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ASSESSMENT OF THE SPATIAL APPROPRIATENESS OF THE FUTURE URBANIZATION OF THE CITY OF (AIN BEIDA, ALGERIA) USING GEOGRAPHIC INFORMATION SYSTEMS, THE ANALYTICAL HIERARCHY PROCESS, AND THE DELPHI METHOD

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ABSTRACT

Spatial adequacy evaluation is a valuable tool for planning land use strategies. It provides planners with data and outcomes that can help them make informed decisions to ensure effective and secure utilization of land in future urbanization processes. The objective of this study is to analyze the urbanization patterns in the city of Ain El Beida to determine the most appropriate areas for urban development. The aim is to create self-sustaining growth centers that effectively support the city, while also helping decision-makers address current expansions and protect agricultural lands. The study utilized spatial analysis methodology to evaluate and map the suitability of expanding the city's future space. It proposed an integration strategy that combined modern methods and techniques of the Delphi methodology to establish criteria for appropriate land use. The influence of these criteria will be analyzed spatially by administering a questionnaire to a sample of specialists in urban planning and city geography, followed by the application of spatial analyst techniques. The user's text is straightforward and precise. within the GIS framework, integrated via the analytic hierarchy approach. The user's text is straightforward and precise. To evaluate the suitability of the spatial location, to determine the significance of the factors influencing the expansion process based on their relative importance, to ensure that the desired goals are achieved in a way that reflects the priority of the decision-making criteria, and to identify the most favorable options for urban development in the study area. The findings indicated that the optimal locations for the urban growth of Ein El-Baida were determined to be 239.57 hectares, which accounts for 26.31 per cent of the entire land area under investigation. These areas are situated on the northern side of the city along National Road 80 (Ain Beida Presh) and on the western side along National Road 10 (Oum el-Bouaghi Ain Beida). These locations have been identified as the most suitable areas for spatial expansion due to their numerous incentives for urban attraction. Firstly, there is a considerable distance from the fertile and generously compensated agricultural areas, which offer unoccupied and level terrain, as well as its proximity to the central area of the pristine city of Ein. The study also determined that integrating GIS with hierarchy is crucial for constructing spatial models that accurately represent physical reality through mathematical means. This integration aids planners in selecting the most appropriate alternatives for urbanization and achieving comprehensive development of the city.

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1. INTRODUCTION.

The burgeoning population increase in developing nations has coincided with the abrupt and swift proliferation of metropolitan regions. Irrespective of the suitability of the land, this results in exerting demands on land utilization, manifesting in diverse ways. argued that a notable symptom of substantial population growth is the trend of suburban and peripheral expansion, which occurs at the cost of the central areas and is typically marked by excessive utilization of land. Similarly, (Subhi Mohamed Qannous, 1994) characterized it as a haphazard and disorganized proliferation. Similarly, (Harper & Gottman, 1967) viewed the expansion process as the act of spreading and extending beyond the predetermined borders of a city. This implies that the urban structure of the city grows without conforming to the constraints of the places where the expansion takes place. The built-up area expands as a consequence of the process of growth and urban development, driven by the growing demand for space to accommodate the needs of the population (Pierre Marland). According to the European Environment Agency (2006), the expansion of urban areas into agricultural spaces is now considered a threat to the environment. This expansion is characterized by the development of residential areas with low population density that are spread out in regions surrounding the city. This spontaneous and ill-equipped expansion is regarded as arbitrary occupancy of space. Due to the ongoing high demand for land and the lack of proper spatial planning, urban areas are expanding and encroaching on agricultural fields. As Jacqueline Garnier pointed out, each instance of urban growth directly competes with agricultural land use.

Evaluating the suitability of Earth's uses in different locations is a useful tool for guiding planning efforts, managing growth and urbanization, (Cote, 1983) and ensuring that human activities and resources are distributed in the most appropriate and desired manner. This assessment, conducted throughout 2008 napkins, also serves as a method for developing a land-use strategy. In his work, "Predicting Earth's Performance: Identifying Possibilities and Constraints for Land Use,"(S. M. I. Mohamed, 2008) explains that land use planning involves assessing the potential of Earth for different types of land uses and considering all available alternatives. This process is crucial for rational decision-making and requires evaluating the available resources. Their objective is to prevent the uncontrolled allocation of urban land uses and protect the city's surroundings, namely agricultural regions.

Algeria is a country that has had a significant population increase in its cities since gaining independence. The population experienced a growth rate of 3.2% from 1966 to 1969, which increased to 3.4% from 1969 to 1971, and further rose to 5.2% from 1972 to 1974. Subsequently, the growth rate reached 5.4% from 1978 and 1985. Due to the urban crisis caused by population overcrowding, uncontrolled growth and expansion, and excessive use of agricultural land, approximately 150,000 hectares of farmland were affected by urbanization between 1962 and 1992. This amounts to an annual loss of 5,000 hectares (Bessey & Petri, 2000). Urbanization in most Algerian cities and their rural areas is unbalanced due to the inadequacy of urban planning schemes. These schemes have failed to accommodate the growing population and guide the city's development. The solutions implemented so far have

been ad hoc and arbitrary, either inherited from the French colonial administration or developed after 1900 and still in use today.

(Ilyas Chorfa, 2004) attributes their failure to the nature of the methods used rather than their implementer. Whereas (Baya, 2015) emphasized the weakness of city management systems in general and the dominance of political decisions over scientific, technical, and architectural considerations when creating these plans. As for (Cote, 1983) , in diagnosing the crisis of the Algerian city, he stated that we have not understood the specificity of the city well, and therefore, our approaches to the city were not sufficiently understanding and analytical. This means that the studies surrounding the city lacked theoretical unity and did not rely on the logic of rationality and scientific accuracy when formulating and implementing urban expansion plans.

Spatial planning for future urban expansion requires evaluating spatial suitability by adopting spatial analysis methods due to their role in analyzing and measuring spatial relationships between geographical phenomena. This ensures the interpretation of spatial relationships and benefits from them, understanding the reasons for the existence and distribution of phenomena on the Earth's surface, and predicting the behavior of these phenomena in the future (Aziz, 2001) . More clearly, Khaled Mustafa Qasim believes that spatial analysis enables us to develop future visions for the distribution of different activities and land uses in the appropriate place and time, achieving a balance between the needs of development in the present, near, and distant future. This is done through building models for analyzing land use suitability and identifying the constraints facing certain uses, adopting more precise and effective evaluation methods and decision-making processes to determine the extent of land suitability with conditions ranging from maximum suitability to unsuitability, based on certain conditions or criteria usually defined from previous studies (Dawood Juma Mohammed, 2018).

The importance of the spatial analysis method lies in its adherence to an analytical methodology that relies on modern methods and techniques, including Geographic Information Systems (GIS), for their ability to use data digitally, which aids in the speed and flexibility of assembling large amounts of data, making it the most effective tool in planning and management (Brail and Klosterman). Combined with systematic mathematical techniques that support decision-making through a hierarchical analysis method that addresses multi-factor decision problems, allowing the decision-maker to choose between several alternatives based on the analysis of controlling suitability criteria for land use (Cook & Russell, 1993) . The Delphi methodology is considered a pioneering method in determining effective indicators and criteria for evaluating social phenomena (Turoff Editors, 2016).

Ain Beida is one of the most important urban centers in the Oum El Bouaghi province in eastern Algeria, due to the high-quality services it offers, similar to other municipalities in the province. It is characterized by its plain nature, which encouraged population settlement and migration towards it, increasing its demographic weight and making it the dominant and most populous municipality with 143,678 inhabitants in 2017, and the smallest in area, covering 52 km² within its province. Due to the limited scope of its territory, the exhaustion of its real estate reserves, a set of expansion constraints surrounding the city, especially the nature of its fertile agricultural lands, several problems have arisen in its expansion and in reaching saturation. The responsible authorities found no planning alternative but to direct the city's expansion beyond its administrative boundaries towards the south, at the expense of the agricultural lands of the municipality of Fkirina, in a random manner and without following a correct scientific approach that takes into account the spatial appropriateness in the city's spatial expansion, in the absence of law enforcement, leading to encroachments on agricultural lands.

This research aims to map the spatial suitability for the future urban expansion of Ain Beida, providing indicators to planners and guiding them in determining the axes of urban mass

expansion in the future period by marking the areas more suitable than others to increase the efficiency and effectiveness of planning decisions, and achieve urban development away from random encroachments on agricultural lands. This involves studying the factors affecting the urban expansion of Ain Beida and deriving suitable spatial criteria based on precise scientific foundations that consider the natural, planning, and economic characteristics of the study area and the urbanization conditions in effect, relying on the Delphi methodology, in addition to highlighting the importance of Geographic Information Systems (GIS) technology and the hierarchical analysis process in building an integrated analytical framework that contributes to improving planning processes and making correct decisions.

2. CASE OF STUDY.

The study area is defined as the city of Ain Beida, located in the high plains of eastern Algeria at an altitude of 900 meters above sea level, on the eastern side of the Oum El Bouaghi Province at the intersection of longitude 7.23° east of the Greenwich and latitude 35.84° north of the equator. It is administratively bordered to the north by the municipality of Berriche, to the south by the district of F'kirina and the municipality of Zorg in the northeast, representing the boundaries of the study area.

Ain Beida occupies a strategically important location as it is situated at the center of three major provincial centers: Constantine 128 km to the north, Batna 132 km to the southwest, and Tebessa 119 km to the east. The importance of its location is further enhanced by its positioning at the intersection of two main axes represented by National Road No. 80, which connects the province of Guelma to Khenchela, and National Road No. 10, linking Constantine to Tebessa, in addition to the railway line that connects Ain M'lila to Tebessa, as well as the military airport.

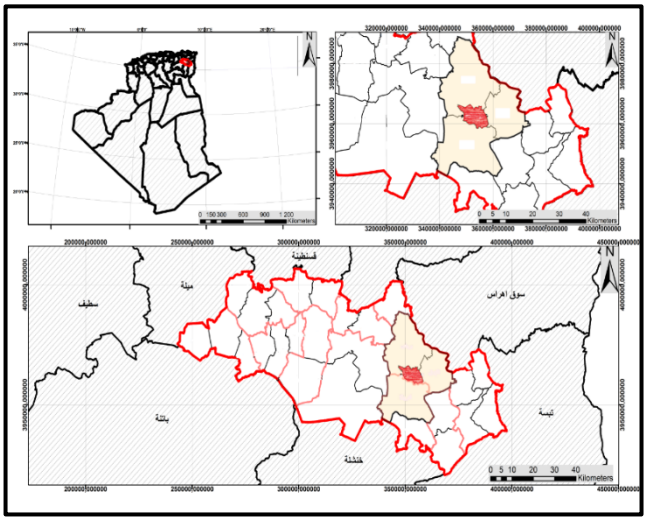


Figure 1. The Administrative Location of Ain Beida Municipality. (Source: 2023).

3. METHODOLOGY AND STAGES OF THE STUDY.

In this study, we relied on the methodology of spatial analysis because it is based on a set of principles, applications, and methods for collecting, analyzing, and presenting data. It is used to achieve the goals of a project, whether in the short or long term, in a cohesive, homogeneous, responsible, and repeatable manner. It includes a set of criteria for evaluating each stage of the work. It also focuses on studying the relationships between the geographical characteristics of natural elements of a specific location to identify its inherent features (Al-

Fanatseh & Ayoub, 2018)(Abdel Hamid Mohamed Abdel Aziz). Based on this, we proposed and established a strategy for integration and combining modern methods and techniques. Starting with adopting the Delphi methodology for the selection and formulation of suitable spatial criteria for the urban expansion of Ain Beida city, to be analyzed through spatial analyst applications.within the Geographic Information Systems (GIS) environment and converting those criteria into levels and layers that affect the process of selecting suitable spatial locations. This is to be integrated with the hierarchical analysis method by calculating the weights of the criteria according to the relative importance of each criterion. Through the overlay of data layers with each other, we were able to build a multi-criteria database that forms necessary inputs translated into the optimal final suitability map for the future period's urban mass expansion. The work was divided into four stages, each stage summarized as shown in Figure 2.

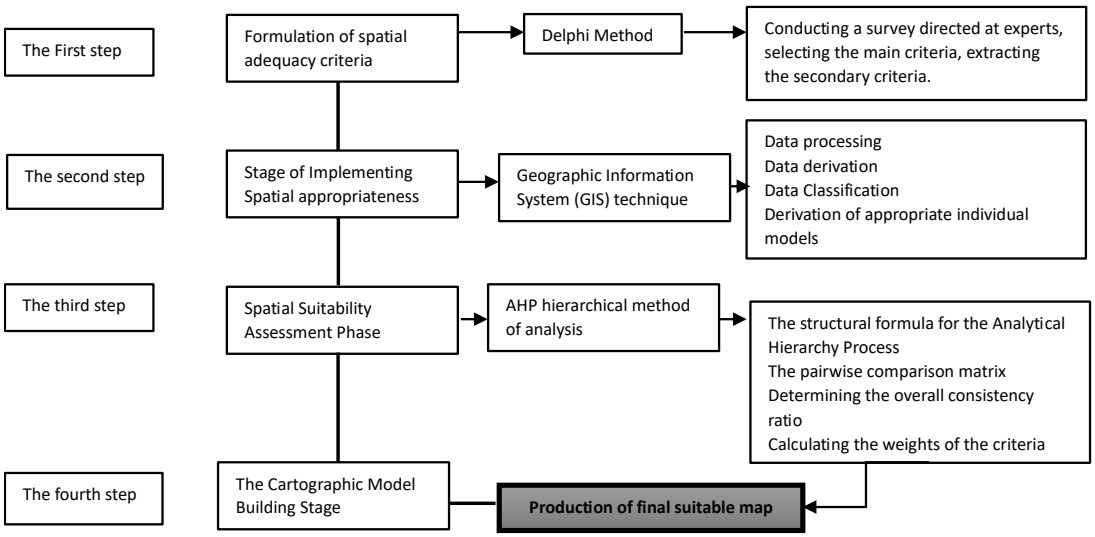


Figure 2. Phases of the methodology proposed in the study. (Source: Researchers, 2023).

3.1. Phase 1. Formulation of spatially appropriate assessment criteria for expansion according to the Delphi methodology.

According to (Dawood Juma Mohammed, 2018), this phase is regarded as one of the most difficult steps in modeling spatial suitability, because it is a non-technical step and is not linked to the capabilities of Geographic Information System (GIS) specialists. Rather, it is connected to the extent of the researcher's understanding and comprehension of their research subject, the methodology they employ to achieve their goals, and the formulation of spatially suitable criteria that are built on scientific foundations compatible with the spatial characteristics and qualifications of the study area. In our study, we adopted the Delphi method as it acts as a tool for deducing and refining the collective judgment in identifying the effective indicators and criteria for evaluating the physical and functional phenomena in a particular case, in a way that ensures the isolation of personal biases or external influences through a series of organized rounds via a formal questionnaire distributed in the first round. Then, a mediator collects them, summarizes the opinions and the reasons upon which their judgments were based, and redistributes them to the individuals whose opinions deviated from the group. Through this process, the range of answers will narrow, and this process is halted when the opinions of the group converge, as noted by (C.Dalkey, 1969) .

Figure (3) illustrates the most important steps of this stage. In this study, our application of this process included three rounds. Starting with the first round, which involved designing a

questionnaire centered around identifying the basic conditions for urban expansion according to the principles and standards of planning and the urban regulations in force, and according to our level of knowledge of previous research.

Subsequently, it was distributed to a purposive sample of experts comprising 30 specialists (15 university professors, 5 urban planners and geographers, and 10 architectural engineers). Based on the synthesis of opinions obtained and the reasons upon which the experts' judgments were built, we nominated the primary criteria for spatial suitability. Relying on the results of this stage, the secondary criteria were derived in the second round. In the third round, the dimensional characteristics were established, and the spatial scopes for the criteria nominated in the study were defined. This process was concluded to be the final round by virtue of the convergence in the range of responses and the achievement of consensus and stability in the results.

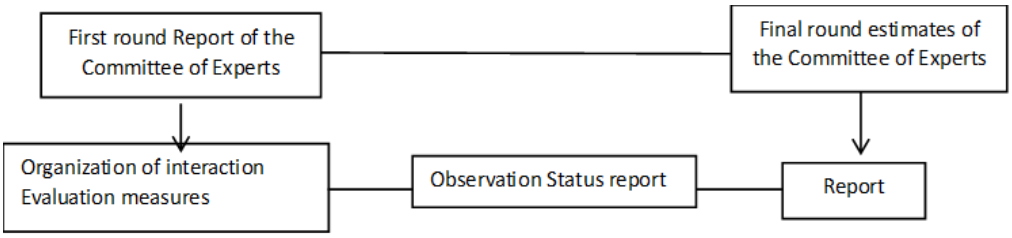


Figure 3. Delphi Methodology Diagram.

3.2. The Second Stage: implementation of spatially appropriate within the Geographic Information Systems (GIS) Environment.

For preparing the list of cartographic data and analyzing the criteria and conditions of the cartographic model, we relied on Geographic Information Systems (GIS) technology, due to its importance at this stage as stated by (Karim & Ali, 2020) that spatial suitability analysis is one of the most useful applications in the GIS for urban planning. This is due to its ability to process, display, and upload geographic information in accordance with its application objective, relying on distinguished human and computer efficiency. (A. Mohamed, 1998) , at this stage we went through the following steps:

Data collection: We obtained the necessary data from various sources: through a field visit to the Directorate of Construction and Urban Planning to obtain the Urban Planning and Development Guide for the city of Ain Beida for the year 2019, and some were downloaded from different websites for road data from the free site OSM and the USGS site as the site for the American Geological Surveys.

A 30-meter precision digital elevation model to extract slope criteria as well as the aerial image captured for the year 2023.

Data derivation: We derived data from some layers. Such as extracting surface slopes from the digital elevation layer of the study area, and converting survey layers to raster data so that all layers become raster such as the population density layer and the nature of land use, and converting linear data layers using the Euclidean division tool as a road network.

Digital classification of data: This stage includes converting the criteria maps into raster type cell maps. We also divided the impact range into five equally distant ranges from the influencing factor, by assigning a value for each factor affecting the expansion according to proximity or distance.

Giving the least suitability to the lowest value 1, and more suitability to the highest value 9, to be distributed as follows (1 low suitability - 3 medium suitability - 5 acceptable suitability

- 7 good suitability – 9 ideal suitability), and this process is done by the Reclassify tool as shown in the figures (5-6-7-8-9-10-11) within the analysis tools."

3.3 The Third Stage: Calculating the weights of the criteria using the Analytical Hierarchy Process (AHP).

Determining the weights for the criteria present in the study is one of the crucial points in this context of analysis. The Analytic Hierarchy Process (AHP) was applied, where the theory has proven its success and high efficiency in solving complex problems (Anane et al., 2012). It is also one of the most important methods and tools used in multi-criteria decision-making. It is a mathematical theory of measurement developed by Thomas L. Saaty in 1980. He defined it as a theory of constructing indicators using pairwise comparisons based on the opinions of experts and decision-makers within a specific scale (Al-Rashed, 2011). Each criterion is assigned a weighted value against all other criteria concerning the goal at the higher level (Al-Fanatseh & Ayoub, 2018).

The hierarchical analysis process in this study went through four consecutive and fundamental stages. It includes determining the relative importance of each criterion compared to the other corresponding criteria, thereby assigning a weighted value for each criterion against all others concerning the goal at the higher level. It starts with creating a hierarchical structure to arrange and sequence all decision elements from the highest to the lowest level (Saaty, 2008), and the values for measuring weight are expressed in a numerical scale defined by Saaty from 1 to 9, as shown in Table (1). Then, a pairwise comparison is made between the elements of the problem at one of the levels, resulting in a matrix of reciprocal pairwise comparisons between the study's criteria, with the condition that the matrix's diagonal is the integer number one since it represents the criterion with itself. After that, the columns are summed, and each value is divided by the total sum. Finally, the rows in the comparison matrix are summed to extract the relative weight, leading to the determination of overall priorities. The consistency ratio (CR) must not exceed 10%; the closer it is to 0, the more consistent the judgments. If the CR exceeds 10%, the judgments contain some contradictions, and therefore, they must be reviewed. We relied on electronically calculating the consistency ratio from the Priority Calculator AHP application.

Table 1. The Quantitative Scale for Determining the Weights of Criteria According to the Importance Level.

Importance Level	Numerical Value
Equally important	1
One criterion is moderately more important than the other	3
One criterion is strongly more important than the other	5
One criterion is very strongly more important than the other	7
One criterion is extremely more important than the other	9
Intermediate values used between weights for numerical comparisons	2-4-6-8

3.4. The fourth step: Construction of the map model for spatial adequacy (The Final Mapping of Suitability).

The cartographic model is a collection of maps in the form of layers that share a common cartographic framework, based on the spatial reference of the study area. It may also contain data specifying the area and geographic location, along with other data related to the classification characteristics of the study region it covers. At this stage, Geographic Information Systems (GIS) are used to provide support for spatial decisions, and define the procedures for multi-criteria decision making, the relationship between 'input maps' and 'output maps'. After

we have reclassified the individual suitability maps for each criterion on a previously unified scale, we perform the integration of the classified cell maps by summing all the criteria multiplied by their weighted weights, provided that the total sum of the criteria weights equals 100%. This is expressed by the following relationship.

The final objective = Criterion (1) x Weight (1) + Criterion (2) x Weight (2) + Criterion (3) x Weight (3) + ..."

4. ANALYSIS AND DISCUSSION.

4.1. The Criteria Influencing the Spatial Suitability Assessment for Urban Expansion in Ain El-Beida City.

"Our application of the Delphi methodology in selecting the most important criteria and indicators for spatial suitability in the study area encompassed three main rounds. For the first round, the survey results identified five factors: (land use nature, urban development heights, population density, topography, and main roads). Based on the first round's results and by focusing more precisely on the characteristics and potentials of resources in Ain El-Beida City in alignment with various variables, and taking into account the attraction and repulsion areas surrounding the city, the results of the second round determined seven secondary criteria: (slopes, mountain elevations, main road network, high population density, highly productive agricultural lands, forest areas, military base, and urban centers). In the final round, these criteria were described in terms of proximity and distance, as well as calibrated with spatial range scales according to urban development standards and the scientific planning measures in practice, as shown in Table (2).

We also note the existence of some conditions that were not selected in the study for reasons including their lesser degree of impact compared to those adopted, such as (water bodies and soil nature), or due to the scarcity and conflicting data surrounding them, such as (land ownership nature), or because they were encroached upon and surpassed, becoming part of the urban fabric of Ain El-Beida City, like (the industrial zone and the high-pressure area).

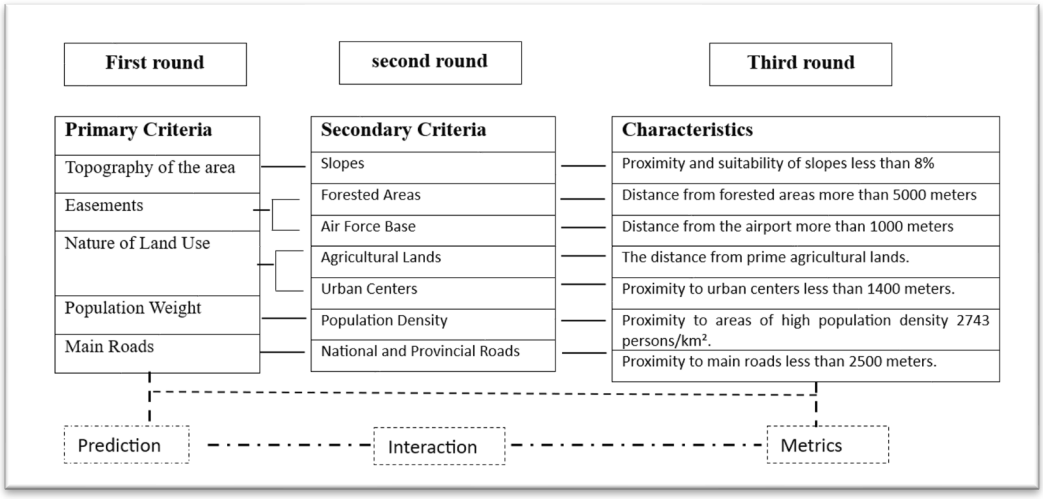


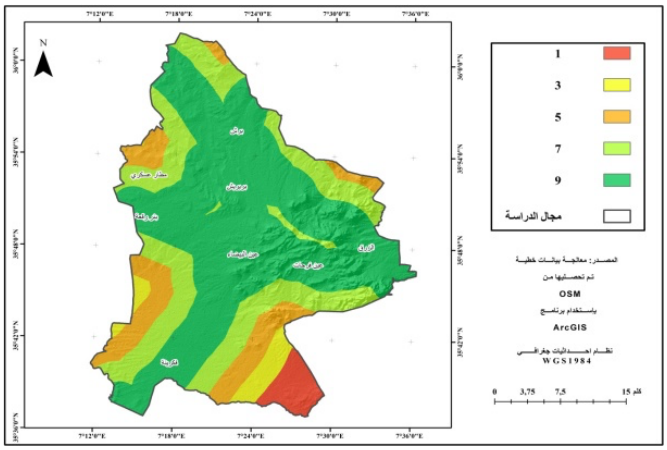
Figure 4. Criteria for Spatial Suitability for Urban Expansion. According to the Delphi Method.

Source: The authors 2023.

4.2. Statistical Applications of Spatial Suitability Criteria for the City of Ain El-Beida by classifying their impact and extracting individual suitability models for each criterion."

There are a number of factors affecting urban expansion in the city of Ain El-Beida, which we evaluated for suitability based on by applying the weighting of classification categories for the criteria, giving a rank to each category as shown in the figures (5) to be translated into maps representing individual suitability models for each criterion. As demonstrated by the produced maps number (1).

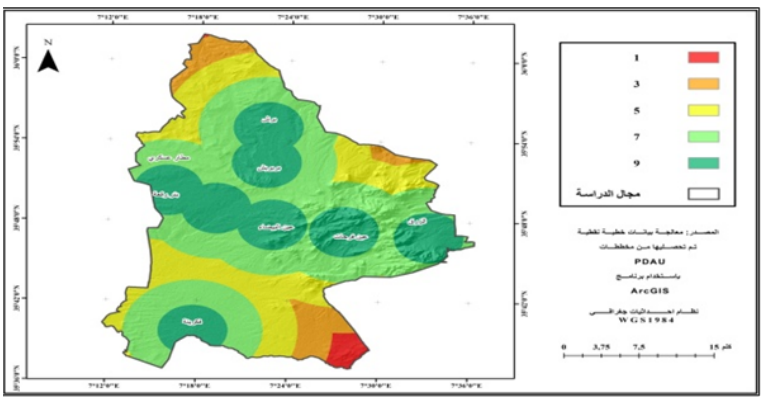
4.2.1 Assessing proximity to main roads.



Map 1. Result of classifying the spatial distance from main roads.

The reclassification table shows the spatial proximity factor to main roads in Figure (5) indicating that the spatial range of less than 2500 meters is the most suitable, receiving the highest classification value of 9. As the distance increases, the importance decreases (more than 10000 meters are the least suitable areas with a classification of 1. The map in Figure (5) also shows that the city of Ain Beida is surrounded by the most suitable areas with a classification of 9, as it is considered a junction point and meeting place of an important road network, most notably the axes of the north-south and east-west national roads, followed by areas of good suitability with a classification of 7, which are areas that are between (2500 to 5000 meters) away from the axes of the national roads. Meanwhile, the unsuitable areas take the lowest value of 1 and are concentrated in the far southeast, more than 100000 meters away from the axis of the national road number 80 in the southeast.

4.2.2. Assessing proximity to main centers.

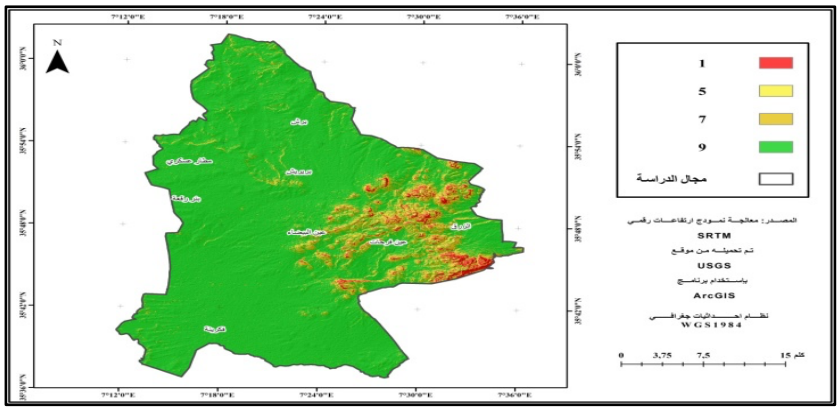


Map 2. Result of classifying the spatial distance from urban centers.

Proximity to urban centers is an important factor in the ease of access to activities in the city center, reduces the economic cost of providing infrastructure services, and contributes to the process of urban homogeneity between existing residential areas and areas of future expansion. On this basis, areas that are less than 1400 meters away were classified with the highest rating of 9, i.e. areas of good suitability.

They appeared in map 2 in the form of radius circles surrounding the urban centers of the study area, and they extend along the east-west axis and include the communities (Bir ouanes - Ain El Beida - Ain Farhat - Zorg), followed by medium suitable areas with a rating of 7 and a distance between (1400-10500 m) surrounding the circles of the most suitable centers, while the unsuitable areas are located in the far south-east and are more than 35000 m away.

4.2.3. Evaluate appropriate regressions.



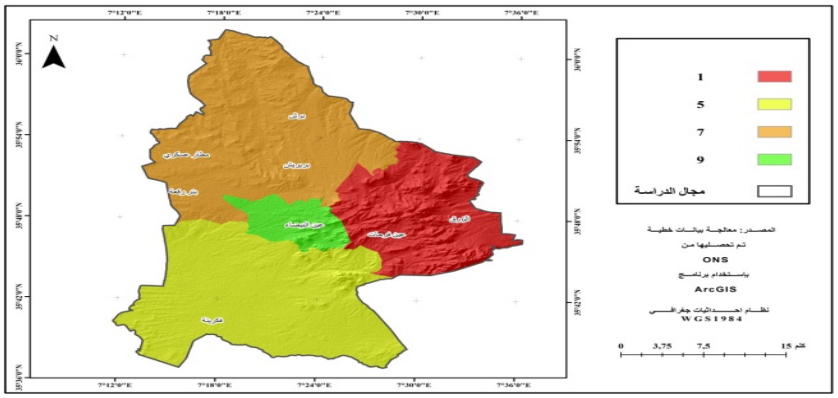
Map 3. Result of the regression fit score ranking.

Lands with a low slope gradient are characterized by their ease of development and their suitability for various human activities due to the simplicity of establishing infrastructure, especially sewage systems, as they do not require high leveling costs. Therefore, a slope gradient of less than 8% is considered most suitable, receiving the highest classification value of 9. As the slope gradient increases, the suitability decreases (more than 20% is least suitable with the lowest classification of 1), as illustrated by the figure (7).

According to map number (3), it is observed that the majority of the study area's land is flat, meaning its slope gradient is less than 8%, surrounding the city of Ain Beida from three sides (north, south, and west).

Meanwhile, the eastern side consists of uneven terrain interspersed with varying degrees of slopes, including moderately steep areas with a classification value of 7 and a slope gradient between 8-15%, which are still buildable but under certain conditions. The areas with steep slopes of more than 20% are located in the far eastern side (municipality of Al Zorg).

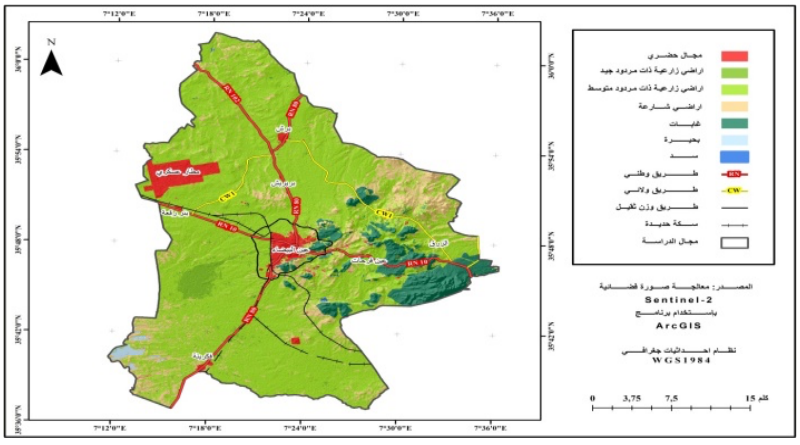
4.2.4 Evaluate proximity to areas of high population density.



Map 4. Result of classifying population density levels.

Population density is one of the most important elements that determine the weights of cities and should be considered when evaluating the suitability for future urban expansion, due to the importance of the human element in attracting development areas and increasing suitability in areas with large population numbers. From the table of reclassifying population density in Figure 8 and the results of Map 4, it is observed that the city of Ain Beida obtained the highest classification value of 9, with more than 2743 people per square kilometer, meaning it is the most suitable area. It is followed by the municipality of Berriche with an acceptable suitability level and a classification of 7, as its population density was estimated at 63 people per square kilometer. The municipality of Fkirina received a medium suitability level. The least suitable is the municipality of Al Zorg with a classification value of 1 and a very low population density of 14 people per square kilometer, especially when compared to the population density of Ain Beida. Additionally, there is an imbalance and lack of uniformity in the distribution of the population between the municipality of Ain Beida and the neighboring municipalities.

5.2.4 Assessing the distance from agricultural areas.

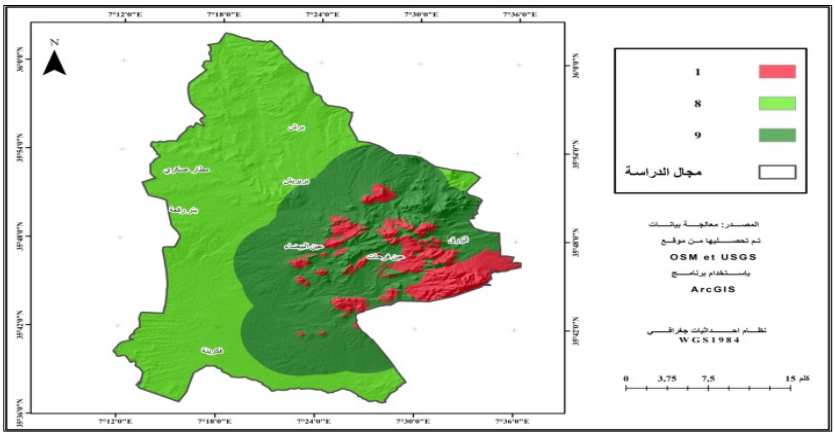


Map 5. Result of categorizing the nature of land use and distance from good agricultural land.

"The spatial suitability rule for agricultural lands posits that the further we are from agricultural lands with good yields, the more appropriate the location becomes for spatial suitability, considering agricultural lands as a primary resource in comprehensive development (Tan et al., 2005). Based on this principle, preserving high-yield agricultural lands has been

prioritized to prevent expansion towards them, which is the main objective of the study. Consequently, the highest suitability value of 9 was recorded for vacant lands as demonstrated in the table, which are situated far from the prime agricultural lands, and the closer we get to these lands, the suitability rating decreases to 1. The map further illustrates that the majority of the study area's lands are agricultural, especially in the southern part known for its good yield. Meanwhile, vacant lands received the highest classification value of 9 and are dispersedly located in the eastern and northern parts, near Ain Beida at the Bir Rech area level."

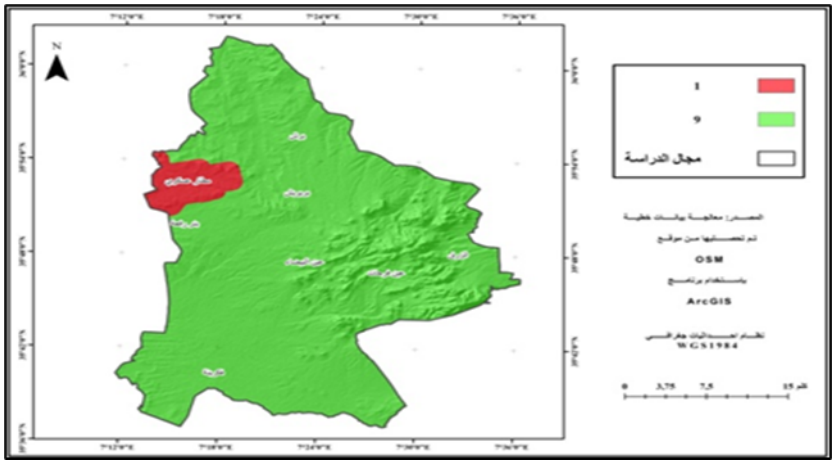
6.2.4. Assessing the Distance from Forested Areas."



Map 6. Classification results of land use nature.

Preserving forested areas is considered one of the highest priorities in urban development processes to ensure the sustainability of natural resources and their role in achieving environmental balance, as well as providing recreational and relaxation spaces for humans. Therefore, their preservation is essential. The figure illustrates that any placement on or adjacent to forested areas within a distance of less than 50 meters is deemed unsuitable for urbanization and is excluded from the development process. These are primarily located in the eastern part of the study area, as shown on map 6. Conversely, areas more suitable for development are those located at least 5000 meters away from forests, found in the northern, southern, and western regions.

7.2.4. Assess the distance from the air force base to the airport.



Map 7. Classification Result.

The proximity of urban areas to the airport has negative effects on city life. From an environmental perspective (pollution), and the auditory and psychological well-being of residents (noise), it is required to leave wide spaces as buffers between them and residential areas, determined in the study to be a distance of more than 1000 meters. As for the areas surrounding the airport and are closer than 1000 meters, they are deemed unsuitable and are located in the northwest as shown on the map (07).

4.3. The construct formula for the hierarchical analysis process aimed at evaluating the urban expansion of Ain El-Beida city.

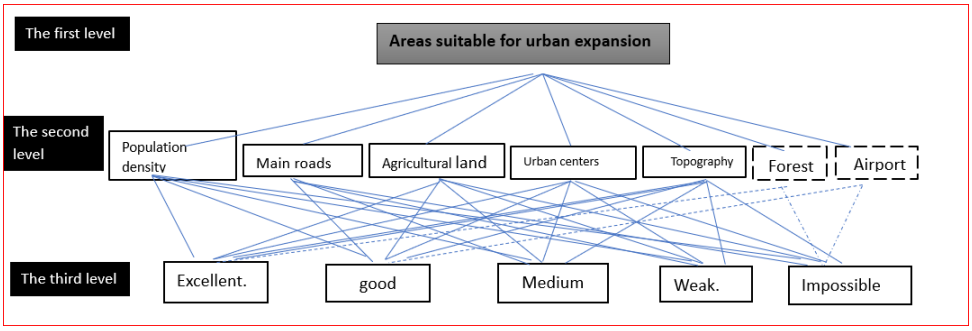


Figure 12. Model of the hierarchical structure for assessing the spatial suitability for the urban expansion of Ain El-Beida city.

From Figure (12), we observe that the hierarchical structure for the case study consists of three levels in a descending order. Starting from the general objective of identifying the best areas for urban expansion, through the seven spatial suitability criteria, to the stage of choosing an alternative from several options at the last level. We also notice a reduction in the number of associative relationships between the criteria of forest areas and the airport with the five suitability indicators in the general structure of the hierarchical analysis, and their association with an alternative (impossible suitability) because these are considered areas where building is prohibited, and therefore, there is no possibility of future expansion on them, and with an alternative (good suitability) when distancing from them. The process of dividing the impact range is limited to two or three factors at most, and when integrated into the final suitability model, they are directly classified as areas excluded from spatial suitability.

4.4. The matrix of pairwise comparisons for the criteria.

The outputs of the hierarchical analysis process to determine the weights of the criteria affecting expansion on the pairwise comparison matrix shown in Figure (), which included 21 pairwise comparisons among all study criteria, enabled us to calculate the overall dominance of each criterion over the rest of the criteria to obtain a matrix with consistent judgments.

Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix:

	1	2	3	4	5	6	7
1	1	9.00	2.00	1.00	2.00	3.00	7.00
2	0.11	1	0.14	0.11	0.14	0.20	0.50
3	0.50	7.00	1	1.00	1.00	2.00	7.00
4	1.00	9.00	1.00	1	2.00	3.00	9.00
5	0.50	7.00	1.00	0.50	1	0.50	5.00
6	0.33	5.00	0.50	0.33	2.00	1	6.00
7	0.14	2.00	0.14	0.11	0.20	0.17	1

Number of comparisons = 21
Consistency Ratio CR = 3.3%

Principal eigen value = 7.267
Eigenvector solution: 5 iterations, delta = 1.2E-8

AHP Scale: 1- Equal Importance, 3- Moderate importance, 5- Strong importance, 7- Very strong importance, 9- Extreme importance (2,4,6,8 values in between).

Figure 13. Matrix of Pairwise Comparisons of Criteria.

The results of the pairwise comparison matrix figure (13), clarify that the maximum impact score of 9 was recorded between the dominance of the criterion of distance from good agricultural lands over the criterion of distance from the airport, and the dominance of the criterion of proximity to high-density clusters over the criteria of distance from forest areas and the airport. A very high impact score of 7 was recorded with the dominance of the criterion of distance from agricultural lands and the high-density criterion over the criterion of distance from forest areas. We also recorded a high impact score of 5 with the dominance of the criterion of proximity and positioning on slopes less than 8% over the criterion of distance from forest areas, while a medium impact score of 3 was recorded with the dominance of the criteria of distance from agricultural lands and high density over the criterion of distance from mountainous areas. Equal impact scores of 1 were recorded between the criteria of distance from agricultural lands with the high-density criterion as well as the criterion of proximity to main roads with the criterion of high population density.

From the preliminary reading of the pairwise comparisons matrix, it is evident that the criteria of distance from agricultural lands and high population density possess the highest importance, followed to a lesser extent by the criteria of proximity to main roads and urban centers, with mountain elevations, water bodies, and forests receiving a low degree of importance.

4.5 Criteria weights.

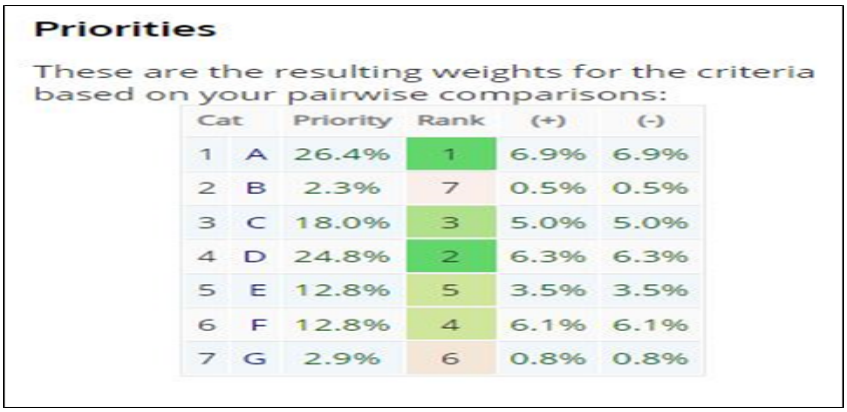


Figure 14. Weights of the criteria.

Table 2. Weights of the criteria used in the analysis.

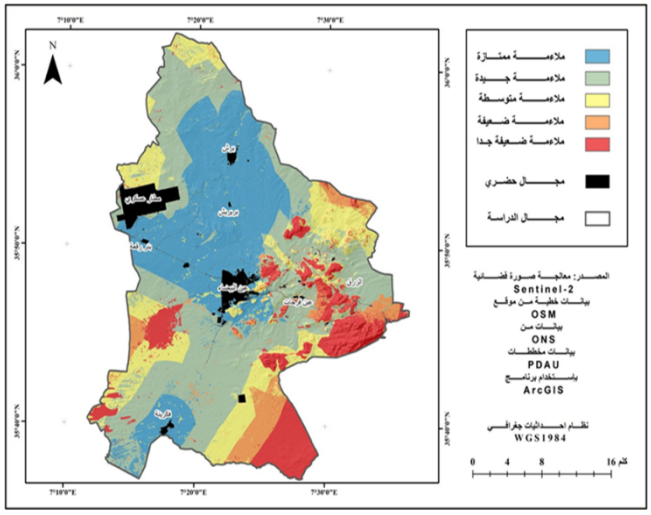
Criterion	Coding	Ranking
26.4%	Distance from good agricultural lands	A
24.8%	Proximity to high population density clusters	D
18.0%	Proximity to national and state roads	C
12.8%	Proximity to slopes less than 8%	E
12.8%	Proximity to urban centers	F
29.2%	Distance from the air force base (airport)	B
23.2%	Distance from forest areas	G

From the results of Table (2) and figure (14), we notice that the criterion of distance from good agricultural lands ranks first with the highest importance percentage of 26.4%. This result directly reflects the fundamental objective of the study to avoid expansion at the expense of agricultural lands. With an importance percentage not less than the first criterion, the criterion of proximity to high population density clusters obtained a percentage of 24.8%, demonstrating the actual importance of the human element in achieving urban development. Following in third

place is the criterion of proximity to main roads with a percentage of 18%. We also recorded a percentage of 12.8% for both the criterion of areas with low slopes and the criterion of proximity to urban centers. This equality is attributed to the direct compatibility and interaction of the impact of these two factors, meaning that the more level the land, the more it encourages and increases the residents' desire to be near urban centers for reasons related to work, shopping, and entertainment places. In the last place, with a low importance percentage, are the criteria of distance from the air force base at 2.9%, and distance from forest areas at 2.3%, both of which are areas where construction is excluded.

In this comparison, the Consistency Ratio (CR) was calculated at 3.3%, as illustrated in Figure (14), indicating the level of consistency and stability is within the threshold defined by Saaty as less than 10% in the Hierarchical Analysis Theory. This means that the criteria adopted in the study are characterized by stability and good consistency among them, and that the obtained relative weights are acceptable and can be relied upon in determining and selecting the best expansion planning alternatives for the city of Ain El-Beida.

5. DISCUSSION OF THE RESULTS.



Map 8. Spatial Suitability for Urban Expansion of Ain El-Beida City. Source: Researchers, based on Geographic Information Systems.

Table 3. Area and Percentages of Each Category of Spatial Suitability Source: Researchers, 2023.

Suitability	Percentage	Area (km²)
Excellent suitability	26.31%	239.57
Good suitability	29.36%	267.30
Moderate suitability	19.24%	175.15
Poor suitability	17.49%	159.21
Very poor suitability	7.58%	69.02
Total	100%	910.25

The areas best suited for future urban expansion (excellent suitability) are located in the northern part of Ain El-Beida city, along the National Road No. 80 that connects Ain El-Beida with Guelma, and in the northwestern part of the city along the National Road No. 10 between Ain El-Beida and Constantine. The total area reached 239.57 hectares, accounting for 26.31% of the total study area. These regions possess several incentives for urban expansion, notably

their flat terrain of medium to poor agricultural quality, including vacant spaces. They are characterized by their distance from mountainous and forested elevations and their proximity to transportation networks, as they are located on important national and provincial roads linking several provinces in eastern Algeria (Constantine, Souk Ahras, Guelma, Annaba, Tebessa up to the Tunisian border). They include two population clusters near the center of Ain El-Beida: Bir Ennas in the west and Bririche in the north, located approximately 6 km and 8 km, respectively, from the city center, which facilitates access to essential city services.

Areas of good suitability received the highest percentage at 29.36% and covered an area of 267.30 hectares, surrounding Ain El-Beida from three sides. On the southern side, which is administratively part of the municipality of Fkirina and thus outside the administrative boundaries of Ain El-Beida municipality, this location boasts many advantages and factors suitable for expansion, including flat land and proximity to National Road No. 80 linking Ain El-Beida with the Khenchela province, as well as its closeness to the city center of Ain El-Beida. What made it less suitable is the good quality of its soil, which supports a variety of crops (fields and orchards), noting that it represents the current expansion area programmed by the authorities in their development plans. The second area lies to the east of the city, also characterized by all the advantages of spatial suitability for expansion. However, it lacks the essential condition of topographic features, being a hilly area interspersed with slopes of more than 8% inclination. The third area, located at the far north of the city, is deemed less suitable due to its distance from the city center of Ain El-Beida.

In this category (good suitability), areas on the southern side were excluded as future expansion areas because they are situated on agriculturally productive lands. The eastern and far northern areas were recommended as suitable for future expansion that could be utilized in the distant future (after decades) as a reserve asset.

Areas of moderate suitability spanned 175.15 hectares with a percentage of 17.49%, scattered across the four directions surrounding the city but primarily concentrated in the northeastern part belonging to the municipality of Zarq, and the southeastern direction towards the municipality of Fkirina. These areas are characterized by their distance from the main road network and by steep slopes ranging from 8% to 20%.

Areas of poor suitability occupied an area of 159.21 hectares with a percentage of 17.49%, concentrated in the eastern and southeastern directions, distinguished by their distance from main roads and the city center of Ain El-Beida, and their uneven, forested terrain.

Areas of very poor suitability obtained the lowest percentage at 7.58%, characterized by their lack of most conditions suitable for spatial expansion.

6. CONCLUSION.

The study demonstrated that the strategy of integrating modern methods and techniques, represented by the Delphi methodology, Geographic Information Systems (GIS) technology, and Multi-Criteria Decision Making (the Analytic Hierarchy Process) within a single environment, constitutes a comprehensive model. It provides an overarching view of the urban environment of the city within its region, enabling the construction of spatial models that mathematically simulate the natural reality. This assists planners in selecting the best spatial suitability alternatives and making informed planning decisions for the future urban expansion of the city based on scientific principles and in harmony with the characteristics and potentials of the area.

The spatial analysis results of the study area revealed that Ain El-Beida city faces significant challenges related to urban expansion, including natural barriers surrounding the city from all four directions. These barriers are manifested in mountainous elevations and forested areas in the northeast and southeast, and agricultural lands in the northwest and south,

which can only be overcome through proper planning methods that consider spatial suitability for expansion.

The best axes for spatial expansion, according to the methodology and analysis approach, emerged in the north of the city, covering an area of approximately 239.57 hectares, along two main roads. The northern axis extends between Ain El-Beida and Bririche, and the northwest axis extends between Ain El-Beida and Constantine, passing through the provincial capital. This area possesses all elements attractive for urban development.

Furthermore, the findings indicate that the current planning decision made by the relevant authorities to direct the urban sprawl of Ain El-Beida city beyond its administrative boundaries towards the southern area on the agricultural lands of Fkirina municipality is erroneous. It constitutes unplanned and haphazard expansion because it disregards the spatial suitability conditions for urban expansion according to prevailing urban planning standards, and fails to consider the natural and economic considerations of the location. The result has been encroachments on fertile agricultural lands, converting them to residential use, and negatively impacting the primary resource of the municipality's economy.

This study has provided a scientific addition and a new comprehensive and long-term planning tool, offering the best planning alternatives for the future urban expansion of Ain El-Beida city. It addresses the issue of irregular and unplanned expansion currently experienced by the city by suggesting suitable areas that can accommodate future population and urban growth while preserving agricultural lands. Therefore, we urge the responsible authorities to follow the results obtained in this study, revise their expansion plans, review their development decisions, and hope they fulfill their responsibility in restoring the status of Ain El-Beida city within its provincial region.

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