the east the Sibous basin, the west of the Soummam basin, the municipality benefits from a dense hydrographic network consisting of a series of valleys extending to the west, the most important of which is the Valley of the Sands, which has been further reduced by the Garouz Dam, which is always flowing, on which the Hammam Garouz Dam was established. Which is located between the national road N° 05 and the state road N° 17, and divides the city of Oued El Athmania into two parts from the southern side, to meet Oued Athmania with Oued Al-Rimal at the exit of the city, where it is characterized by its dryness in summer and its flow in other seasons, especially in winter?

As well as Oued Bouyagour passes from the west, cutting the city of Oued El Athmania in the center to meet Oued Al-Rhumal at the exit of the city, where it is characterized by its dryness in summer and its flow in other seasons. Especially winter and originates from the northern highlands of the municipality of Ain El Molouk. Oued El Athmania meets Oued al-Rhumal at the exit of the

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city, Oued El Athmania is characterized by its dryness in summer and its flow in other seasons, especially in winter.

6.1.4. Geology of the region.

Through this study, it was found that most of the formations of the region are surface formations, represented by clay that is spread in the north, and calcareous marne and marne are spread in most areas of the field of study.

6.1.5. The amount of annual precipitation in the field of study:

The amount of runoff is related to the amount of rain to which the area is exposed. When the water level rises above river banks or dams, the water begins to flood, causing flooding caused by rivers. The amount of precipitation in the city of Oued El Athmania ranges between 350-500 mm per year, as it has a semi-arid climate characterized by dry and hot summers and cold and rainy winters.

6.1.6. Wind:

Cold humid northwesterly winds blow in winter, while hot dry Sirocco winds blow in summer at a rate of 31 days a year, while the rest of the year the precious winds are between northwesterly, and southwesterly, easterly, and northeasterly (Revision of the PDAU Directive Plan for the Municipality of Oued El Athmania, 2021).

6.2. Human factors:

6.2.1. Land use standards:

The city has known urban expansion in all directions since independence from 1962 to 1984, where the growth was in the northern, eastern, and southern sides of the first nucleus (Map N°. (3)), random and chaotic growth continued after independence, so the city knew urban growth in disregard of all laws and plans in force in organizing and controlling construction, for example the urban development directive plan for the year 1967 shows that the banks of the Bouyagour valley It was dedicated to the cultivation of fruit trees and by the end of the seventies the built area was estimated at 100 hectares, and with the beginning of the eighties the urban extension was in two directions, northeast and south with the spread of modern building materials, which encouraged the multiplicity of housing units and one building to achieve the maximum economic benefit in the city, as urban growth was in line with paved roads and waterways.

The stage of urban growth continued after 1984 to the present day, which includes the period after the administrative division, where it became affiliated with the state of Mila, so it knew rapid urban growth, this period was characterized by the emergence of new poles for construction and reconstruction represented in the new allocations, which contributed significantly to the urban development and the field of the city, as well as the emergence and application of new housing

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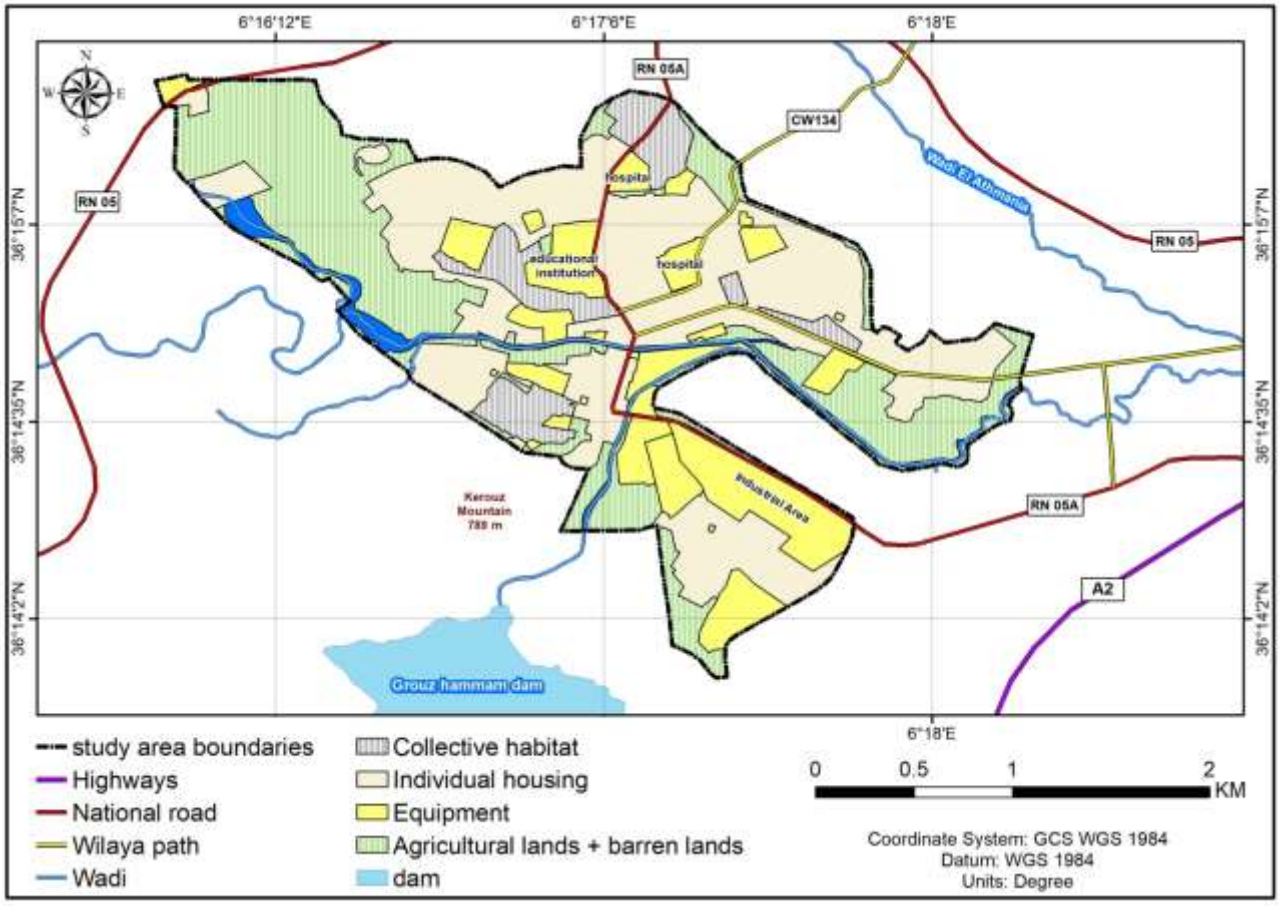
policies in the city, thus doubling the number of housing and increasing the built area by extension, and the city knew during this period the urban expansion on Calculation of agricultural land in most directions The city also witnessed a significant expansion in the collective pattern, and this period witnessed a large demand for housing the deficit for the year 2000 was estimated at: 95 housing and in 2005 was 1586 housing, according to the technical interests of the municipality In light of this case, construction and reconstruction have been carried out in some vacant areas, which are only 60 meters away from the Bouyagour valley, despite the degree of danger, in the absence of awareness of the danger (Review of the master plan for development and reconstruction PDAU of the Municipality of Oued El Athmania, 2021)



Map n° (3): Land uses in the Oued El Athmania city (Done in 2023-04-23 by the researcher).

One of the most important forms of land exploitation prevailing in the study area includes the uses of residential, agricultural, commercial, and industrial functions.

6.2.2. Population development of the field of study:

The city of Oued El Athmania witnessed a large demographic explosion due to the natural increase of rural displacement, where the city's population developed from 35,934 people in 1998 people to 40,688 people in 2008 with a growth rate of more than .1.39% and a population density estimated at

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148.5 people / km2, indicating that the future population for the year 2023 was estimated at 56,795 people.

The number of dwellings in the city of Oued El Athmania in the latest estimates is estimated at 4626 dwellings, distributed over an area of 276 hectares, of which 3817 dwellings are occupied by 86.51% of the total dwellings, and 809 dwellings are not occupied by an estimated 17.48% of the total dwellings. The majority of the housing of the city of Oued El Athmania is of the individual type, as its number reached 4560 dwellings, or 40.87% of the total housing of the sector, followed by the collective pattern of 59.17%, with an estimated number of dwellings estimated at 6589 dwellings, while we note the lack of semi-collective dwellings.

7. Using the AHP analytical hierarchy method to calculate or weigh the criteria used:

Multi-criteria decision analysis depends on a set of methods to determine the weights of standards that may affect the studied phenomenon, among these methods and the most famous of which is the AHP analytical hierarchy method, which has proven its effectiveness in many multiple decision studies, where this method can be relied on to determine the weights of the criteria used affecting the phenomenon and determine the most important of them, after doing a set of steps that we will address To them in this section in detail, and to illustrate the most important steps of the method workflow:

7.1. Analytical hierarchy process (AHP):

In the application of multi-criteria decision analysis, the analytical hierarchy process, a structured technique for dealing with complex decisions, has been applied in structuring flooding factors. In theory, AHP instead of describing the right decision helps decision-makers find the most appropriate one for their needs and understand the problem. This means that AHP is a decision-making approach based on the real ability of people to make critical decisions. It allows the active participation of decision-makers in exploring all possible options to fully understand the underlying problems before reaching an agreement or reaching a decision. Therefore, the purpose of the AHP program is to judge the specific alternatives for a particular goal by developing priorities for these alternatives and the criteria were chosen (Duc TT,2006, Dicky. A,2020)

In the application of AHP, the pairwise comparison technique is used to derive the priorities of criteria in terms of their importance in achieving the goal. Similarly, the priorities of alternatives (i.e., competing options under consideration) are derived from bilateral comparisons in terms of their performance against each criterion (DHIMI, 2020). Thus, the AHP program is based on three principles: decomposition, comparative judgment, and synthesis of priorities. By organizing and evaluating alternatives in relation to the hierarchy of multifaceted attributes as shown in Figure 1,

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AHP provides an effective quantitative decision-making tool for dealing with complex and unstructured problems. AHP allows for a better framework And easier and more efficient to determine the selection criteria The process thus makes it possible to integrate judgments on intangible qualitative criteria along with tangible quantitative standards (DHIMI, 2020).

Once the hierarchy is established, the expert and participants use the AHP program to prioritize all its nodes. By doing so, information is drawn from experts and participants, and it is processed mathematically. Priorities are distributed along the hierarchy according to their structure, and their values depend on the information entered by the users of the process. In AHP, multiple pair comparisons are based on a standardized nine-level comparison scale (Dehimi, 2021, Harbi. H et al,2001.)

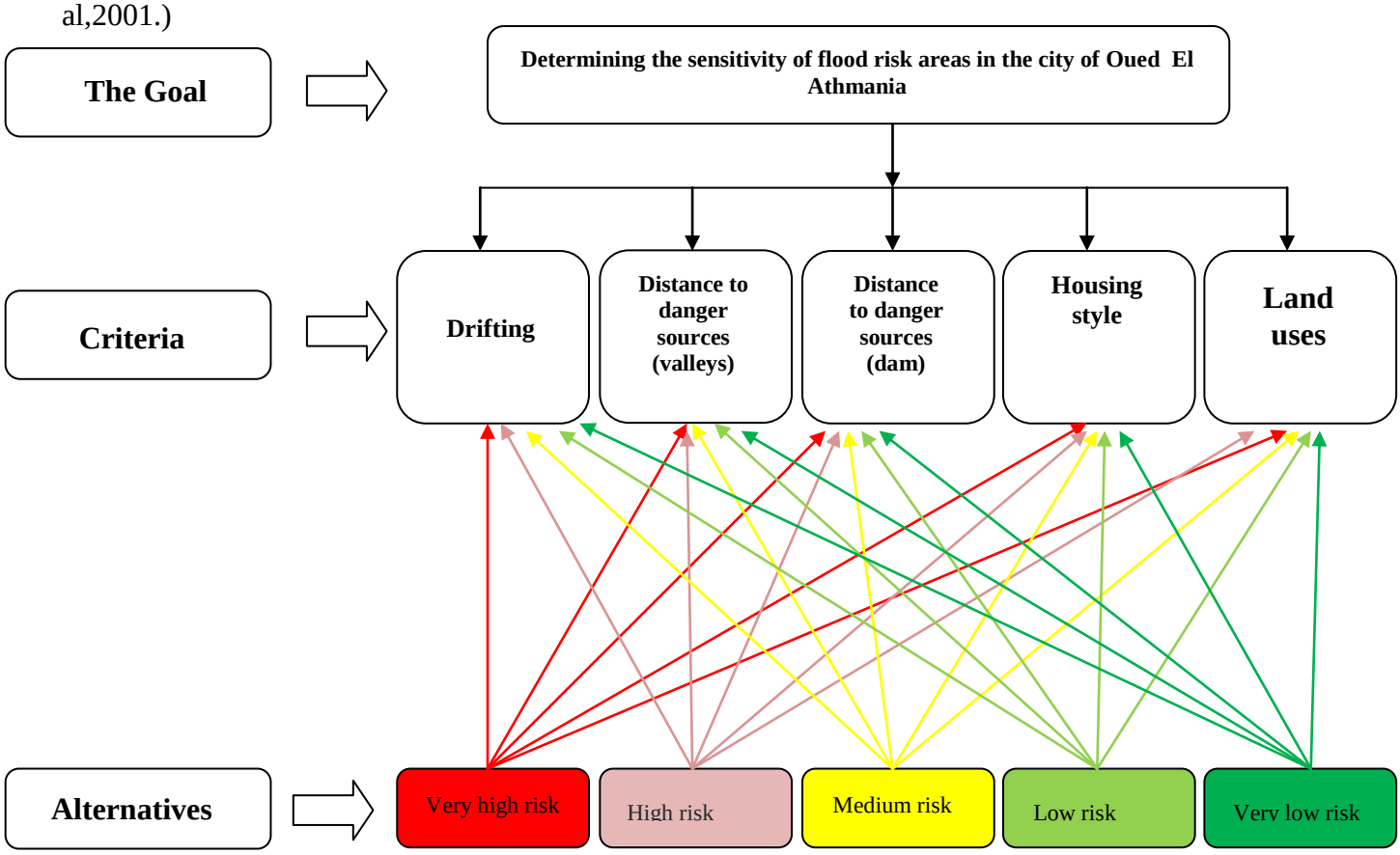

Figure 1: General structure of sensitivity map design using AHP (Done in 2023-04-23 by the researcher).

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Table 1: Bilateral comparison between the studied criteria of the Oued El Athmania City

Standard	Slopes	Distance to sources of danger (valleys)	Distance to sources of danger (dam)	Housing style	Land Uses
Slopes	1	2	3	4	4
Distance to sources of danger (valleys)	0,5	1	2	3	3
Distance to sources of danger (dam)	0,333333333	0,5	1	2	2
Housing style	0,25	0,333333333	0,5	1	2
Land Uses	0,25	0,333333333	0,5	0,5	1
Total	2,333333333	4,166666667	7	10,5	12

After conducting the two-way comparison process, the sum of each of the columns is calculated (Table N°. (1)), then we divide each value in the two-way comparison table by the sum of the value of one column, and then the average of the row values is calculated to reach the weights of the criteria that have been worked on, as shown in table (2) :

Table 2: Calculation of the weights of the criteria used in the analysis

Standard	Slopes	Distance to sources of danger (valleys)	Distance to sources of danger (dam)	Housing style	Uses earth	Weight
Slopes	0,428571429	0,48	0,428571429	0,38095238	0,333333333	0,410286
Distance to sources of danger (valleys)	0,214285714	0,24	0,285714286	0,28571429	0,25	0,255143
Distance to sources of danger (dam)	0,142857143	0,12	0,142857143	0,19047619	0,166666667	0,152571
Housing style	0,107142857	0,08	0,071428571	0,0952381	0,166666667	0,104095
Land Uses	0,107142857	0,08	0,071428571	0,04761905	0,083333333	0,077905
Total						1

After extracting the weights, the bilateral comparison that was previously made must be confirmed, by calculating the consistency coefficient (CR), as the condition for the validity of the bilateral comparison is that the CR coefficient is < 0.1, and this is calculated by multiplying the value of each weight extracted from Table (2) by all the values of the columns corresponding to it in Table (01), or by dividing this weight from Table (2) by all values in the rows For Table N°. (1) and the inclusion of values in a third table in the form of columns as shown in Table N°. (03), where the

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second method was used in our study, after that the total values of the rows are calculated and divided by the weights that were calculated in the second table, and the max coefficient is extracted, then the CI coefficient is calculated according to the equation, and the CR coefficient is extracted through the method data (Figure N°. 01) where the CR is extracted according to the number of criteria used in the analysis, Then calculate the RC coefficient according to equation N°. (02), and confirm its value, which was mentioned earlier, and if you do not meet the condition, it is evidence that there is an error in the first bilateral comparison table.

Table 3: Results of Verification of the Consistency Coefficient Value CR

Standard	Slopes	Distance to sources of danger (valleys)	Distance to sources of danger (dam)	Housing style	Uses earth	Total	Weight	
Slopes	0,410285714	0,510285714	0,457714286	0,416380952	0,311619048	2,1062857	0,4102857	5,1337047
Distance to sources of danger (valleys)	0,205142857	0,255142857	0,305142857	0,312285714	0,233714286	1,3114286	0,2551429	5,1399776
Distance to sources of danger (dam)	0,136761905	0,127571429	0,152571429	0,208190476	0,155809524	0,7809048	0,1525714	5,1182896
Housing style	0,102571429	0,085047619	0,076285714	0,104095238	0,155809524	0,5238095	0,1040952	5,032022
Land Uses	0,102571429	0,085047619	0,076285714	0,052047619	0,077904762	0,3938571	0,0779048	5,0556235
							L MAX	5,0959235
							CI	0,0239809
							RI	1,12
							RC	**0,021411**

From the results obtained, we found that the consistency coefficient is less than 0.1, so the bilateral comparison between the criteria is correct and the weights reached can be relied upon.

8. Dealing with the criteria used

In this step, distance maps are derived and maps are reclassified according to a specific scale to determine the importance of each field in each criterion through spatial processing and analysis tools in the GIS software environment, where we have determined a scale of 0-5 where we express the number 5 that the area is very sensitive to flood risk and 0 to the area that is not sensitive to flood, as shown in Table (4).

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Table 4: Scale of reclassification of the studied criteria in the Othmania Valley region

Standard	Category	hazard
Regressions (%)	<3	Very high risk
	3_ 7	High risk
	7_12	Medium risk
	12_ 25	Low risk
	>25	Very low risk
Distance to valleys (meters)	0 _ 50	Very high risk
	50 _ 100	High risk
	100_ 200	Medium risk
	200_ 400	Low risk
	>800	Very low risk
Distance to dam (m)	0 _500	Very high risk
	500 _ 800	High risk
	800 _ 1000	Medium risk
	1000_ 1500	Low risk
	>1500	Very low risk
Housing style	Collective housing	Very high risk
	Single housing	High risk
	Industrial Zones	Medium risk
	Agricultural areas and barren land	Low risk
Land Uses	Metropolitan Area	Very high risk
	Industrial Zones	Medium risk
	Agricultural areas and barren land	Low risk

According to the Department of Civil Protection and the Municipal Construction and Building Authorities and the results obtained from Table (4), the neighborhoods most affected by the risk of flooding are those found in non-reconstructible flood areas, especially those located on the banks of the valleys (Photos (1,2,3,4,5,6), for non-compliance with the rules of construction and construction, or those located in lowlands or with slopes, which causes them to be flooded, mainly related to random neighborhoods.

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The values of the chosen scale are given based on the study of each of the types that make up the layer by itself.

During the study of the characteristics of each type, and the degree of its impact on the studied phenomenon, and after applying the aforementioned steps, a Reaching the results contained in maps No. (4, 5, 6, 7, 8) (Done in 2023-04-23 by the researcher).

Image (1, 2): The unprepared part of the Oued Bouigour (Done in 2023-04-23 by the researcher).

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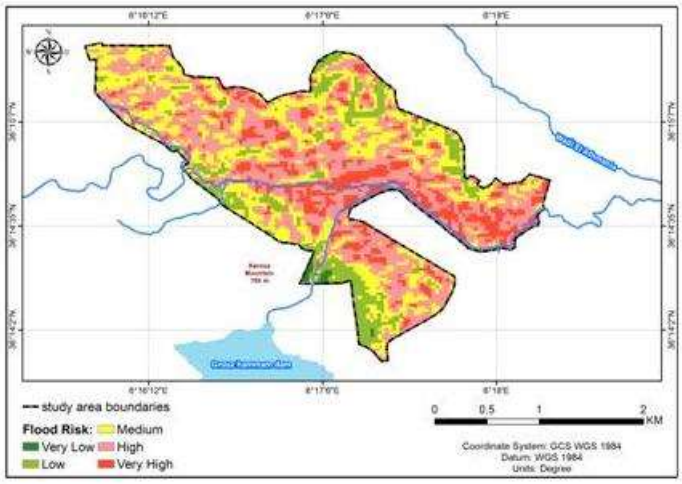
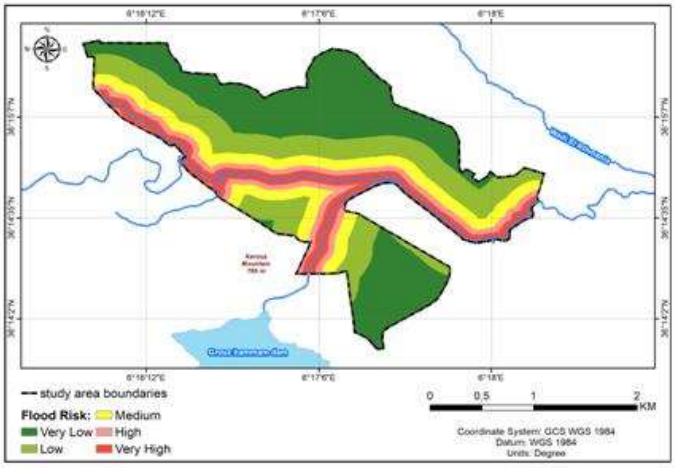
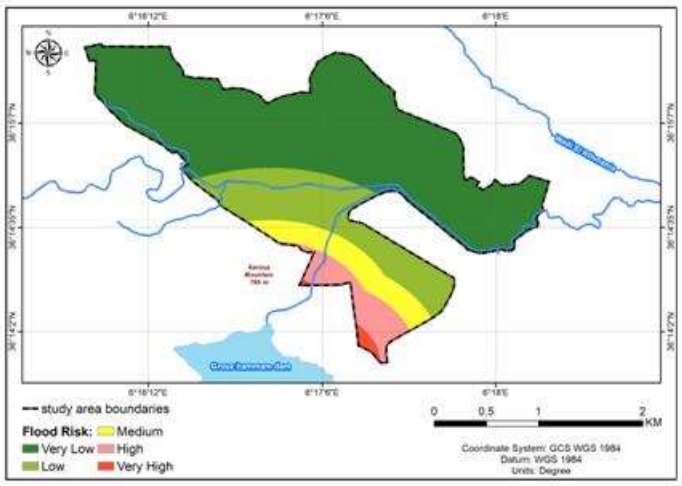


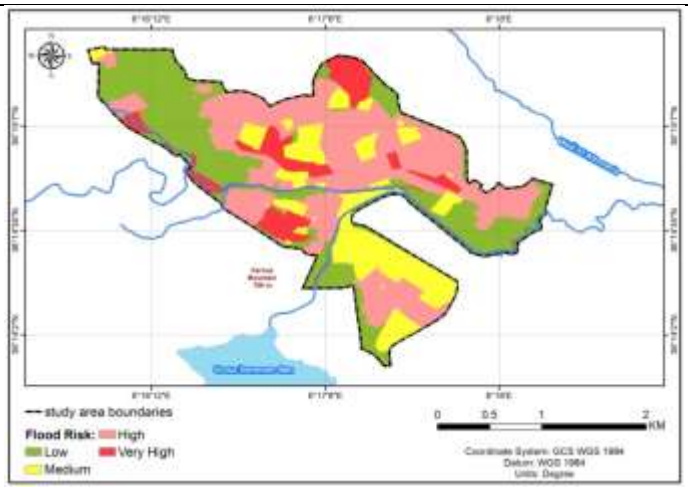
Map n° (5): Regression criterion for the Oued El Athmania



Map n° (4): Distance criterion for valleys of the Oued El Athmania



Map n° (7): Dam Distance Standard for the Oued El Athmania



Map n° (6): Building Pattern Standard (Residential Density) for Oued El Athmania

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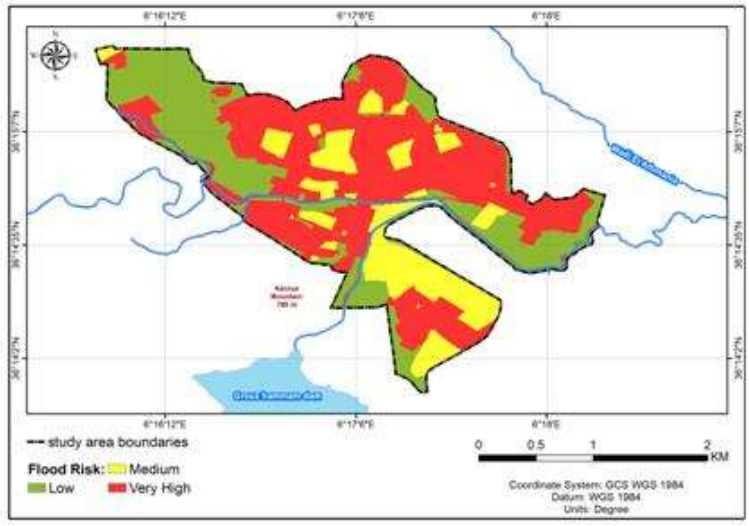

Map n° (8): Land Use Standard for the Oued El Athmania

Analysis result: After doing all the previous steps, the layers (criteria) are merged, taking into account the weight of each criterion according to the following relationship:

Final Goal = (Criterion$_{(1)}$ x Weight$_{(1)}$) + (Criterion$_{(2)}$ x Weight $_{(2)}$)+(Criterion$_{(n)}$ x Weight$_{(n)}$)

After conducting the spatial analysis process to study the sensitivity of the flood risk, depending on the aforementioned methods and the criteria that were determined, the final result was reached that divides the area of the study area into sub-areas that expresses the sensitivity of the study area to flood risk, we conducted a geographical analysis on the classification of areas by height to know the topography of the areas, and then classify the latter according to their proximity or distance from the valley.

The degree of sensitivity of the risk lies in the city center, which is the area where Oued Bouyagour meets Oued Al-Rhumal where there is an average residential density (the number of housing is 250 houses with an area of 25 AH) with a concentration of all services and equipment, followed by the urban sector wreckage located within walking distance of the valley characterized by a weak population density as an average residential density (the number of housing 90 housing with an area of 8.2 AH), with a residential area dominated by the character of traditional individual housing, these two sectors have greatly threatened The risk of flooding because they are near the valley. The urban sector is very close to Oued Bouyagour, characterized by a population density of medium housing, and chaotic housing

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Photo n° (3 and 4): The spread of chaotic construction in flood-prone areas (Done in 2023-04-23 by the researcher)

Photo no 6: Chaotic construction on the flood beds of the valley (Done in 2023-04-23 by the researcher).

Photo n° 5: Construction on top of the flood beds of Loa Bouyagour (Done in 2023-04-23 by the researcher).

Followed by the two sectors of Bosna Ahmed residential nature of an individual nature with high population density and housing (the number of housing 299 housing area of 20.2 AH) and Makhloufi Suleiman (several housing 130 housing area of 8.9 AH) is also threatened by flooding, and finally the industrial area: far from the valleys, but characterized by the phenomenon of Silaf on the level of the Division of Farooj in the northwest of the region, but the possibility that there is a threat to the region in the future (Map N° (9)).

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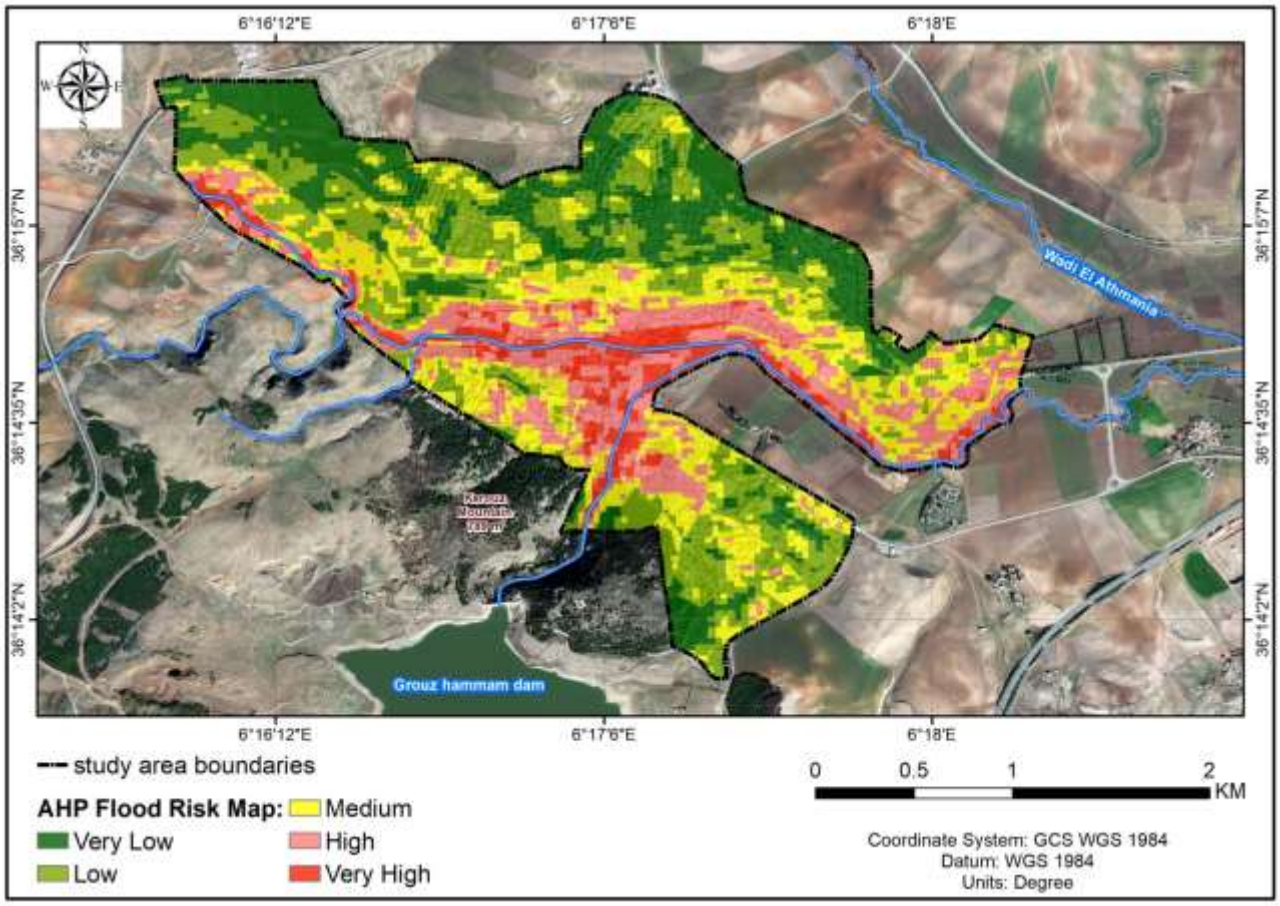

Map n° (9): Danger Sensitivity Map of the Oued El Athmania City

(Done in 2023-04-23 by the researcher).

Conclusion

The city of Oued Athmania is classified as a high-risk area for floods, the city has been exposed since its inception to this danger, and with the development of the economic and social situation, it has become more threatened than before, as it is today suffers from the addition of valleys in the urban center Kalsilav in the urban expansion areas of the city. This research presented an experimental approach to mapping urban flood exposure by integrating AHP and GIS techniques. The proposed approach could assist decision and policymakers in rapidly assessing the phenomenon of urban flooding. For the city of Oued Athmania, the flood risk map was derived using a multi-parameter approach that combines physical, social, and economic factors, measured in terms of morphological and topographic variables. Flood map validation through the comparative area and depth measurements show that the proposed approach is reliable with up to 92% of accuracy level. This research suggests that derived flood risk indicators are also reliable, and therefore can be used in decision-making toward flood management planning.

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The results of this study confirm that the integration of AHP and GIS technologies provides a powerful tool for decision-making procedures in flood risk mapping, allowing for coherent and efficient use of spatial data. The use of multi-criteria assessment of various factors has also proven useful in identifying risk areas for flood mapping and possible forecasting. Overall, the results of the case show that the GIS-AHP-based class model is effective in identifying flood risk areas.

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