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# Localization of sustainable urban projects using the AHP method. Case of the city of M'sila

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**Summary**

This research tackles the ongoing challenge of unsustainable urban growth in Algeria by using the analytical hierarchy process (AHP) to enhance site selection for sustainable urban initiatives in M'Sila. The study used AHP's systematic approach to develop a regional suitability map, including environmental, social, and economic factors. This differs from earlier ad-hoc methods, offering a clear and impartial assessment via pairwise comparisons. The resultant map delineates regions that reconcile project demands with sustainability goals. The versatility, openness, and ability of AHP to incorporate both quantitative and qualitative data are emphasized as primary strengths. The research highlights AHP's substantial impact on enhancing urban planning in a resource-limited context, while recognizing constraints including data availability and subjective qualitative evaluations. The produced suitability map indicates that 46.31% (106.94 km$^2$) of M'Sila is classified as very suitable, 21.44% (49.51 km$^2$) as moderately suitable, 10.14% (23.42 km$^2$) as weakly suitable, and 3.64% (8.41 km$^2$) as unsuitable for sustainable urban growth. The technique included a two-phase process: the AHP phase is succeeded by GIS-based spatial representation. The results provide a crucial resource for Algerian policymakers and stakeholders, facilitating evidence-based decision-making and a transition to sustainable urban development methods amid rising urbanization and resource constraints. The research indicates that AHP offers a robust framework for addressing the difficulties of urban planning in resource-limited environments.

**Keywords**

sustainable development • urban project • localization • M'sila • AHP • arc GIS

## 1. Introduction

Urban development plays a crucial role in shaping the future of communities. By incorporating sustainable practices into urban projects, we can create more liveable and resilient cities for future generations. Urban projects in which the private and public sectors contribute to increasing the urban space of cities are discussed [Benaissa and Khalfallah 2021]. It was found that the localization of these projects requires careful planning that helps preserve real estate spaces and regulate land use [Gherbi 2015].

In recent years, Algeria has begun to pay special attention to urban projects, as it has established many institutions interested in developing programs and policies that aim to achieve sustainability in its various dimensions, especially with regard to the localization of urban projects and their spatial suitability. On this basis, the urban project has had a decisive role in achieving sustainable development, directly affecting the environment, society, and economy [Kalfas et al. 2023].

The planning, design, and construction of cities and urban areas have an influence on resource consumption, carbon emissions, quality of life, and economic opportunities. Therefore, incorporating sustainability principles into urban projects is crucial to sustainable development [Weymouth and Hartz-Karp 2018].

Several factors concerning the environment were taken into account. The experts presented criteria for the localization of projects through a questionnaire that included specialists in the field. The data was evaluated using the AHP approach, and GIS produced a spatial suitability map for localizing urban projects in cities [Aburas et al. 2017]. GIS map was determined based on 11 factors using AHP. Social, economic, and environmental variables were the main focus of the research presented. These techniques have the most significant number of variants but often require the participation of specialists while relying on specialists in different fields and residents.

This research paper presents many results obtained by integrating AHP and geographic information systems for an analysis of the importance and methods of localizing sustainable urban projects within cities to achieve an integrated urban environment in terms of quantity [Lahcene et al. 2024], quality, and quality of life. The study area was the city of M'sila.

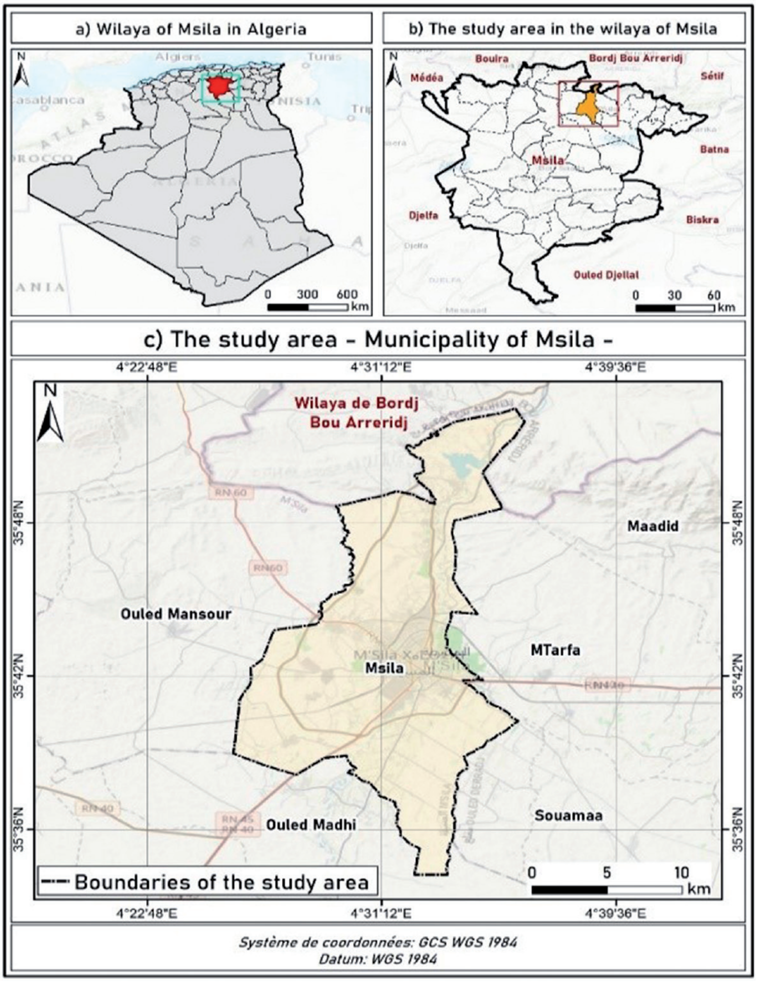
Algeria has developed a multi-pronged strategy for managing its urban projects sustainably. This includes national urban development plans, public transportation investment, renewable energy integration, green building codes, waste management initiatives, urban greening, and smart city technologies. While these strategies address challenges such as rapid urbanization, environmental degradation, and inefficient resource use, several limitations hinder their effectiveness. These limitations include funding constraints, inadequate institutional capacity, inconsistencies in policy implementation, a lack of inter-agency coordination, and low public awareness. Furthermore, Algerian cities' vulnerability to climate change adds another layer of complexity.

Ultimately, achieving sustainable urban development in Algeria requires overcoming these obstacles through increased funding, capacity building, stronger political will, enhanced public participation, and proactive adaptation to the effects of climate change. The success of these efforts depends on consistent policy implementation, meticulous monitoring, and effective evaluation mechanisms.

## 2. Materials and methods

### 2.1. The study area

M'sila, an Algerian city, is located on the northwestern side of the Chott Al Hodna basin. It is bordered by the Al-Hadna mountain range to the north and the Chott Al-Hadna to the south. These natural features intersect with National Road No. 40, National Road No. 45, National Road No. 60, and a waterway (Oued Al-Qasab). The state's population, as of 2019, was approximately 9,583,361, with a population density of 74 people/km$^2$, indicating a vibrant and dynamic community. As the National Bureau of Statistics estimates, the total area is 18,075 km$^2$, with diverse land use and wide suitability for land (Fig. 1).



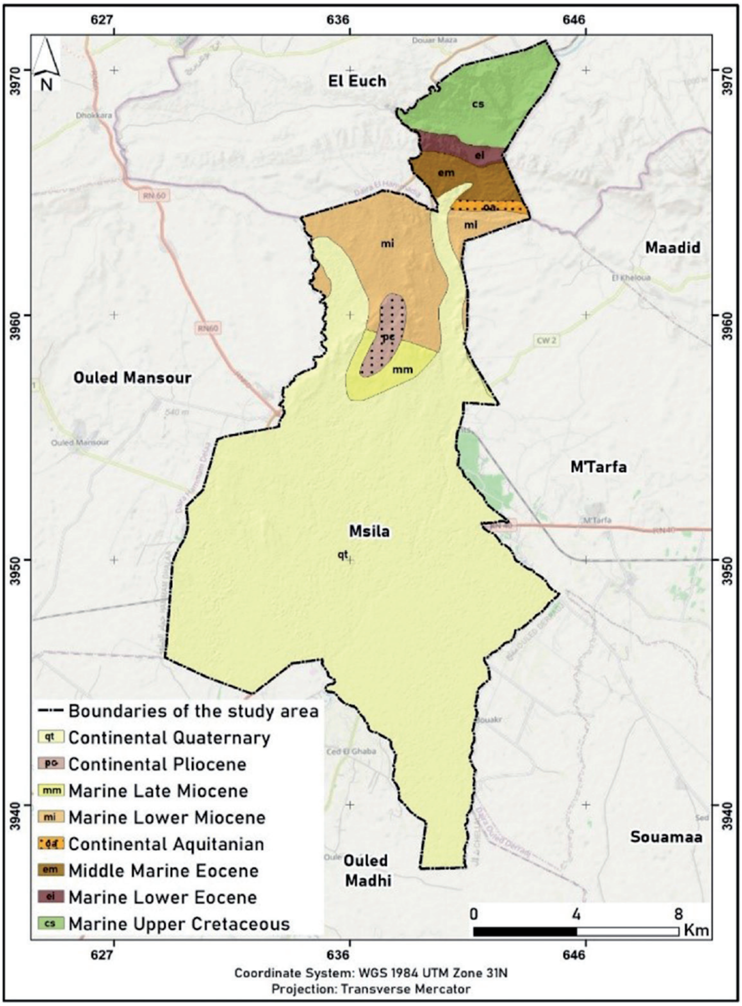

Source: compiled by the researchers using the ARC GIS software

**Fig. 1.** Location of the study area, the city of M'Sila

## 2.2. Data collection

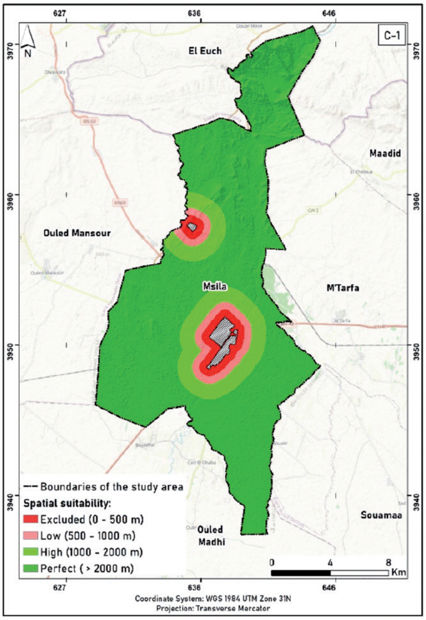
### 2.2.1. Spatial suitability factors for the localization of urban projects

Expert Choice v11, an application of multi-criteria analysis using AHP, was used to evaluate the weights of criteria. These criteria were developed by experts and specialists in order to evaluate the suitability of localizing urban projects within cities. The process began with a thorough geospatial data collection that ensured the reliability of the results. Layers of selection criteria and sub-criteria were then created in the open-source Arc GIS software. The results are displayed graphically in Figures 2–8.



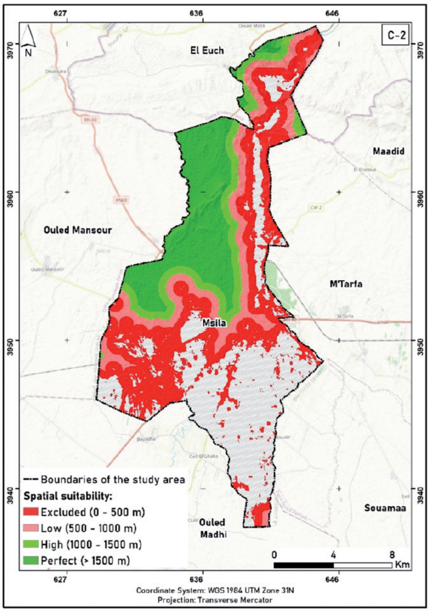

Source: compiled by the researchers using the ARC GIS software

**Fig. 2.** Geology of the study area




Source: compiled by the researchers using the ARC GIS software

**Fig. 3.** Contamination sites




Source: compiled by the researchers using the ARC GIS software

**Fig. 4.** Proximity to green areas

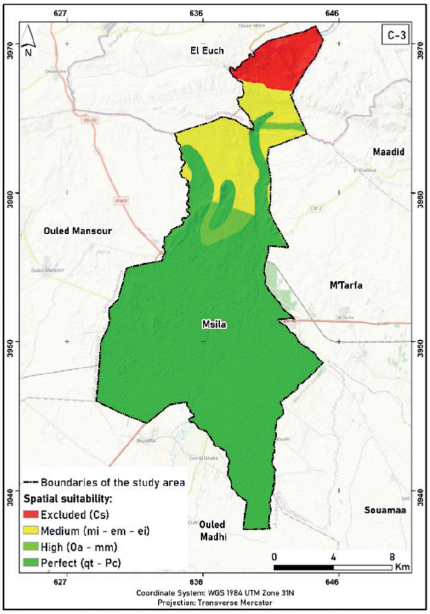



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**Fig. 5.** Geology

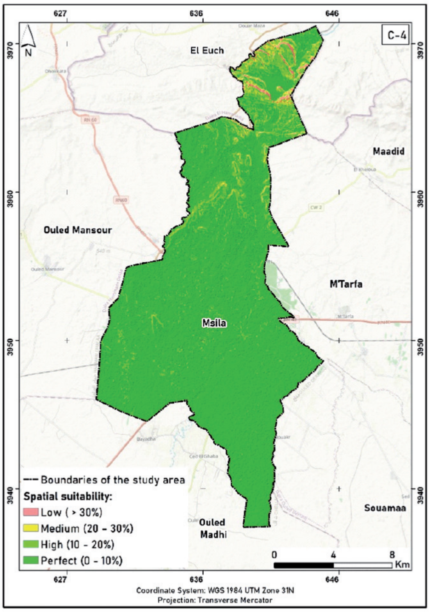


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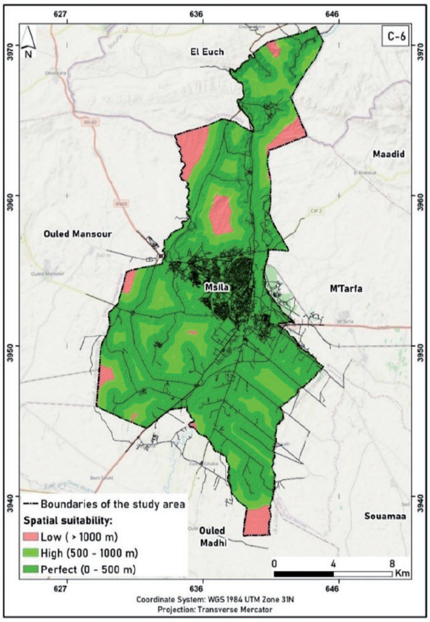
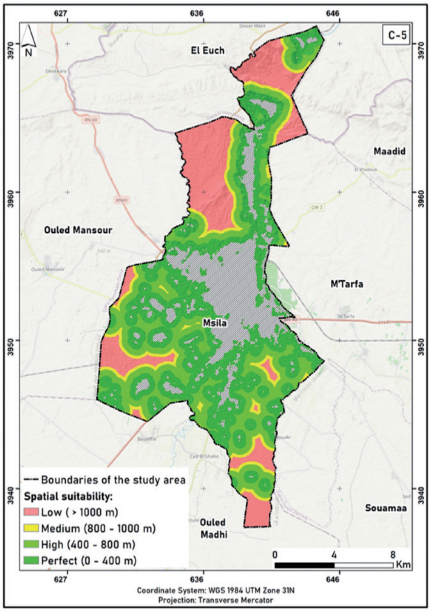
**Fig. 6.** Slopes




Source: compiled by the researchers using the ARC GIS software

**Fig. 7.** Proximity to roads




Source: compiled by the researchers using the ARC GIS software

**Fig. 8.** Proximity to urban areas

#### 2.2.2. Environmental criteria

The reconstruction plan for the city of M'sila determined the following criteria: contamination sites, proximity to green areas, geology, and slopes in order to process its data. The sub-factors of suitability are as follows: contamination sites: 0–500 m, 500–1000, 1000–2000 m (> 2000 m); proximity to green areas 0–500 m, 500–1000 m, 1000–1500 m, and > 1500 m; geology: the geological features were determined according to the permeability and type of soil; slopes: 0–10%, 10–20%, 20–30% and > 30%.

#### 2.2.3. Economic criteria

In calculating this criterion, we took into account the organisedrailways in the case study and significant routes. Information was collected from the 2018 M'sila City Reconstruction Plan. Experts identified the following range of suitability: 0–400 m, 400–800 m, 800–1000 m, and >1000 m (Fig. 7).

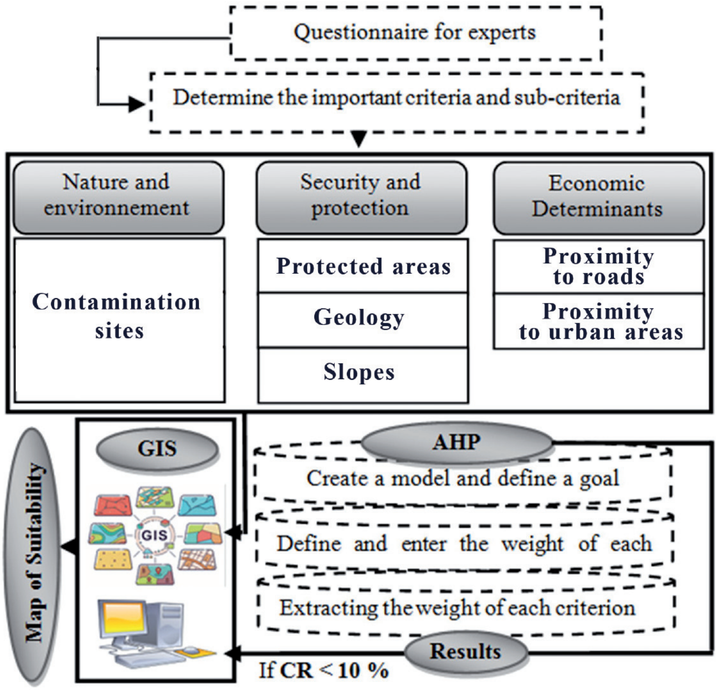
#### 2.2.4. Social criteria

The M'sila state planning and reconstruction plans provided relevant data. The opinions of experts and technicians were considered when determining stratigraphy in urban areas and archaeological sites using the ARC GIS application. The following distances from residential areas were considered appropriate: 0–400 m, 400–800 m, 800–1000 m, and > 1000 m.

## 3. Methods

The selection of sites for the localization of urban projects is considered one of the challenges related to spatial decisions. Such spatial problems usually have many alternative solutions [Rikalovic et al. 2014]. Deciding on the spatial suitability of land allocated for various residential projects and industrial activities is a complex process, especially due to the data and their spatial features. It must, therefore, take into account many possible alternatives as well as appropriate multifaceted and often conflicting criteria [Benaissa and Khalfallah 2021], economic, environmental, climatic, social, etc. The questionnaire technique is often applied to determine various criteria organizing a group evaluation method. The suitability of land for the localization of urban projects is determined by calculating the statistical significance [Mevlut 2013]. The significant value ratio in the urban area is used to analyze whether the location is suitable for urban projects [Davide et al. 2023].

Next, we applied the AHP technique, used to solve complex decision-making problems [Liu et al. 2020]. In order to suggest appropriate areas for the localization of economic, environmental and social projects, this decision-making tool relies on accurate measurement and comprehensive evaluation [Gyani et al. 2022]. It ensures consistency in evaluations and reduction of bias in the decision-making process. It is also a valuable tool for recording subjective and objective evaluation metrics [Fernandez 2016]. AHP and Interactive Computer Software (Experts' Choice Version 11), which are the basis for this investigation.




Source: compiled by the researchers using the ARC GIS software

**Fig. 9.** The analysis used for this research

### 3.1. Analytic hierarchy process (AHP)

Urban measurement and evaluation techniques are one of the most important components of this research because they integrate existing knowledge about the city and determine its value [Allal et al. 2022]. The analytical hierarchy process (AHP) can be used to choose from various methodologies (MCDM). One of the most widely used techniques is the AHP method. AHP has been used to analyze and improve many human decision-making and judgment processes [Thomas 2013]. It is very suitable for solving complex problems [Bhole Tushar 2018], thus it is widely used in many different sectors. It is an approach that works well [Tavana et al. 2023]. Since it can only help one decision maker (or a group of decision makers) to solve the problem, finding answers in AHP is not statistical [Chen 2006]. In terms of capability, MCDM is one of the most important aspects of AHP. It evaluates the quantitative and qualitative aspects of a decision [Sahoo and Goswami 2023]. Additionally, because the AHP is flexible in allowing revision, decision makers can sometimes change expert judgment and add new aspects to the hierarchy.

Once the hierarchy is established, binary comparisons are used to identify and quantify the relative importance of each solution element. Expert Choice V 11 is a decision-making tool that assists decision-makers by arranging data on the complexity of a multi-solution problem into a hierarchical model that includes a goal, possible scenarios, agents, and choices. The comparison matrix is used to establish the priorities. We begin with a consistent matrix with known priority pi. Alternatives I and J are compared using pi/pj, which is multiplied by the results of the priority vector p [Ishizaka and Labib 2009]:

$$\begin{bmatrix} P1 / P1 & P1 / P2 & \cdots & P1 / Pn \\ P1 / P1 & P1 / P1 & \cdots & P1 / Pn \\ \vdots & \vdots & \ddots & \vdots \\ Pn / P1 & Pn / P1 & \cdots & Pn / Pn \end{bmatrix} \begin{bmatrix} P1 \\ P2 \\ \vdots \\ Pn \end{bmatrix} = n \begin{bmatrix} P1 \\ P2 \\ \vdots \\ Pn \end{bmatrix} \tag{1}$$

Alternatively grouped:

$$Ap^{\rightarrow} = np^{\rightarrow} \tag{2}$$

where:

A – the comparison matrix,
n – the matrix dimension,
E – the prioritizing vector.

Priorities are only significant if they are derived from coherent or nearly coherent matrices, a concept of utmost importance in our understanding of decision-making. This is demonstrated by the authors' proposal of a consistency index (CI) in Kereush and Perovych [2017], see also Yudi and Azwir [2018]:

$$\text{CI} = \frac{\text{Marks eigein value} - n}{n - 1} \tag{3}$$

$$\text{Marks eigein value} = \sum \text{wi} \cdot \text{ci} \tag{4}$$

The consistency of the answer is measured using the consistency ratio (CR) [Panchal and Debbarma 2017], which may be calculated by (5). Table 1 presents the random consistency index (RI) [Lipovetsky 2020].

$$\text{CR} = \frac{\text{CI}}{\text{RI}} \tag{5}$$

**Table 1.** Random consistency index

| n | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| RI | 0 | 0 | 0.58 | 0.90 | 1.12 | 1.24 | 1.32 | 1.42 | 1.45 | 1.49 |

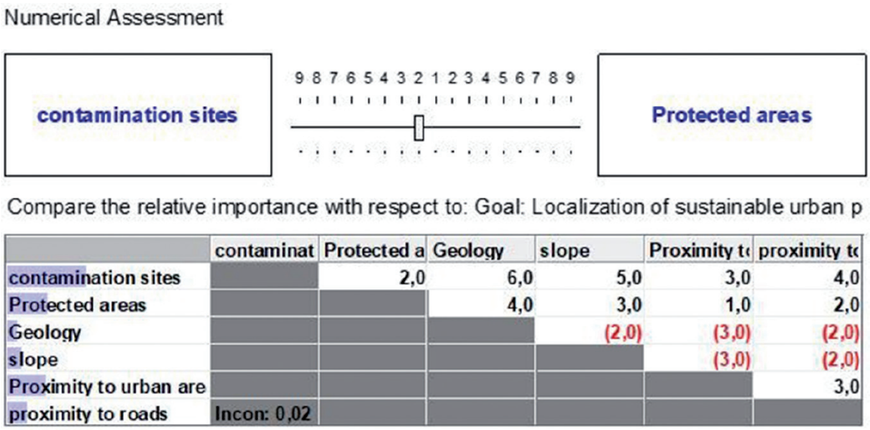
The data are deemed inconsistent if the CR is 10%. The matrix is considered to have sufficient consistency if the consistency ratio (CR) is less than 10% [Saman et al. 2013].

### 3.2. Geographic information system (GIS)

The process of mapping and integrating computer-based information with the ability of data layer management to combine geographical information layers for suitable decision-making is known as geographic information system (GIS) [Kazemi 2016]. Alternative, adaptable, and scalable methods can be achieved by combining data with a GIS software [Saouli 2020]. Land use trends can now be evaluated quantitatively and qualitatively due to the availability of digital data archives since 1987 [Ayache 2021]. As a result, a number of studies have been carried out that highlight the use of GIS in conjunction with Delphi, AHP, or a combination of these techniques for modelling and assessing spatial appropriateness [Kazemi 2016]. It helps decision-makers analyze the appropriate alternatives, prioritize the weights of the choice criteria, and visualize the outcomes.

## 4. Results and discussion

This study employed the analytic hierarchy process (AHP) method and geographic information systems (GIS) technology to develop a strategy for evaluating and managing sustainable urban development project localization and urban land consumption. The state of M'Sila was selected as the study area. A panel of experts developed a set of criteria to assist in identifying suitable locations for sustainable urban development projects. The AHP method was applied using Expert Choice software to derive appropriate land suitability indices. The consistency ratio was 0.02, less than 0.1, thus considered satisfactory.



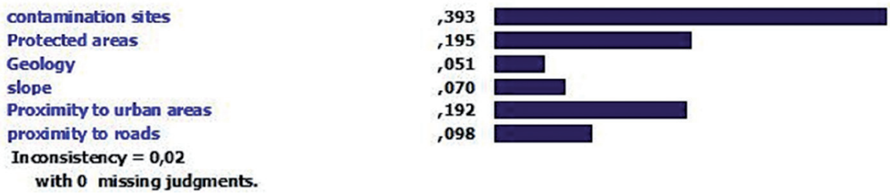

| | contaminat | Protected a | Geology | slope | Proximity t | proximity t |
|---|---|---|---|---|---|---|
| contamination sites | | 2,0 | 6,0 | 5,0 | 3,0 | 4,0 |
| Protected areas | | | 4,0 | 3,0 | 1,0 | 2,0 |
| Geology | | | | (2,0) | (3,0) | (2,0) |
| slope | | | | | (3,0) | (2,0) |
| Proximity to urban are | | | | | | 3,0 |
| proximity to roads | Incon: 0,02 | | | | | |

Source: prepared by the researchers using the open-source Experts' Choice Version 11 software

**Fig. 10.** Results of AHP in main and sub criteria

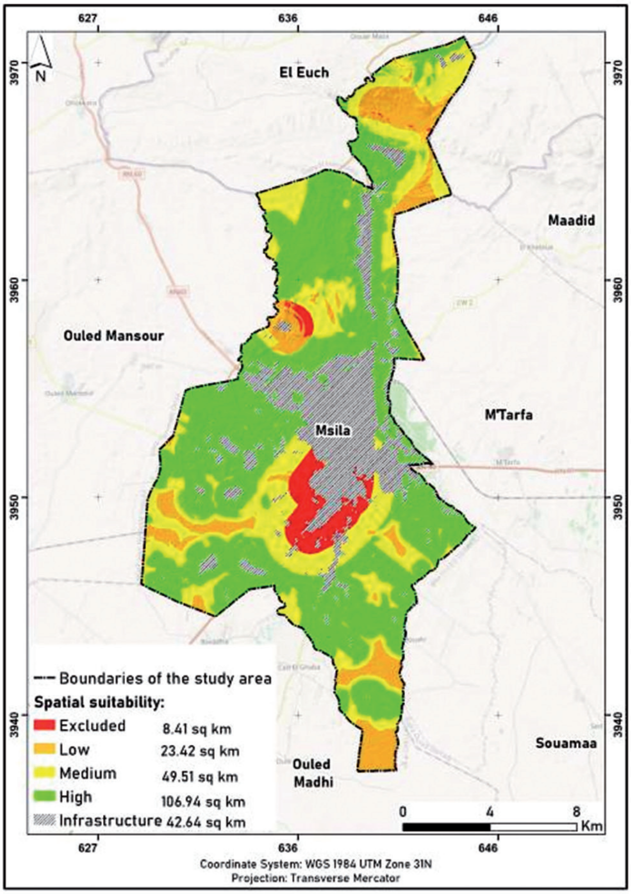
Following the AHP analysis, spatial analysis was conducted for the study area, including creating a geographic database of the criteria provided by experts within the

GIS environment. A developed model integrated all the data to extract a map depicting land suitability for sustainable urban development project localization.




Source: prepared by the researchers using the open-source Experts' Choice Version 11 software

**Fig. 11.** Priorities with respect to goal




Source: compiled by the researchers using the ARC GIS software

**Fig. 12.** Map of the suitability of land for the settlement of urban projects in the area of M'Sila

**Table 2.** AHP key criteria rating

| Criteria | Weight | Rating |
|---|---|---|
| Contamination sites | 0.393 | 1 |
| Protected areas | 0.195 | 2 |
| Geology | 0.051 | 6 |
| Slopes | 0.070 | 5 |
| Proximity to urban areas | 0.192 | 3 |
| Proximity to roads | 0.098 | 4 |

**Table 3.** The percentage of the AHP scale for localizing urban projects in the city of M'Sila

| Classes | Area [km²] | % |
|---|---|---|
| Excluded | 8.41 | 3.64 |
| Low | 23.42 | 10.14 |
| Medium | 49.51 | 21.44 |
| High | 106.94 | 46.31 |
| Infrastructure | 42.64 | 18.47 |
| Total | 230.92 | 100 |

## 5. Conclusion

The findings of this study show that the hierarchical analysis (AHP) approach in the context of geographic information systems (GIS) is an adequate scientific method for determining suitable locations for establishing sustainable urban projects in the state of M'Sila, Algeria. The study found that combining the AHP application with the Expert Choice software resulted in the extraction of specific criteria that have a significant impact on the suitability of the sites, whereas GIS technologies allowed for precise analysis of these standards and the creation of a map displaying the best regions to settle projects. Figure 12 shows the result of the spatial analysis using geographic information systems software, which determines the final evaluation of the spatial suitability model for the localization of urban projects in the city of M'Sila using the analytical hierarchical method. It was found that most of the areas suitable for ideal and good construction are located in the western and northwestern parts of the city, and they are lands that are mostly public property, unsuitable for agriculture, far from easements and close to the existing road network as well as the city's surroundings. These lands represent 46.31% of the total area of the municipality, which are ideal for the localization of urban projects. Meanwhile, areas classified as average for these projects cover 21.44% of the total area of the municipality. Areas with low suitability and non-suitable for urban project settlement represent 10.14% and 3.64%, respectively. These areas are privately owned lands areas as well as subject to urban easements.

The study underlines the need to incorporate AHP and GIS into sustainable urban growth planning to ensure the selection of appropriate building sites, safeguard natural resources, and achieve sustainable development.

However, understanding the need to review results is essential to keep up with changes in local conditions and update standards, thus ensuring the effectiveness of the project's localization strategy. The research also highlights the necessity of including diverse interests in the process of setting standards and implementing strategies to guarantee their long-term viability and effectiveness in meeting the objectives of sustainable urban expansion.

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