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New Housing Estates in Algerian Cities Faced with the Potential Risk of Flooding. The Case of Khenchela

*[1]Dr. MEDDOUR Larbi

[1]Department of Architecture, Faculty of Science and Technology, University 08 Mai 1945 Guelma.

Algeria

Abstract: *The poor consideration of natural hazards during the planning of new urban extensions has flagrant repercussions, especially if it is subject to settlements of great anthropic vulnerability, such as collective housing areas. Our aim in this manuscript is to demonstrate the effect of this reality on the city and its users.*

Keywords: *Collective Housing, Flood Risk, Urban Sprawl*

1. Introduction

As a result of excessive demographic growth and the increase in urban population rates, most Algerian towns have undergone major expansion, sometimes doubling or even tripling in size in recent decades.

This situation has led to the construction of large collective housing complexes on available land, without any knowledge of the repercussions of their geographical, geological and topographical nature.

This situation has led to the emergence of new challenges facing the smooth running of the city, including the possibility of exposure of these parts of the city to flood risks, which is one of the concerns of the authorities and society as a whole.

The city of Khenchela, with its flooding situation, is one of the areas most likely to be exposed to the various risks defined by law no. 04-20 of 25 December 2004 on the prevention of major risks and disaster management as part of sustainable development.[1]

According to this decree, and based on the data it requires, the town of Khenchela is exposed to three (03) major risks, namely: Flooding, forest fires and industrial and energy risks.

So, the invitation of new techniques of remote sensing of geographical information system remain among the best tools of orientation and help to the decision in order to a more efficiency.

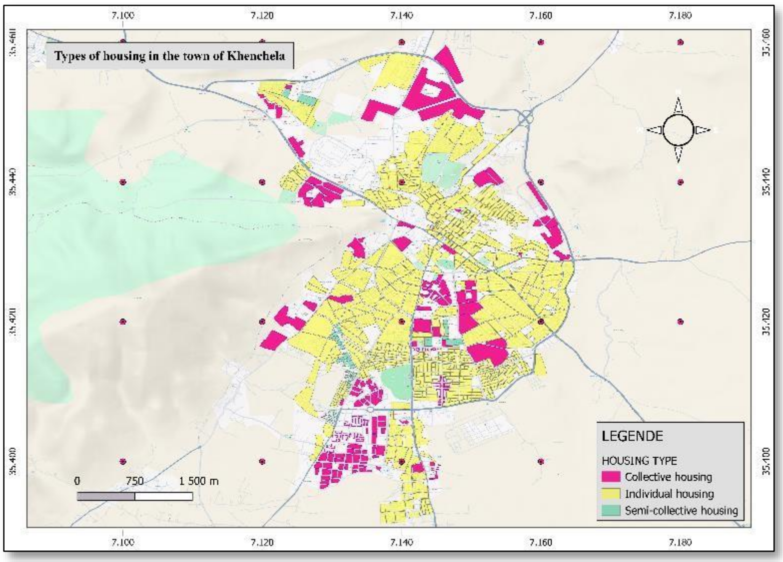
Most of the works dealing with the subject of flood risks are very general and have had no desire to deal with specific points in the city, as can be seen from the numerous works [2], [3], [4], [5], [6], [7], [8], [9]. What flood risk studies have in common with the general urban environment can be summed up in the sections dealing with the geomorphological and topographical nature of the land and the climatology of the regions in which the city is located. However, the difference between these studies and our point of view takes into account the scale of the areas covered (housing estates), their demographic and planning characteristics, and the behaviour of users in the face of the hazards of climate change and the risk of flooding.

2. Presentation of the Case Study

The city of Khenchela is a medium-sized town [10, 11], located in eastern Algeria, at the end of the Aurès mountain range. It lies at the foot of the Djebel Chabort, which backs onto it to the west, and is bordered to the east by the oued Boughoggal and the fertile lands of N'sigha to the south and Djebel Elmonchar to the north.

The town's recent history tells us that it was created during the colonial period at the top of a steep hill, with a residential area, a military fort and a number of local facilities.[12]. Following the country's independence in 1962, this town inherited a residential heritage of individual housing and a few collective housing buildings.

Over the years, as the city grew and the population increased, the town, like other towns in the country, embarked on a policy of managing the housing crisis, and as a result, major collective housing programmes were carried out. The strange irony is the way in which they have been built, and the huge number of housing estates that have been built. Because of this and the scarcity of optimal land reserves, the areas intended to house these programmes were chosen on fertile, relatively flat agricultural land, which meant that they had to contend with the natural risks of flooding (map 01).



Map 1Type houssing in Khenchela citys

3. Proposed Methodology

The methodology envisaged is based on an analysis of the phenomenon through the application of the multi-criteria method assisted by the geographic information system, while capturing the cartographic report of the population density in collective housing neighbourhoods.

These neighbourhoods are home to the densest residential mass of any housing type in the city. It is also clear that this occupation is accompanied by the occupation of large areas by car fleets, with an operating density that is several times the normal norm. The assessment criteria are divided into two groups: the first concerns hazards and the second vulnerability.

3.1. Flood Risk Assessment Using the Ahp Method

We used five criteria to assess the risk of flooding in an urban area according to the adjusted pairwise comparison matrix.

Distance from the canal network: signified by the easement margin reserved between the water line of a runoff that passes through the town and the first subject that may be exposed to flood risk.

-Slope: signified by the angle of inclination in relation to the normal of the natural terrain in a defined location.

-Land use: indicates the nature of the impermeability of the ground; landscaping, paving, building terraces and all open surfaces.

-Rainfall intensity: defined by the meteorological data supplied to the relevant departments in each region.

-Topography: defined by terrain relief.

-The results obtained after the formation of the pair-wise comparison matrix is constructed on the basis of the judgements of experts in the field as follows:

3.3.1. Step 1: Sum of each column

After adding up the values in each column of the matrix of different evaluation criteria :

TABLE I: Matrix of different evaluation criteia

CRITERIA	DISTANCE FROM THE NETWORK OF CANALS	SLOPE	**LAND USE**	RAINFALL INTENSITY	TOPOGRAPHY
Sum of column values	3.607	3.607	9.833	15.5	20.0

To normalise the matrix and calculate the weight, each element must be divided by the sum of its respective column. The result is the normalised pairwise comparison matrix. The weights (priority vector) are calculated as the average of the normalised values for each criterion. The resulting priority weights are as follows:

TABLE II: Calculate of risks waight

CRITERIA	**DISTANCE FROM THE NETWORK OF CANALS**	**SLOPE**	**LAND USE**	**RAINFALL INTENSITY**	**TOPOGRAPHY**	**Sum of the ranks**	**Weight**
DISTANCE FROM THE NETWORK OF CANALS	0.277	0.277	0.407	0.387	0.350	1.698	0.384
SLOPE	0.277	0.277	0.407	0.387	0.350	1.698	0.384
LAND USE	0.069	0.069	0.102	0.129	0.150	0.519	0.118
RAINFALL INTENSITY	0.046	0.046	0.051	0.065	0.100	0.308	0.070
TOPOGRAPHY	0.039	0.039	0.034	0.032	0.050	0.194	0.044

3.1.2 Step 2: Consistency check (calculation of λmax)

For the consistency check, we start by calculating the weighted sum of each criterion. To do this, we multiply each pairwise comparison value by the corresponding weight and sum the results for each row. We then calculate λmax by dividing each sum of the weighted values by the corresponding weight.

TABLE III: Calculation of λmax

CRITERIA	*Sum of weighted values*	*Calculation of λmax*
DISTANCE FROM THE NETWORK OF CANALS …….	1.698	1.698/0.384=4.4219
SLOPE …………………………………….………..…	1.698	1.698/0.384=4.4219
LAND USE……………………………………..…...	0.519	0.519/0.118=4.3983
RAINFALL INTENSITY………………………………….	0.308	0.308/0.070=4.400
TOPOGRAPHY …………………………………………...	0.194	0.194/0.044=4.4091

This refined model guarantees a high level of consistency and reliability for assessing flood risk in urban areas using the AHP method. The results obtained after completion of all the calculation operations are summarised in the table below:

TABLE IV: Classification Lavels of Creteria

Class	**Classification**	**Description standard value**
Distance from the network of canals	0-20 m	1.0
	20-50 m	0.75
	50-100 m	0.5
	>100 m	0.25
Slope	0-2°	1.0
	2 - 5°	0.75
	5 - 8°	0.5
	> 8°	0.25
Land use	Urban area	1.0
	Terre nue	0.5
	Foret	0.25
Topography	1000-1100	1.0
	1100-1150	0.5
	>1150	0.25
Rainfall Intensity	400 mm/year (high)	1.0
Depending on the climate	350 mm/ year	0.75
	300 mm/ year (moderate)	0.5
	200 mm/year (low)	0.25

3.2. For The Vulnerability Map:

Given your new order of importance for the vulnerability criteria, we will create the pairwise comparison matrix accordingly:

3.2.1. Housing Type

Following the creation and standardisation of the pair-wise comparison matrix for the vulnerability criteria taking into account the importance of the criteria, the calculation of the priority vectors and the consistency check, it is agreed that this refined model guarantees high consistency and reliability for the assessment of vulnerability in an urban area using the AHP method according to the following results.

TABLE V: Classification of Vulnirability Creteria

Class	**Description**	Description Standard value
Type de logement	Collective housing	1.0
	Semi collective housing	0.75
	Individual housing	0.5
	Other buildings	0.25

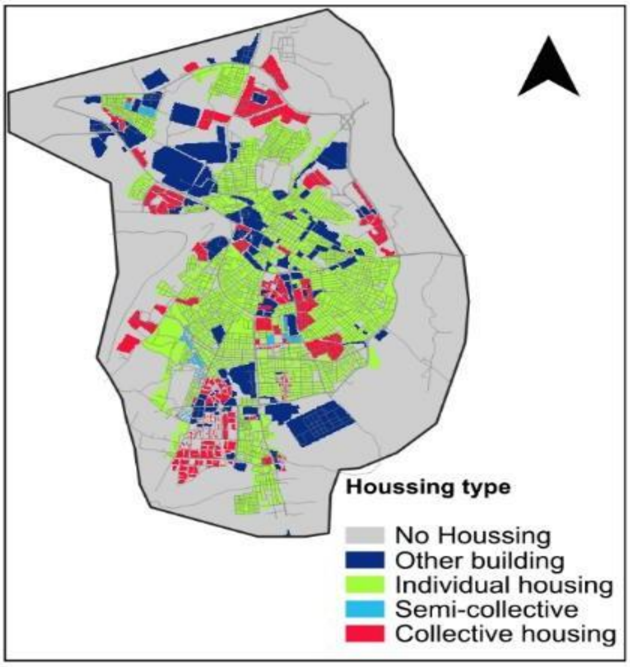
4. Conclusion

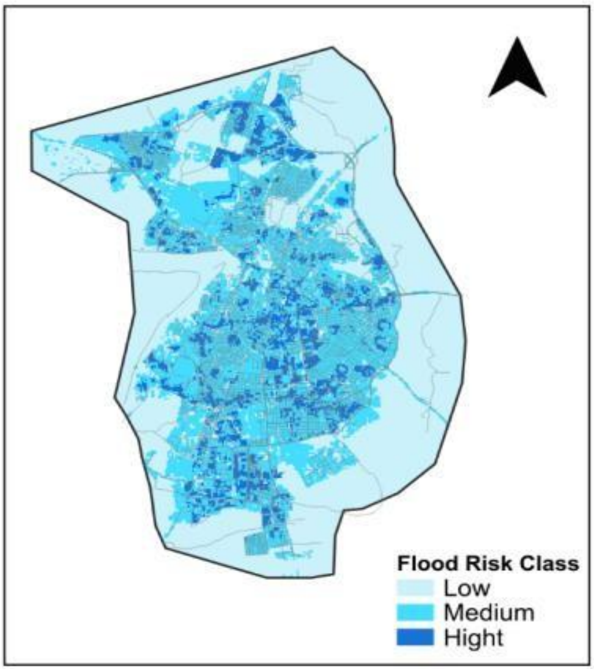
The graphical representation obtained after analyzing the results shows that three clouds of the degree of exposure of collective cities to flood risks are recorded; either:

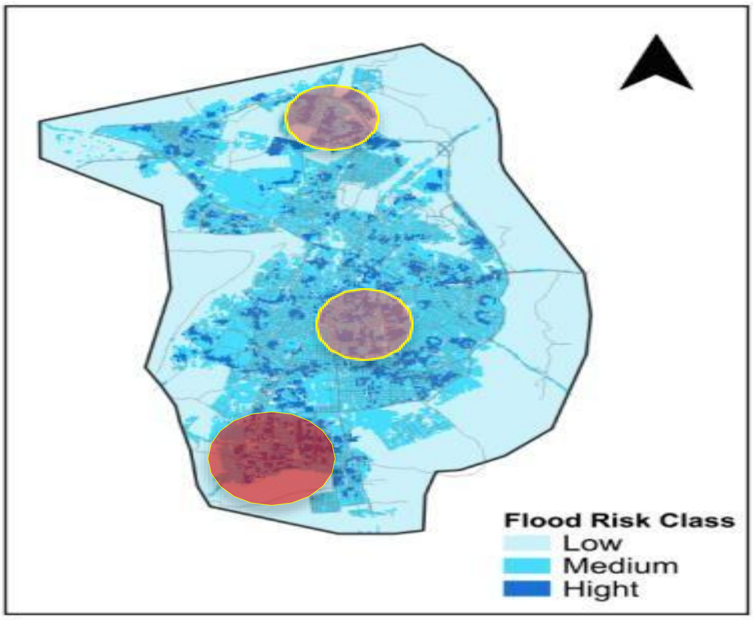
-The housing estates located to the south of the town, where the N'sigha run-off accumulates from upstream on the Chabord mountain. This location coincides with large collective housing estates (10,000 homes). [13].

-The housing estates located in the middle of the city, which were built in the 1980s, are highly susceptible to flooding. The main cause is always linked to the topography and the passage of a thread of run-off through this part of the town (see map ....) on the one hand, and the superimposition of major traffic routes on this thread of water on the other.

-The third point is located to the north of the town, at the junction of two downstream points in the region's catchment area, namely Mount Chabor to the south and the Elmonchar mountains to the north. This housing estate also includes university halls of residence, which are located not far from the site, adding to the risk of flooding.







Map 2: Localisation of Flood Risk Houssing In Khenchela City

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