

Application MultiCriteria Decision Analysis- Approach AHP- to develop land suitability for urban sprawl

GUERROUDJ Abdelhalim^(1, 2), HADEID Mohamed⁽²⁾, DJELLABI Brahim⁽³⁾ Mega Nabil⁽⁴⁾

⁽¹⁾ Amar Telidji University – Laghouat, Algeria, email: a.guerroudj@lagh-univ.dz

⁽²⁾ EGEAT Research Laboratory – Oran 2 University, Algeria, email: hadeid009@yahoo.fr

⁽³⁾ LAMOS Research Unit – Bejaia University, Algeria, email: brahim_infocomp@yahoo.com

⁽⁴⁾ Hamma Lakhdar University – El Oued – Algeria, email: mega-nabil@univ-eloued.dz

Correspondent author email: a.guerroudj@lagh-univ.dz

Abstract

In urban planning philosophy, everyone views the city's future and the priorities concerning these needs. These variants must respect the planning principles. In this study, we tried to solve the problem of the choice of land for urban sprawl, based on several factors to assign the optimal weights to these, and then combined. Our developed prototype GIS/AHP (Geographic Information System/Analytic Hierarchy Process) seeks to find solutions to respect the principles of development but with a justification for the choice of the land base.

To show the potential of this prototype, we carried out a diachronic study of the "urban planning and development master plan"(UPDP) of the municipality of El-Bayadh -in its current situation compared to its initial state- in terms of development and the precautions to take before revising it.

Through this research, we have seen some dysfunctions in the combination of development rules to this end; we combined the geographic information system with the multi-criteria analysis to take into account parameters concerning land management, like vegetative cover lithology; constraints to be met such as the flood hazard map; and other legislative criteria such as legal ownership. The combined GIS / AHP solution has advantages in land choice according to the maximum parameters, controlling the whole municipal territory by knowing all its characteristics and widening the choice interval in terms of the land plot.

Keywords: Urban sprawl, land plots, flood hazard, GIS / AHP, UPDP.

1. Introduction

Despite all planning organizations that have been created in Algeria between 1962 and 1990, like Secretariat state of planning which later became the Ministry of planning and Land Management. The establishment of animation service and economic planning which has been integrated later in 1980 on the planning direction and land planning), Thus, this period is characterized by lack of a land-use master plan.

Although, Algeria has been adopted a new national land-use plan and regional land-use plans. The last one is considered a privileged instrument for land use management. It is supposed to ensure inter-regional coherence and coordination; in addition, it supports decision-making for equipment localization and implants activities at a regional level. Also, it is both an arbitration instrument and consultation for the use of space between regions and wilayas to optimize the projects investments in such region (Leila Saharaoui and Yassine Bada, 2021)

From the 1990s, controlling the growth of cities once again became a concern of public authorities. In this new regulatory context, and to limit the harmful effects of urbanization and land overconsumption, public action has revised urban planning instruments. In this logic, the revision of the UPDP was launched, to promote the renewal of the urban zone, and the rational use of the land. The study of the UPDP is supposed to follow the directives of the hierarchical superior instruments.

In this regard, we review the city of El-Bayadh which is located in the steppe zone of Algeria, it knows a slow development in this, but due to rapid population growth, the urban area has expanded in an uncoordinated manner. The UPDP revision in the period between 2006 -2016 shows a lack of control of planning factors. We propose to integrate the planning factors in a SIG/AHP prototype particularly the flood hazard map of El-Bayadh municipality to determine the optimal location of urban sprawl.

According to Shukla, 2017, GIS, and AHP method is a vital tool for identification, comparison and multi-criterion decision making analysis of urban development site's proper planning and management. The AHP model has different applications in several studies like Groundwater quality assessment study (Nabil Mega and Salim Khechana, 2021), environmental risks study (Guerroudj Abdelhalim and all, 2017); and also has been used by several authors in planning studies, like land suitability analysis (Jahangeer A. Parry and all, 2018). In the land suitability model field for citrus cultivation (Emre Tercan, Mehmet Ali Dereli, 2020), and for ecotourism suitability decision making (Hasan Zabihi and all, 2020), Suitability evaluation of urban construction (E. Ustaoglu, A.C. Aydinoglu, 2020).

2. Study area

To show the contribution of the risk map to town planning, the study area that we have selected is an area affected by the floods in October 2011 and 1953 (Guerroudj, Aet al, 2017). El-Bayadh is a municipality in the boycott of El-Bayadh, the city capital, located 370 km south-east of Oran, 520 km south-west of Algiers, and 500 km north-east of Bechar. It extends from 33°29'19.37" N to 33°47'29.35" N latitude and 0°51'9.36" E to 1°10'36.24" E longitude. It is located at an altitude of about 1400 meters above mean sea level. The geographical area of El-Bayadh municipality is about 463, 50 sq km. (Guerroudj, A, 2019).

The city of El-Bayadh is split in two by wadi El-Biod, with an area of approximately 10 sq km and a population of 135 461 (Census of Algeria, 2020).

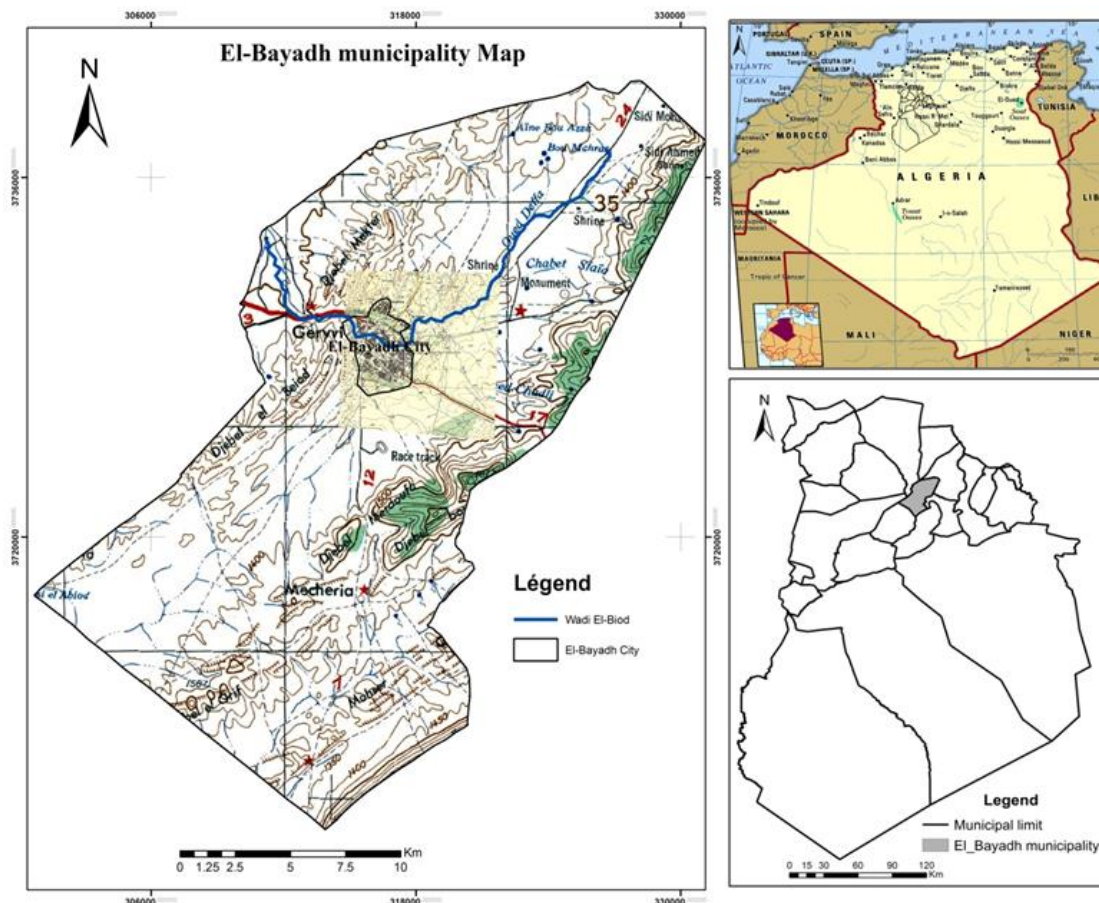


Figure 1. Location of the Study area

3. Data and Methods

The methodological approach adopted in this research consists of determining urban sprawl from El-Bayadh city by multi-criteria study used parameters included, when

carrying out urban planning and development master plan –UPDP- of Algerian cities. The method selected in integration and parameter weights calculation is AHP (Analytic Hierarchy Process) method (Saaty, 1980). This study used physical parameters for the suitability analysis like slope, vegetative cover, lithology, and other parameters defined as legislated constraints such as the flood hazard map; and legal ownership. Acquisition of these parameters has been carried out using remote sensing and GIS techniques. The results obtained by combining these parameters are compared with studies established in urban planning and development master plan (2006 and 2016 UPDP).

The 2006 UPDP presented a proposal of urban sprawl and developable land from El-Bayadh city because this last besieged by the green dam. It requires a sprawl beyond the limit of this dam. This choice was focused on the southern part of the city, on a land plot (property tax base) of about 15 hectares. Besides, the UPDP 2016 contains a map showing risk areas with four distinct classes:

Risk flooding caused by the overflow of Wadi El-Biodh: This Class includes neighboring areas of wadi with a strip about 35 m wide on both sides; Risk flooding caused by stormwater stagnates: This Class requires a specific study; Risk from landslides: this is clay soils and sloping land; Risk flooding and landslides. For the last two classes, there is also a need for geotechnical study and appropriate actions. (Extract from the 2006 UPDP is shown in Figure 2a)

The 2016 UPDP presents a continuity of the 2006 UPDP; it brings out only urban sprawl from El-Bayadh city, where we find equipment and accommodation, in other words, the UPDP 2006 forecasts. Did not take risks into account, either in the areas affected by the 2011 flood or in developable land, what constitutes a threat for the return of the flood scenario in these new areas. (Extract from the 2016 UPDP is shown in Figure 2b)

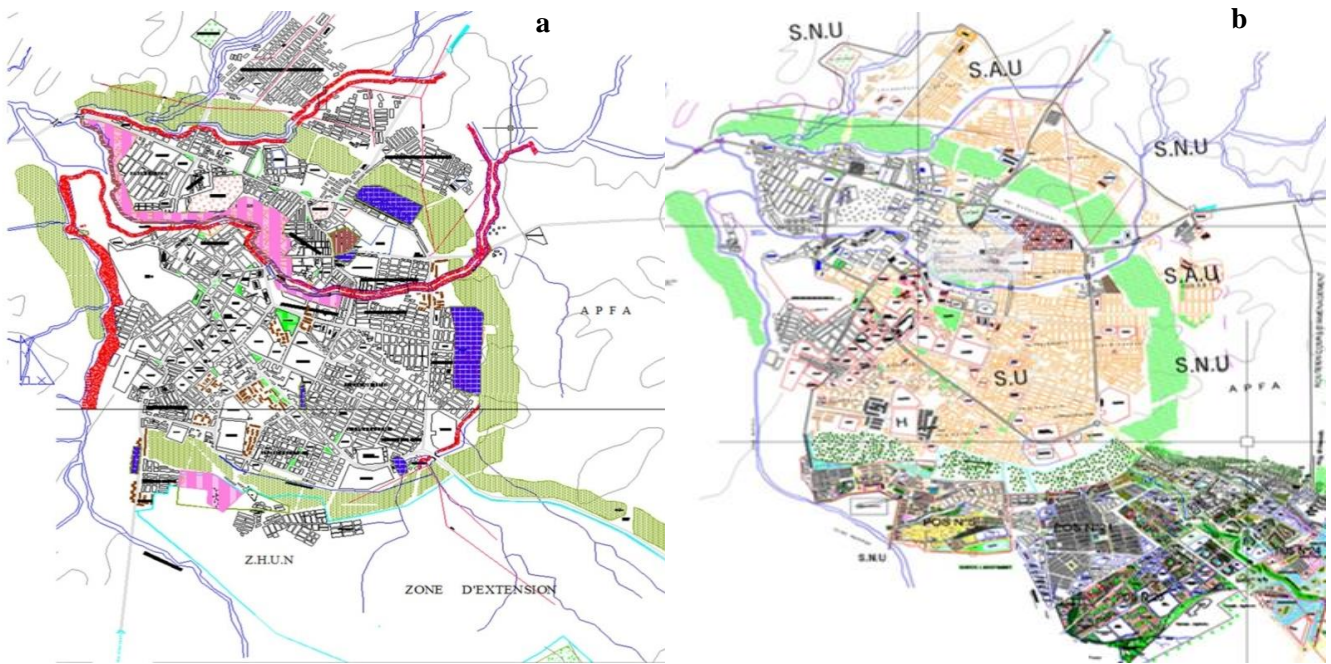


Figure 2. Extract from UPDP of the El-Bayadh municipality (a: 2006, b: 2016)

The review of these plans (2006 and 2016 UPDP) shows that only two parameters are included in the choice of urban sprawl. The first requires that this zone be close to the conurbation (old city), and their legal ownership belongs to the public domain.

3.1. Determination developed land for urban sprawl of El-Bayadh municipality by the AHP approach

The determination of developed land for urban sprawl consists of applying the multi-criteria combination of the chosen parameters. These parameters were integrated into the decision-making process form of thematic layers and raster images (For each type of data, we applied a preliminary treatment as required GIS/AHP integration formats). These parameters are then given weightage as per the Saaty's AHP method (Saaty, 1980) (are weighted relative to each other according to the degree of importance of each in the operation of establishing Suitability map). The flow chart of the methodology adopted is presented in Figure 3.

3.2. The analytic hierarchy process

According to Akash R.L end, all, the Analytic Hierarchy Process (AHP) is one of the modern popular multi-criteria analytical techniques used to get the best suitable solution for the problem or goal under consideration from available alternatives considering multiple impactful criteria and choices. AHP is used to get out of the

complex decisions that are impossible to overcome using standard methods (Dipti, Sengar). The AHP method allows assigning a value representing the preference degree for a given alternative to each additional alternative. Such values can classify and select alternatives based on a hierarchical structure (Chai end, all). The (AHP) Principe is based on the pairwise comparison. It consists in structuring the hierarchy of decision criteria and the alternatives in a tree-like form (decision tree) at several levels. The criteria and alternatives are compared in pairs at each level of the decision tree by using absolute numbers 1 to 9 from the fundamental scale AHP (Saaty, 2007). The Saaty's scale is presented in Table 1.

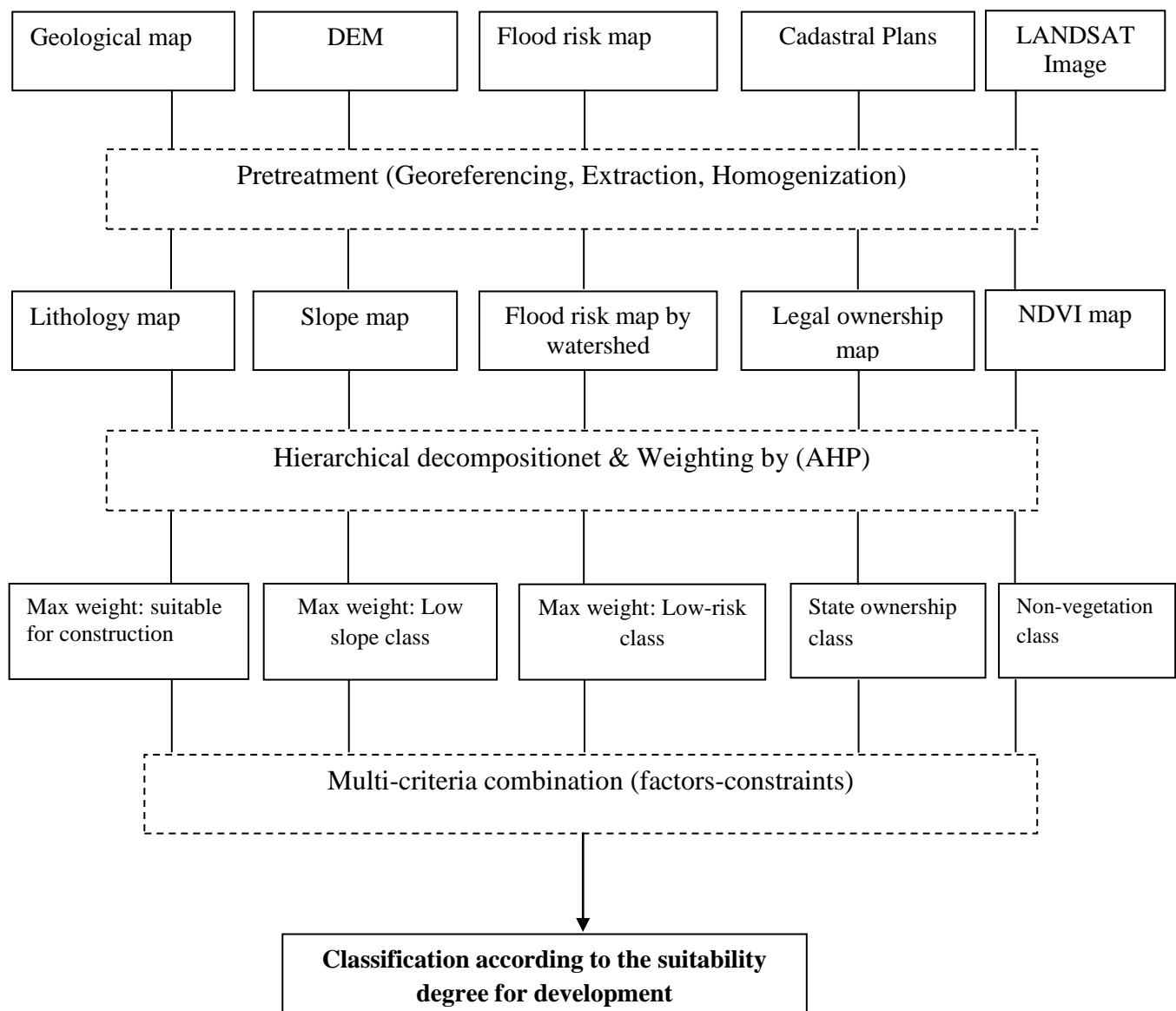


Figure 3. Flow chart of methodology.

Table 1.The comparison scale of pairwise Saaty (Saaty, T. (1994)

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgment slightly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Demonstrated importance	An activity is strongly favored and its dominance is demonstrated in practice
9	Absolute importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent judgments	When compromise is needed

3.3 map layers for suitability analysis

3.3.1. Vegetative cover / NDVI map

Vegetative cover (NDVI map) has been prepared by using the satellite image Landsat8. The vegetative cover information help in the choice of land for urban sprawl. The lowest area is under the vegetative category. The NDVI map is shown in Figure. 4a.

3.3.2. Lithology map

A lithology map has been extracted from the geological map;we have taken information from geologists scientists about the properties or the sensitivity of these rocks to construction. This information was used as criteria to classify the lithologies map according to the subject study Figure. 4b.

3.3.3. Slope map

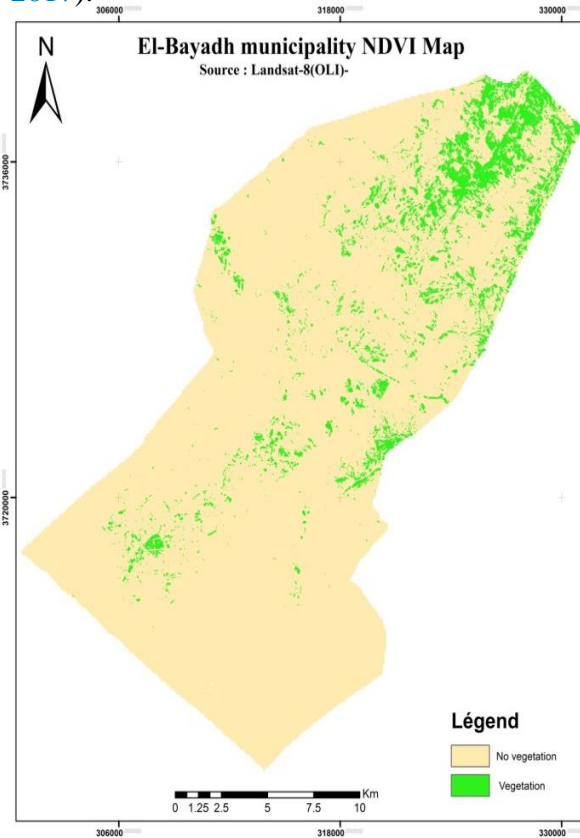
The slope map is an essential layer in this study, created by using DEM elevation GTOPO30. We followed a process of improving the quality of this model by integrating contour lines of the topographic map (Figure. 4c).

3.3.4. Legal ownership map

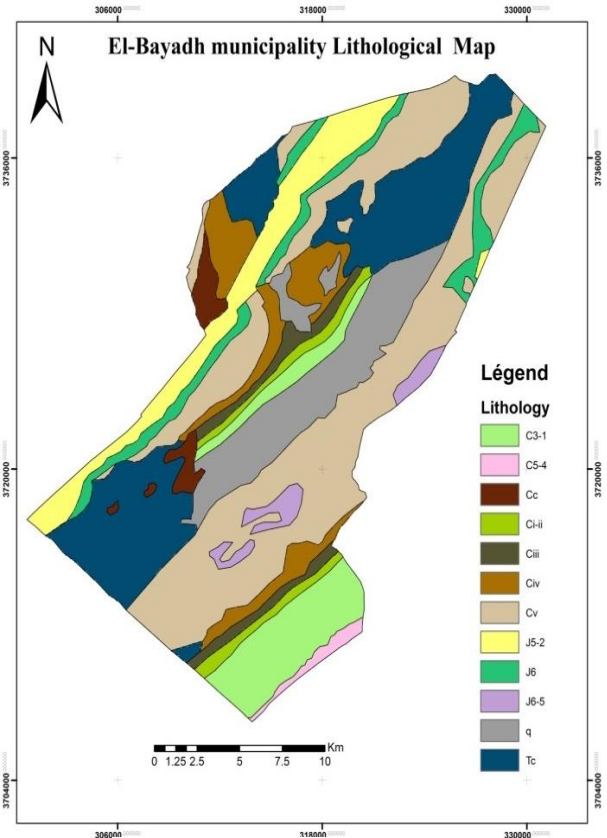
Legal ownership map has been extracted from cadastral plans; this map contains two classes, state ownership which presents more than 90% of El-Bayadh municipality, end the rest of private ownership (Figure. 4e).

3.3.5. Flood risk map

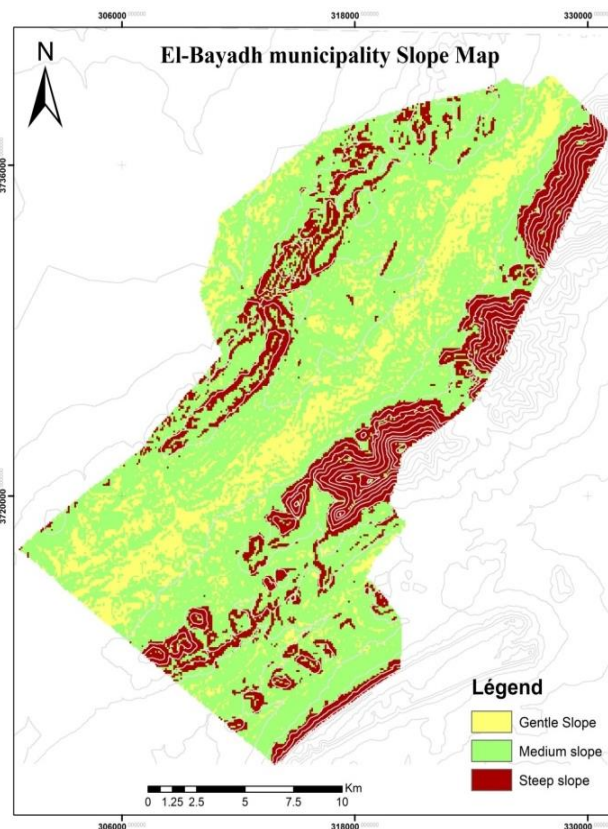
The flood risk map obtained by a spatial multi-criteria combination (AHP method) with integrating risk information by watershed, Figure. 4e shows the result of this combination. The flood hazard map shows five classes of risk (Guerroudj. A end all, 2017).



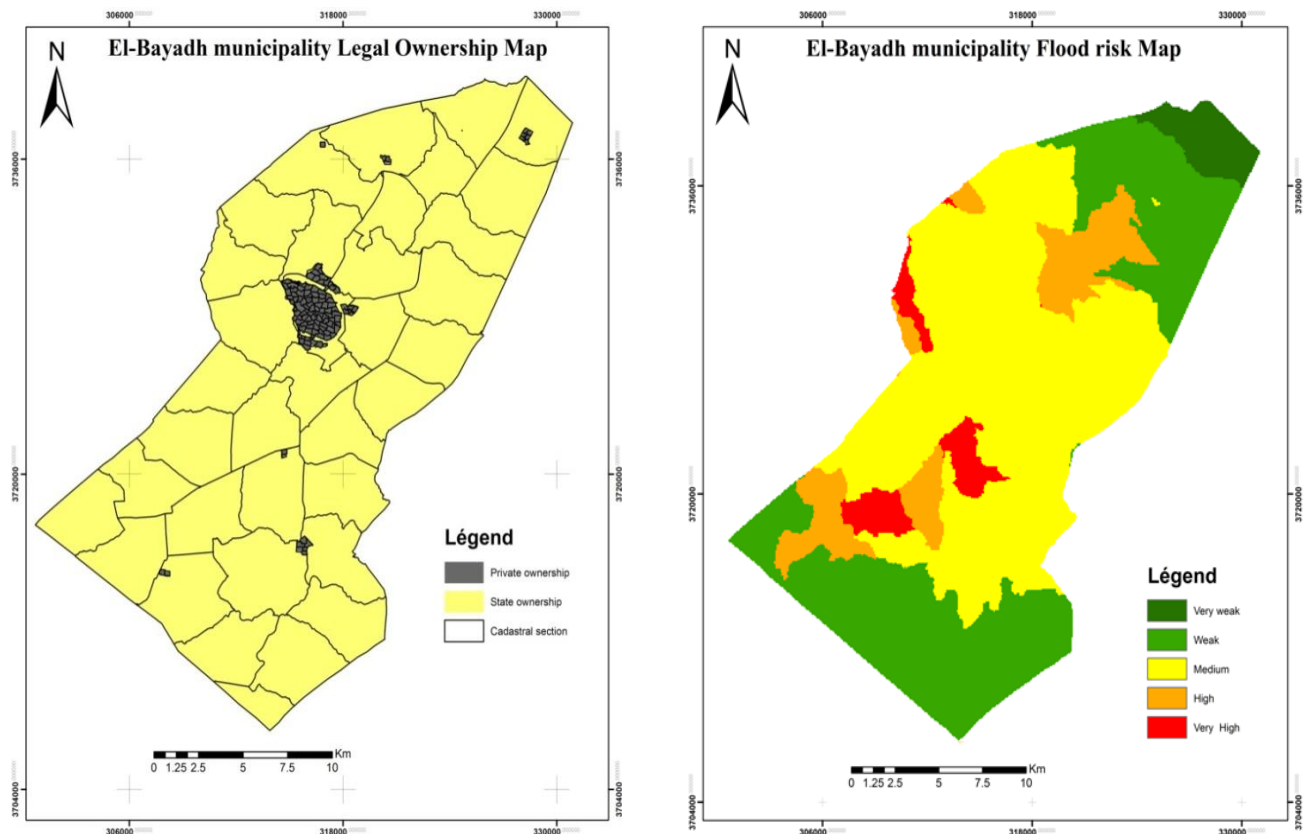
Source: Landsat-8 OLI - 2020 (a)



Source: Geological map (b)



Source: SRTM DEM-2014 (c)



Source: Directorate of Land Registry-2020 (d)

Source: Guerroudj A-2019 (e)

Figure 4. (a-e): Various map layers for suitability analysis

5. Results and Discussion

Depending on the approach followed, figure 5(a) shows a suitability map of urban sprawl in the El-Bayadh municipality issue from the spacesuit (by the AHP approach). Reading this map shows that there are five terrain classes, indicating the terrain's suitability to development while respecting criteria related to land bases and planning principles. The lands are well classified and identified from weak to strong aptitude. Figure 5(b) shows a suitability map of urban sprawl in El-Bayadh municipality ousing the cadastral section as a spatial integration unit to facilitate the presentation and interpretation.

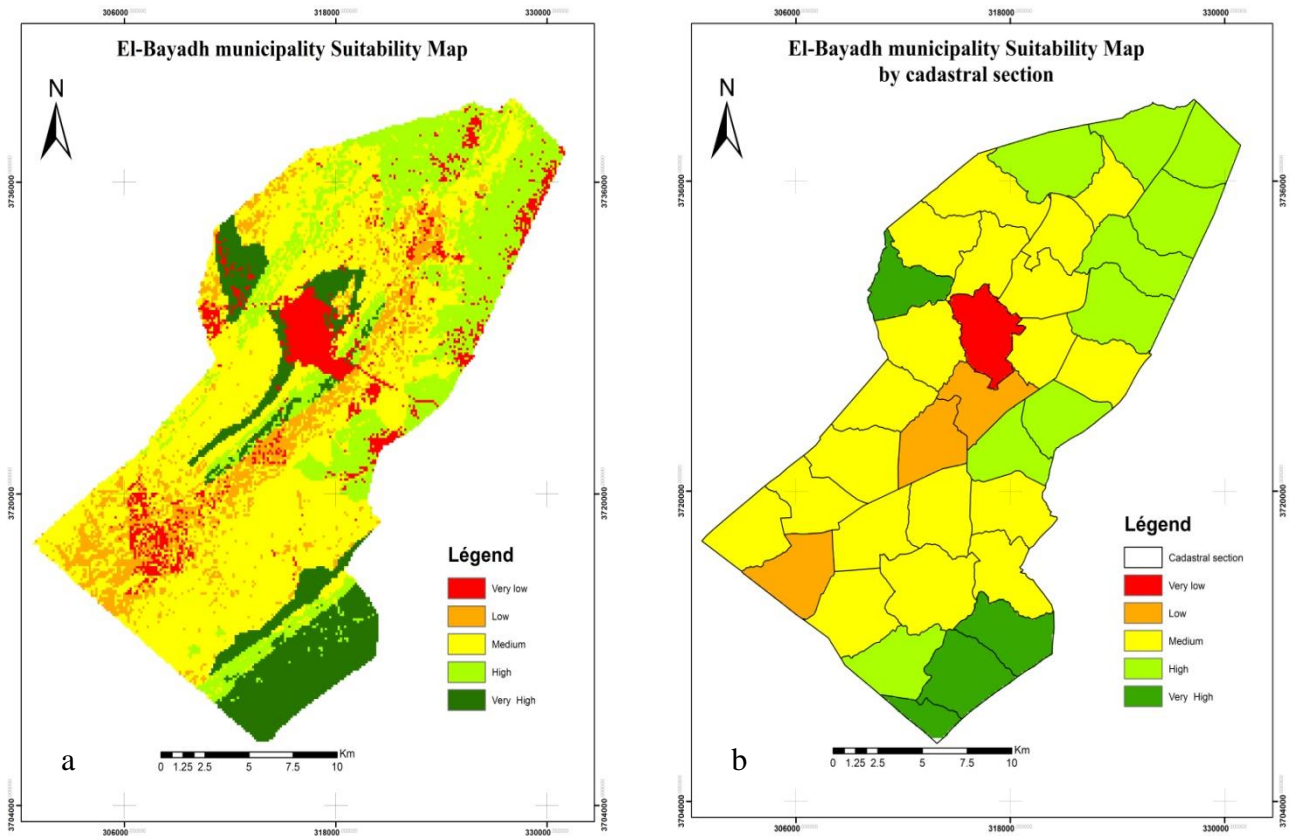


Figure 5. (a) Suitability map of urban sprawl in El-Bayadh municipality
 (b) spatial integration unit: cadastral section

Conclusion

Comparing the results from the methods (GIS / AHP) regarding the choice of most appropriate land bases at spatial planning and developable land indicates disagreement with forecasting of urban planning and development master plan UPDP 2006 and what has been achieved in UPDP 2016. The main remark drawn from this UPDP (2006 and 2016) relates to the choice of urban extension, which is still based on two main criteria: Proximity to the former city and legal ownership. From a management and planning perspective, the proposal is acceptable, but the operation is still slow and will always arrive at this choice. This is not the case in the approach (GIS / AHP), where the criteria are introduced initially, and the results are still valid relative to the weight of the criteria. The revision of (UPDP) in Algeria requires integrating multi-criteria analysis to effectively manage the planning rules under standards end stricter criteria, mainly the flood risk map. The latter affects the majority of Algerian cities and causes human and material damage. The example discussed in this work demonstrates the efficiency of this suggestion according to the

data used and with the selected criteria. It can constitute essential support for the other regions of the country.

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