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URBAN SATURATION IN ALGERIAN CITIES: FACTORS AND TREATMENT METHODS WITHIN THE FRAMEWORK OF URBAN SUSTAINABILITY: A CASE STUDY OF THE CITY OF TÉBESSA

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ABSTRACT

Throughout history, cities have undergone transformations due to social, urban, environmental, and economic changes, which have contributed to altering their shape, and growth patterns. This evolution has led to continuous urban expansion in response to the increasing needs of the population, resulting in boundless urban sprawl. The constant effort to provide urban services has driven the integration of new land areas within the framework of urban expansion, often at the expense of the surrounding rural areas, which serve as the city's main life source. These rural areas are the primary base for urban expansion and simultaneously the main supplier of labor and raw materials.
Currently, urban expansion in Algerian cities, in general, and in Tebessa in particular, poses challenges in urban development and planning. This situation calls for exploring alternative approaches when natural or human barriers prevent the optimal use of urban land in alignment with the city's needs, leading to urban saturation. These approaches should consider the principles of sustainable urban development and rely on tools focused on protecting natural resources within and around the city, as cities are not only the main threat to the natural environment but also the first victims of its degradation.

KEYWORDS

Urban Saturation, Urban Sprawl, Urban Expansion, Sustainable Urban Development, City of Tebessa

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Introduction.

The concept of urban growth is crucial for understanding urban transformations and their impact on the environment and society. It refers to an increase in population density exceeding 2,000 inhabitants per square kilometer and a city size greater than 10,000 residents. Urban growth involves the population's engagement in the production and distribution of technology, as well as in commercial, industrial, and service professions, characterized by a high degree of labor division and social complexity.

Additionally, it signifies the directed changes occurring within the city, which include residential developments, the construction of high-rise buildings, the establishment of streets and neighborhoods (Zucchelli Alberto,1983). Urban growth is accompanied by an expansion of the urban area to meet the demands of the increasing population. The term "urban expansion" indicates the tendency of people to settle in cities, leading to an increase in the size of these cities, especially larger ones (Abdelrazak Abbas Hussein, 1977). This phenomenon is a logical outcome of the urban development process (Merlin Pierre, 1955).

Thus, urban expansion is a multifaceted concept that signifies the growth of a city and its suburbs at the expense of the surrounding lands. This phenomenon leads to the development of rural areas adjacent to cities, increasing their population density and enhancing the level of services available within those areas (Sayed Hanfi Awad, 1997).

Cities continuously expand for various reasons, with the most significant being political, economic, and social factors. Political decisions often lead to the establishment of cities with all their components. Economically, the development of industrial and commercial establishments drives this growth, while social improvements in certain cities have made them attractive centers for populations from other communities.

However, unregulated urban expansion can result in the phenomenon of urban sprawl. This occurs when urban areas extend into the surrounding environment without an urgent need for such growth. It involves the continuous exploitation of urban land towards the outskirts of the city and the outward spread of urban fabric, whether horizontally or vertically (Saouli Rim Amina, BenhassineTouam Nassira, 2021), Consequently, this represents a form of uncontrolled urban growth that typically occurs on the fringes of cities, where most construction is often haphazard and characterized by low-density developments.

Thus, urban expansion is an inevitable consequence of population growth, while urban sprawl often exceeds the rate of population increase. The phenomenon of urban sprawl contradicts many principles of urban sustainability and has numerous implications and consequences (Messaadi Ibtissem, Raham Djamel, 2020), the most significant of which is urban saturation. Urban saturation refers to the increased density of construction and residential clusters in specific areas, where it becomes difficult to find green spaces or open areas. This phenomenon is prevalent in major cities around the world and significantly impacts the quality of life for residents in those regions. It is a natural outcome of population growth and economic development, indicating the city's inability to accommodate further increases(Luc Gwiazdzinski, Manola Antonioli, Guillaume Drevon, Vincent Kaufmann, and Luca Pattaroni, 2020).

Urban saturation has many negative effects, the most critical of which include the destruction of green spaces and agricultural land, increased consumption of natural resources, and the generation of large amounts of waste and pollution. It also affects biodiversity in the region and contributes to rising temperatures, thereby influencing both local and global climates.

Regarding its social and economic effects, the most important include the deterioration of public services, increased social tension, and a rise in pollution-related health issues of various kinds. Additionally, from an urban perspective, it leads to higher housing costs, a shortage of public spaces, and increased traffic congestion.

Many cities around the world are experiencing urban saturation, each employing its own methods to address this phenomenon. For example, Tokyo, one of the most affected cities by urban saturation globally, has adopted a range of strategies to tackle this issue. Key among these strategies are the development of a public transportation system, effective utilization of green spaces, and the promotion of technological innovation. In contrast, New York City has implemented different strategies, including encouraging bicycle usage, promoting vertical farming, developing impoverished neighborhoods and improving their services, and advocating for sustainable urban planning. All of these solutions fall under the concept of urban sustainability, which aims to create a harmonious environment that aligns with nature and prioritizes the quality of human life.

In Algeria, many cities are facing the phenomenon of urban saturation for various reasons, including common factors such as the shortcomings of urban planning and development tools currently in use, which promote urban sprawl rather than construction within the city. These tools create a sectoral division among functions within the urban area and fail to consider the life basin, restricting interventions to the urban surroundings only. There are also unique reasons that distinguish each city from the others. For instance, the city of Tebessa has experienced notable development and rapid urban growth in a short period, especially after its administrative elevation to a provincial center in 1974(Directorate of the Environment of the province of Tebessa, 2011), which brought with it a range of investments that allowed the city to emerge from isolation. This led to significant demographic growth, along with migration from rural areas to the city in search of better living conditions. All of this resulted in the city expanding in a random and uncontrolled manner in all directions, amidst numerous challenges and obstacles. Consequently, Tebessa has become one of the most significant Algerian cities suffering from urban saturation. In this context, we raise the following question:

What are the reasons that have caused the city of Tebessa to suffer from urban saturation, and what solutions can be proposed within the framework of urban sustainability principles?

To address this question, we relied on several quantitative methods. These included field research methodology through contact with various specialized authorities: the technical services of the Tebessa Municipality, the Programming and Statistics Directorate of Tebessa Province, the Directorate of Construction, Urban Planning, and Architectural Engineering of Tebessa Province, and the Meteorological Office. We utilized interview techniques, field observation techniques, and an analytical approach to analyze the data collected, aiming to obtain meaningful information and insights. This included the Analytic Hierarchy Process (AHP), which was conducted using Geographic Information Systems (GIS) with the ArcGIS 10.7 software.

1. Tebessa City: The Gateway to Eastern Algeria.

Tebessa City is located in eastern Algeria, approximately 30 kilometers from the Tunisian border, about 700 kilometers from the capital city of Algiers, and 386 kilometers from the Tunisian capital. This strategic position is significant as it is traversed by three national roads and two railway lines. The city also has an airport for domestic flights located in the northern part of the city, which was previously an international airport. Tebessa covers an area of 2,961 hectares, representing 15% of the total area of the municipality, which had a population of 244,690 residents in 2021(Directorate of Programming and Budget Monitoring of the province of Tebessa, 2021).

The location of Tebessa City is of great significance for overland connectivity in the eastern part of the country, as it links Algeria with the Republic of Tunisia, making it a vital border trading city. It plays a pivotal role in commercial and economic interactions for eastern cities, especially those located along National Road No. 10. The strategic importance of Tebessa's location can be summarized as follows:

- An important overland connection in the eastern part of the country (linking the Algerian and Tunisian republics).
- A border area with a Maghreb dimension, containing four border posts.
- A place for tourism attraction and a center for commercial and economic interactions due to its position along National Road No. 10.

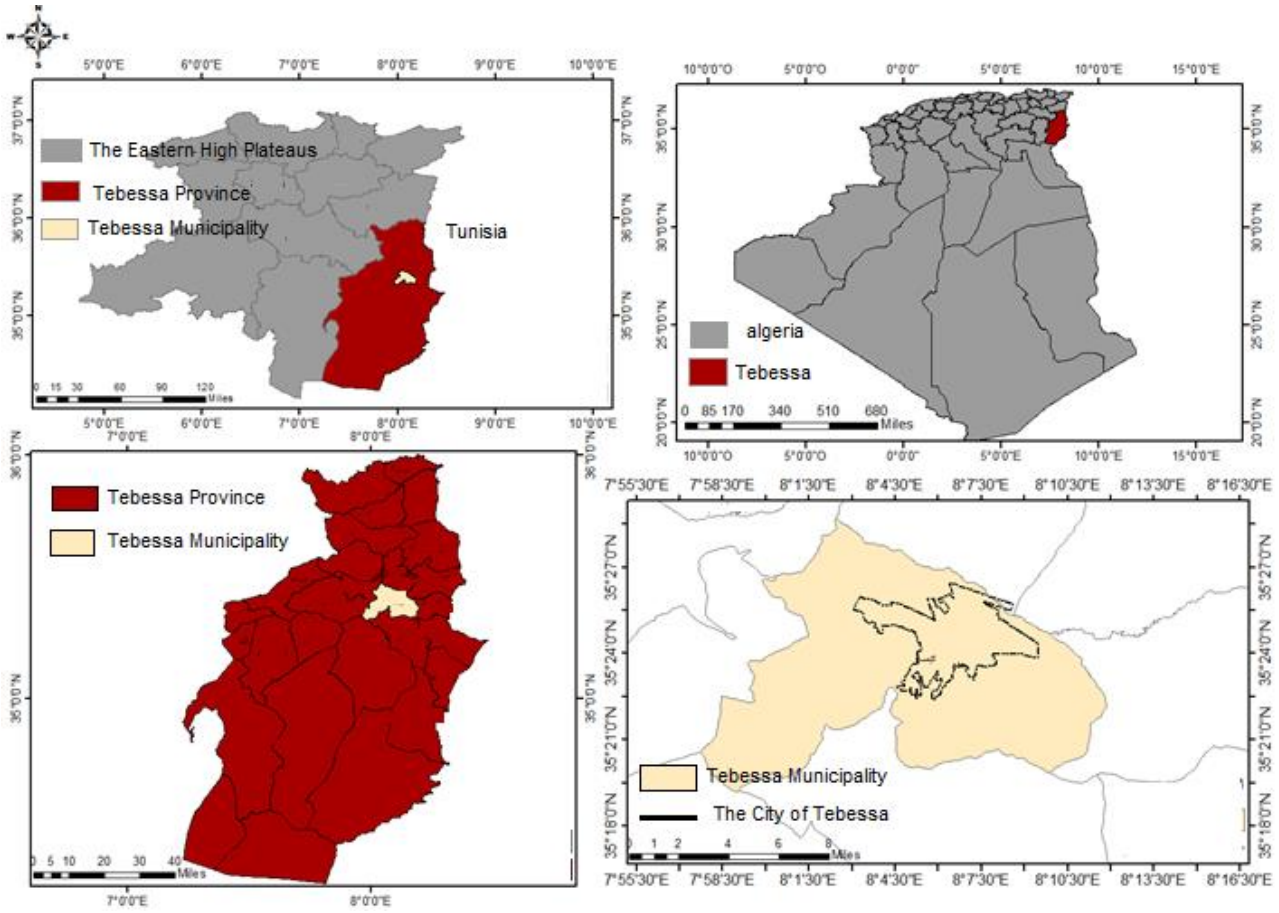


Fig.1. Map (01): The Location of the City of Tebessa in Relation to the Nation, the Eastern Region, the Province, and the Municipality (Source: Authors (2024)using ArcGIS 10.7.)

2. Tebessa City: An Urbanly Saturated City.

The study of urban development in Tebessa City has confirmed that the programmed area for urbanization in the master plan for spatial planning and urban development has been dictated by the topography and nature of land ownership in the city. It did not take into account the easements, geotechnical conditions, hazards, and other obstacles characteristic of the region. As a result, Tebessa is experiencing irrational horizontal urban sprawl due to the indiscriminate consumption of land in areas with low to medium geotechnical suitability and highly productive agricultural lands. The expansion of Tebessa has occurred on high-yield lands adjacent to the urban environment, which are spread over large areas, particularly in the northern part of the city. This area is witnessing rapid urban expansion due to the passage of National Road No. 16. Such lands are also found in the western part of the city, especially to the north and south of National Road No. 10.

Among the most significant reasons that have caused Tebessa City to suffer from urban saturation are:

2.1. The Multiplicity of Easements and Natural and Artificial Obstacles Across the Urban Area of Tebessa City and Its Expansion Zone:

Tebessa City and its expansion area (Tebessa Municipality) encompass nearly all types of easements (14 types). The natural obstacles include steep slopes, with 47% of the municipality's area having a slope ranging from 12% to 57% (Review of the Land Use and Urban Planning Master Plan for the Municipalities of Tebessa, 2012) , agricultural lands, and forests covering mountainous areas. The mountains represent approximately 50% of the municipality's area, specifically Mount Azmour in the southern region, along with Mount Anwal and Mount Adakan in the southwestern part. These mountains are characterized by steep slopes and forest cover, which pose a barrier to urban expansion in this area and render land suitable for development scarce. Additionally, the mountains account for 14% of the city's area. As for the rivers, some of them penetrate the urban environment while others are located in the expansion zone. They originate from the southern part of the city, flowing northwards, and their easements must be respected. These wadis include: Wadi Zaarour, Wadi Naqis, Wadi Rafana, Wadi Al-Saqi, and Wadi Al-Kabir.

The artificial obstacles include the national and provincial roads, as well as the railway line connecting Annaba and Bir El Ater, which is used for transporting phosphate from Jebel El Anq. This railway divides the city into two parts and poses many dangers to housing and residents, such as risks to pedestrians, especially children, due to the numerous openings in the surrounding fence, the noise caused by the trains, and visible cracks in the housing resulting from non-compliance with safety distances(Directorate of the Environment of the province of Tebessa, 2011).

Additionally, there is a high-voltage power line and a power generation station. This line runs through the city from the south and west, acting as a barrier to the city's expansion in that direction, along with a gas transmission line. The city also includes an industrial area covering 130.06 hectares, which occupies most of urban sector number 06, a military area of 8.96 hectares, an airport spanning 255 hectares, and a number of cemeteries. As for archaeological sites, they include the Byzantine wall, the Arch of Caracalla, the Temple of Minerva, the Basilica, the archaeological park, the amphitheater, the church, and the ancient mosque.

2.2. One-Third of the Urban Area of the City is at Risk of Flooding:

The lands located on the Marja Plain are of low suitability for construction, characterized by a slight slope (0-3%). These areas represent 28% of the city's total area and consist of highly compacted red clay to a depth of 4 meters. These lands are periodically exposed to flooding, and any construction on them requires deep foundations and prior flood protection, which increases construction costs.

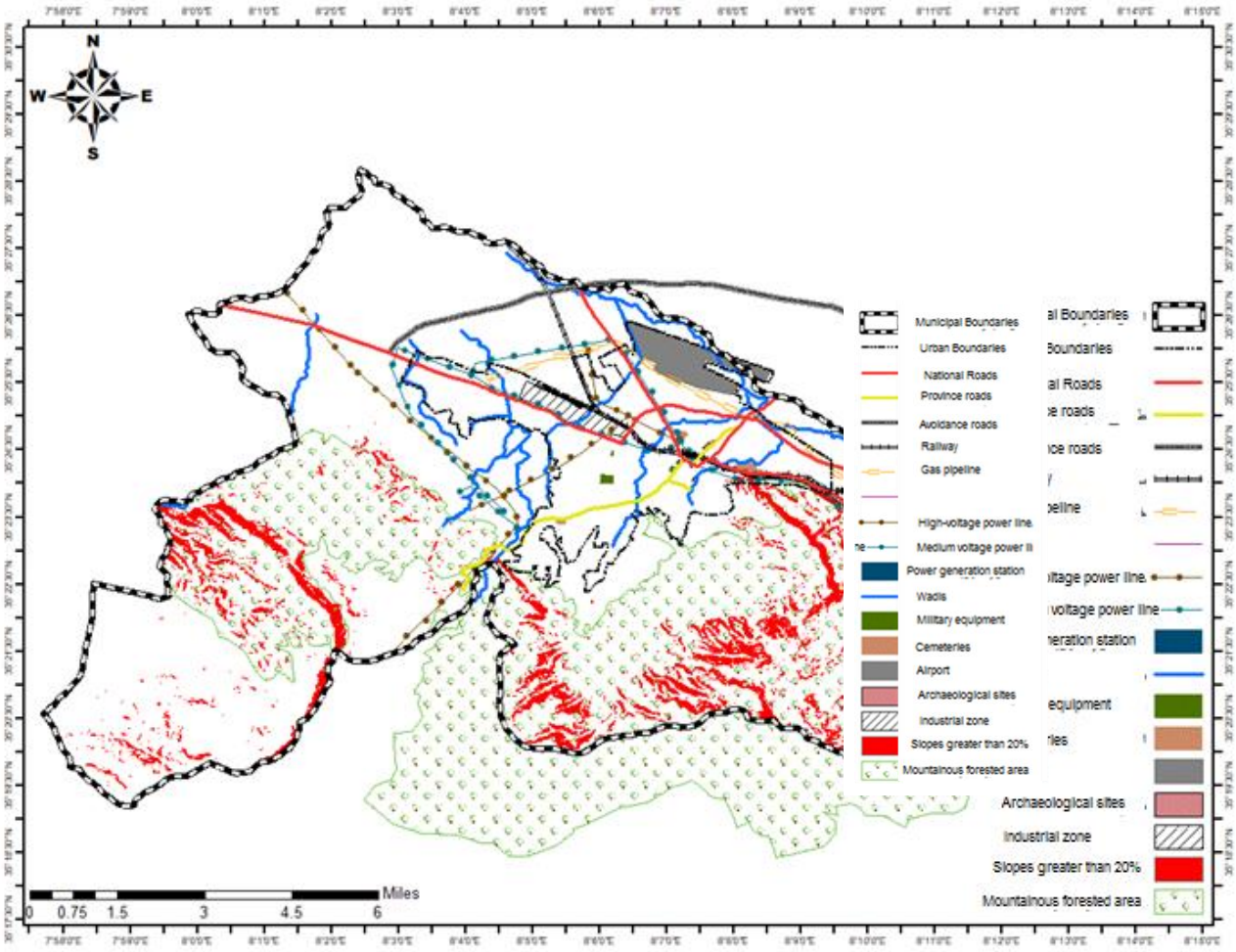


Fig. 2. Map (02): Distribution of easements in the municipality of Tebessa
(Source: Authors (2024) using ArcGIS 10.7.)

2.3. Dominance of Individual Housing in the City's Housing Stock:

Individual housing units constitute 86% of the total housing in the city of Tebessa, resulting in greater consumption of land.

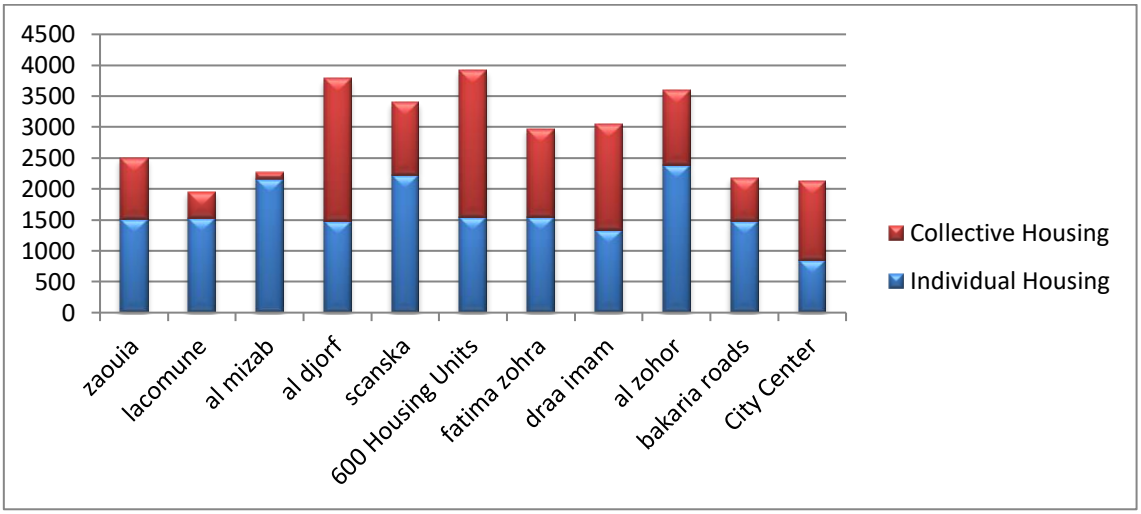


Fig.3. Graph 01: Distribution of the Housing Stock in the City of Tebessa
(Source: Authors' achievement, 2024.)

2.4. Almost Non-existent Urban Pockets within the Urban Fabric of the City:

The city of Tebessa is punctuated by a few urban pockets that do not exceed 0.1% of its total area. These include the forest reserve located in sector number 05 (Skanska), which occupies an area of 21,008.67 m²; a commercial center in the El-Wiaam neighborhood in sector number 06 (600 housing units), estimated to cover an area of 1,481 m²; a commercial center in sector number 11 (city center), which occupies an area of 5,571.74 m²; and a commercial center in sector number 04 (Jurf), with an area of 4,434 m².

Fig. 4. Photo(01): The Commercial Center in Sector Number 11 (Source: Authors, 2023.)

Fig. 5. Photo(02): The Commercial Center in Sector Number 04 (Source: Authors, 2023.)

2.5. Urban Expansion as a Result of Urban Planning Directives:

The urban expansion coefficient is a metric used to measure the speed of urban growth in a specific area and to determine whether a city is experiencing urban sprawl. It is calculated by dividing the increase in population by the increase in land area used for urban development over the same time period. This coefficient helps estimate the sustainability and effectiveness of urban expansion in the region.

The urban expansion coefficient is calculated using the following formula:

$$\text{Urban Expansion Coefficient} = \frac{\text{Urban Growth Rate}}{\text{Population Growth Rate}}$$

Where the population growth rate T is given by:

$$T = \sqrt{N \cdot \frac{P_1}{P_0}} - 1$$

Where:

- P_1 = population at the end year
- P_0 = population at the initial year
- N = difference in years

For example:

Given:

- $P_1 = 244,690$ (final year population)
- $P_0 = 198,281$ (initial year population)
- $N = 14$ (difference in years)

The calculation becomes:

$$T = \sqrt{14 \cdot \frac{244690}{198281}} - 1 \approx 3.35$$

For the Urban Growth Rate T_1:

$$T_1 = \sqrt{N \cdot \frac{P_1}{P_0}} - 1$$

Where:

- P_1 = area of the city at the end year
- P_0 = area of the city at the initial year

Assuming:

- $P_1 = 3298.68$ hectares (final year area)
- $P_0 = 2300.31$ hectares (initial year area)

The calculation becomes:

$$T_1 = \sqrt{14 \cdot \frac{3298.68}{2300.31}} - 1 \approx 11.47$$

Thus, the urban expansion coefficient is calculated as follows:

$$\text{Urban Expansion Coefficient} = \frac{T_1}{T} = \frac{11.47}{3.35} \approx 3.42$$

Since the urban expansion coefficient is greater than one, it indicates that the city of Tebessa is experiencing urban sprawl, with the area of the city increasing in a disproportionate manner relative to its population. This phenomenon can be attributed to the directives of the urban planning tools currently in use, particularly the spatial planning scheme that was revised in 2012. This plan encompasses five municipalities (Tebessa, Hammamt, Bouhlaf Al-Dir, Kueif, and Bakaria).

The expansions outlined in this plan were characterized by the cancellation of the classification of agricultural land, in accordance with Executive Decree No. 11-239 dated July 9, 2011, which aimed to allocate these lands for housing and infrastructure development. Additionally, there has been expropriation for public benefit concerning lands owned by private individuals. (Review of the Land Use and Urban Planning Master Plan for the Municipalities of Tebessa, 2012).

3. Research Findings: Spatial Suitability for Urban Expansion as a Solution to Address Urban Saturation within the Framework of Urban Sustainability.

The city of Tebessa, while characterized by strengths that have contributed to its continuity over the years, also faces numerous obstacles that limit suitable areas for urban expansion. Utilizing hierarchical analytical processes alongside Geographic Information Systems (GIS) will assist in addressing the issue of urban saturation in the city. This approach aims to guide urban expansion to maintain sustainable urban growth by achieving a balance between urban development needs and the preservation of the environment and urban resources.

Spatial suitability for urban expansion refers to the identification of appropriate locations for urban development based on several factors that adhere to the principles of urban sustainability. Analyzing and evaluating these factors will assist in determining suitable sites for urban expansion and making strategic decisions that align with sustainable development goals for urban areas. In this context, 11 factors have been selected:

1. Distance to Urban Areas: This criterion aims to ensure continuity within the area while also facilitating easy access to services and facilities.

2. Distance to Slopes: This helps evaluate the suitability of sites for urban expansion. Areas with slight slopes are more appropriate for construction in terms of cost and ease of infrastructure development. In contrast, steep slopes are prone to drainage issues, soil erosion, and flooding, which increases the engineering costs required for safety and sustainability.

3. Distance to Agricultural Land: This criterion contributes to guiding sustainable urban expansion that protects natural resources.

4. Distance to Vegetation Cover: The goal is to maintain ecological balance and protect against natural hazards, especially since the city of Tebessa faces flood risks. Vegetation can help reduce exposure to this risk and mitigate potential negative impacts, while also serving as a resource that supports sustainable development.

5. Distance to Watercourses: This is one of the important criteria in assessing the spatial suitability for urban expansion. The distance between urban areas and watercourses provides a buffer against rainfall and flooding, thereby helping to reduce the impact of floods on residential areas. Thus, this criterion contributes to risk reduction.

6. Distance to Medium and High Voltage Power Lines: This aims to protect residents and property while managing safety-related risks.

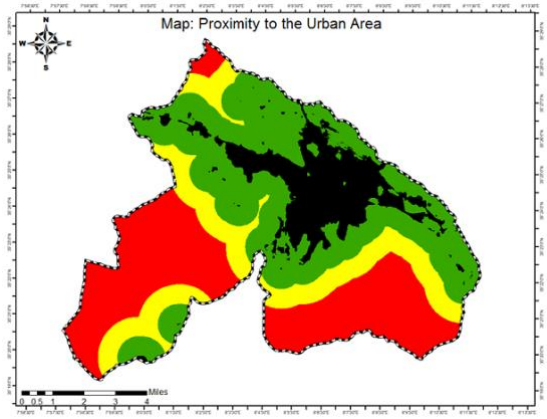
7. Distance to Gas Lines: The objective is to ensure the safety of residents by avoiding hazards such as leaks and explosions, in addition to protecting the environment.

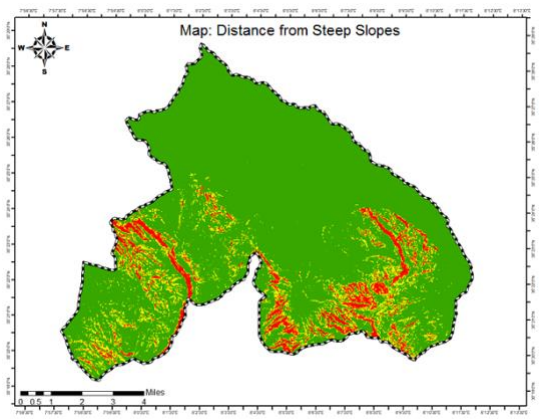
8. Distance to Railways: This criterion aims to ensure the safety of residents and minimize vibrations and noise.

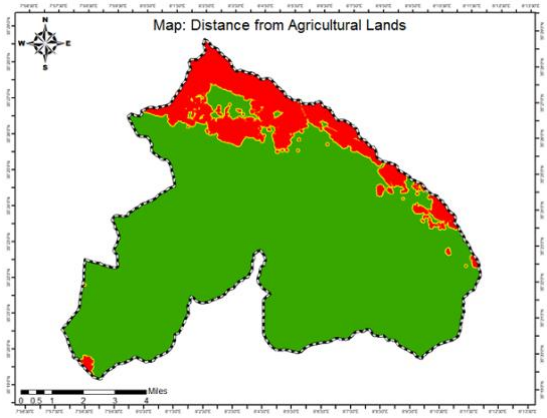
9. Distance to Industrial Areas: This is intended to reduce the negative impacts of industrial activities on residents and the environment.

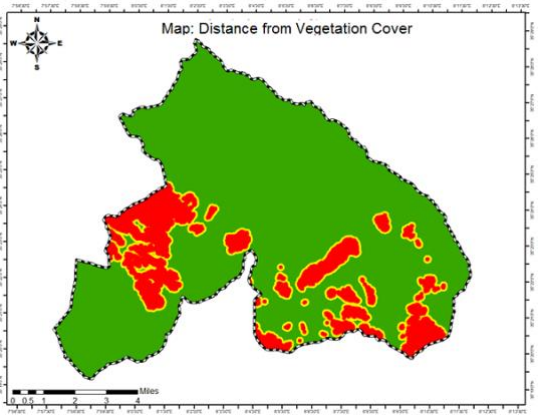
10. Distance to National and Provincial Roads: The goal is to avoid negative interactions between residential activities and traffic flow, ensuring road safety since these roads often carry high traffic volumes at high speeds, along with associated noise.

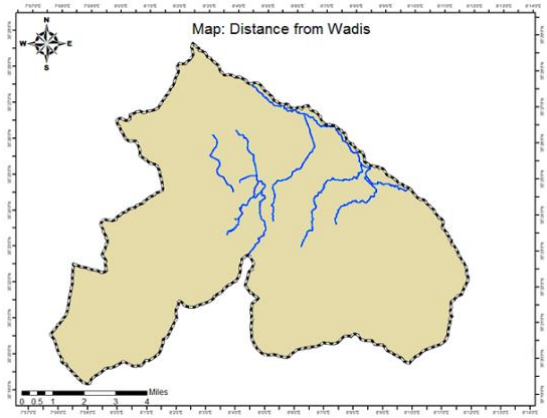
11. Distance to Airports: Air traffic and airport activity can create noise disturbances for nearby residents. Airports are also sensitive locations in terms of safety and security; therefore, maintaining a safe distance from residential areas is necessary to mitigate potential risks such as aircraft accidents or chemical spills.

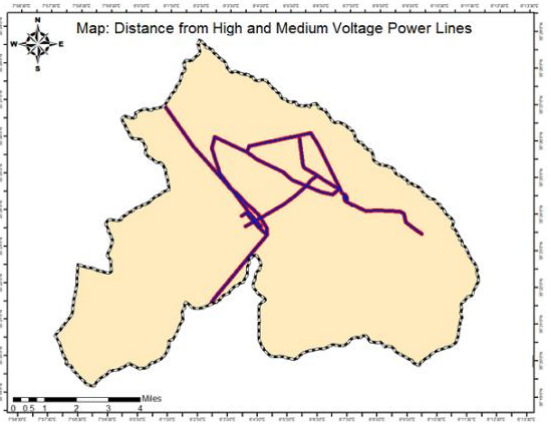

Map: Proximity to the Urban Area
Miles

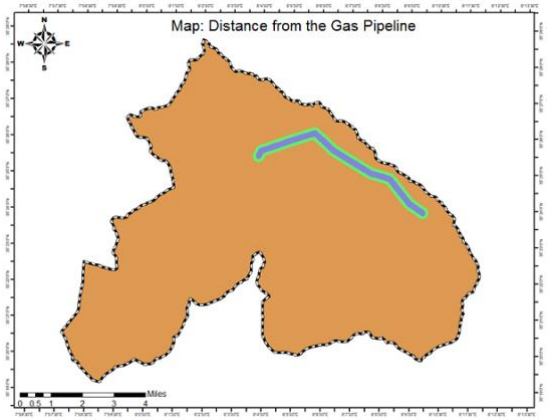

Map: Distance from Steep Slopes
Miles

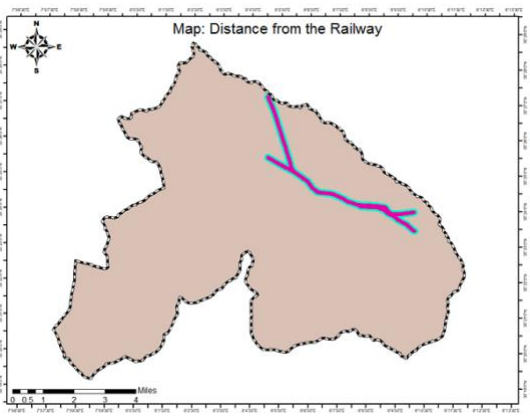

Map: Distance from Agricultural Lands
Miles


Map: Distance from Vegetation Cover
Miles


Map: Distance from Wadis
Miles


Map: Distance from High and Medium Voltage Power Lines
Miles


Map: Distance from the Gas Pipeline
Miles


Map: Distance from the Railway
Miles

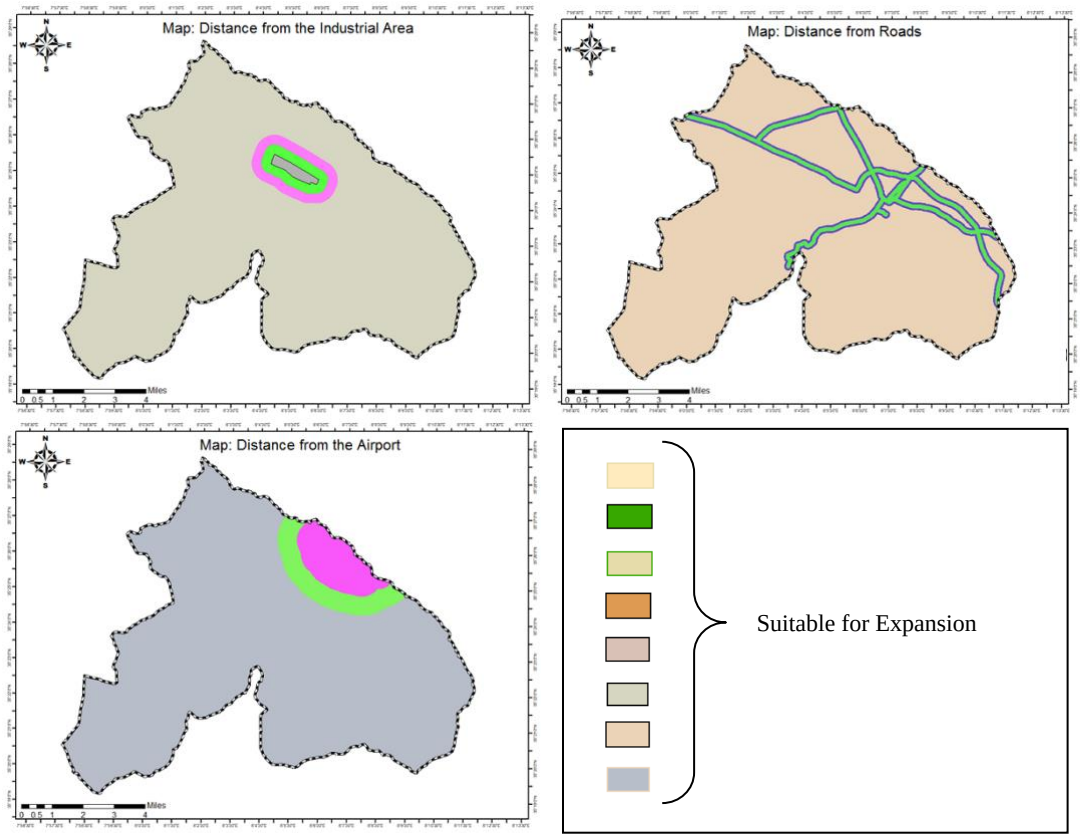


Fig. 6. Map (03): Hierarchical Analysis of the Municipality of Tébessa (Source: Authors (2024) using ArcGIS 10.7.)

The Analytic Hierarchy Process (AHP) is a simple, flexible, practical, and multi-criteria decision-making method for addressing complex and ambiguous problems that are difficult to analyze quantitatively. Proposed by American researcher Thomas Saaty in the early 1980s, this method consists of three main components: the ultimate goal or problem to be solved, the criteria for evaluating alternatives, and the possible solutions referred to as alternatives. The process involves the following steps: Stakeholders compare the importance of criteria in pairs, one at a time, AHP converts these evaluations into numerical values, allowing for comparison across all possible criteria, Finally, the numerical priorities for each alternative option are calculated, resulting in a ranking of the most preferred solutions based on the values provided by all users (Zarqi Ammar, 2022).

In the context of assessing land suitability for expansion in the municipality of Tebessa, the hierarchical analysis will utilize a pairwise comparison matrix for the factors that play a role in generating a suitability assessment map for expansion areas. This approach aims to achieve a balance among various factors while maintaining sustainable development and enhancing the quality of life in the region.

Table. 1.
Pairwise Comparison of Factors using AHP (Source: Authors, 2024.)

The distance to the city	Vegetation cover	Industrial zone	Agricultural lands	Airport	Roads	Wadis	Powerlines	Gas pipeline	Railway	Regressions	Factors
1	2	3	4	5	6	7	8	9	10	11	12
2	1	0.75	0.3	0.25	0.9	0.5	0.9	0.3	0.75	1	Regressions
4	3	1	0.75	0.5	2	0.9	2	0.75	1	1.33	Railway
6	5	3	1	0.9	4	2	4	1	1.33	3.33	Gas pipeline
3	2	0.9	0.5	0.3	1	0.75	1	0.25	0.5	1.11	Powerlines
5	4	2	0.9	0.75	3	1	1.33	0.5	1.11	2	Wadis
3	2	0.9	0.5	0.3	1	0.33	1	0.25	0.5	1.11	Roasd

1	2	3	4	5	6	7	8	9	10	11	12
7	6	4	2	1	3.33	1.33	3.33	1.11	2	4	Airport
6	5	3	1	0.5	2	1.11	2	1	1.33	3.33	Agricultural lands
4	3	1	0.33	0.25	1.11	0.5	1.11	0.33	1	1.33	Industrial zone
2	1	0.33	0.2	0.16	0.5	0.25	0.5	0.2	0.33	1	Vegetation cover
1	0.5	0.25	0.16	0.14	0.33	0.2	0.33	0.16	0.25	0.5	The distance to the city
43	32.5	17.13	7.65	5.05	19.17	11.87	17.51	5.86	10.11	20.05	Sum

Table. 2.
Extracting Weights through Pairwise Comparison Process (Source:Authors, 2024.)

The distance to the city	Vegetation cover	Industrial zone	Agricultural lands	Airport	Roads	Wadis	Powerlines	Gas pipeline	Railway	Regressions	Factors
0.0465	0.0307	0.0437	0.0392	0.0494	0.0469	0.042	0.0513	0.0511	0.0741	0.0498	Regressions
0.0930	0.0923	0.0583	0.0980	0.0988	0.1042	0.075	0.1142	0.1279	0.0989	0.0664	Railway
0.1395	0.1538	0.1750	0.1307	0.1778	0.2085	0.168	0.2284	0.1706	0.1318	0.1662	Gas pipeline
0.0697	0.0615	0.0525	0.0653	0.0592	0.0521	0.063	0.0571	0.0426	0.0494	0.0554	Powerlines
0.1162	0.1230	0.1167	0.1176	0.1482	0.1564	0.084	0.0761	0.0853	0.1098	0.0997	Wadis
0.0697	0.0615	0.0525	0.0653	0.0592	0.0521	0.280	0.0571	0.0426	0.0494	0.0554	Roasd
0.1627	0.1846	0.2334	0.26143	0.1976	0.1738	0.112	0.1903	0.1895	0.1978	0.1994	Airport
0.1395	0.1538	0.1750	0.1307	0.0988	0.1042	0.093	0.1142	0.1706	0.1318	0.1662	Agricultural lands
0.0930	0.0923	0.0583	0.0435	0.0494	0.0579	0.042	0.0634	0.0568	0.0989	0.0664	Industrial zone
0.0465	0.0307	0.0194	0.0261	0.0329	0.0260	0.021	0.0285	0.0341	0.0329	0.0498	Vegetation cover
0.0232	0.0153	0.0145	0.0217	0.0282	0.0173	0.016	0.0190	0.0284	0.0247	0.0249	The distance to the city

Table. 3.
Extraction λ MAX (Source:Authors, 2024.)

			0.021	0.031	0.065	0.134	0.191	0.076	0.112	0.057	0.168	0.093	0.047	
	Weights	Sum	The distance to the city	Vegetation cover	Industrial zone	Agricultural lands	Airport	Roads	Wadis	Powerlines	Gas pipeline	Railway	Regressions	Factors
11.65	0.0477	0.556	0.042	0.031	0.049	0.040	0.047	0.069	0.056	0.051	0.050	0.070	0.047	Regressions
11.71	0.093	1.094	0.085	0.095	0.065	0.100	0.095	0.153	0.100	0.114	0.126	0.093	0.063	Railway
11.89	0.168	2.00	0.127	0.158	0.197	0.134	0.172	0.307	0.224	0.228	0.168	0.124	0.159	Gas pipeline
11.74	0.057	0.671	0.063	0.063	0.059	0.067	0.057	0.076	0.084	0.057	0.042	0.046	0.053	Powerlines
11.87	0.112	1.331	0.106	0.126	0.131	0.120	0.143	0.230	0.112	0.076	0.084	0.103	0.095	Wadis
12.49	0.076	0.960	0.063	0.063	0.059	0.067	0.059	0.076	0.373	0.057	0.042	0.046	0.053	Roasd
11.62	0.191	2.223	0.149	0.190	0.262	0.268	0.191	0.256	0.149	0.190	0.186	0.186	0.191	Airport
11.59	0.134	1.558	0.127	0.158	0.197	0.134	0.095	0.153	0.124	0.114	0.168	0.124	0.159	Agricultural lands

11.18	0.065	0.734	0.085	0.095	0.065	0.044	0.047	0.085	0.056	0.063	0.033	0.093	0.063	Industrial zone
11.44	0.031	0.362	0.042	0.031	0.021	0.026	0.031	0.038	0.028	0.028	0.033	0.031	0.047	Vegetation cover
11.52	0.0213	0.245	0.021	0.015	0.016	0.022	0.027	0.025	0.022	0.019	0.028	0.023	0.023	The distance to the city

λMAX = 128.7522307/11 = 11.7047482
CI = (L MAX - n)/(n -1)= (11.7047482 -11)/10=0.070474824
RI(11) = 1.51
CR = CI/(RI)=0.070474824/1.51=0.046672069

The use of multi-criteria analysis methods in conjunction with Geographic Information Systems (GIS) aids in decision-making for evaluating potential land for urban expansion. The primary outcome is a composite map created based on the weights obtained from the Analytic Hierarchy Process (AHP) analysis, assessing the suitability of various criteria identified as relevant to urban expansion in the region.

Each criterion's justification regarding its importance, as detailed during the classification process, contributes to assigning weights to these factors. According to the previous table, a weighted overlay analysis will be performed in GIS using spatial analyst tools. This will enable the extraction of a suitability map for urban expansion, reflecting the spatial distribution of land suitability based on the established criteria and their associated weights.

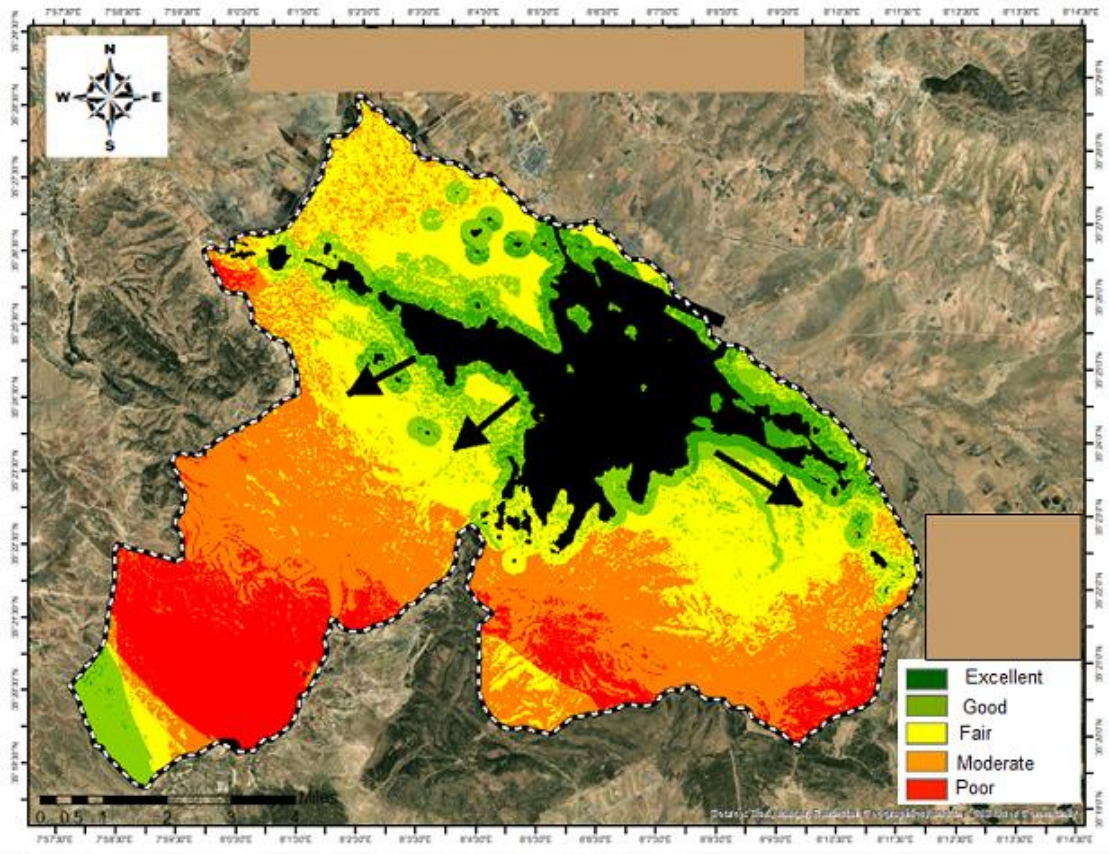


Fig. 7. Map (04): Spatial Suitability for Urban Expansion of the City of Tébessa (Source: Authors(2024) using ArcGIS 10.7.)

- **Excellent Construction Category**: Its area is approximately 8 km², accounting for 5% of the municipality's total area.
- **Good Construction Category**: Its area is estimated at 14 km², which is 9% of the municipality's total area.

- **Fair Construction Category**: This includes high-voltage power lines, rivers in the southern part of the city, the industrial zone, gas lines, and the bypass road in the northwest. Its area is about 54.01 km², representing 34% of the municipality's total area.
- **Moderate Construction Category**: This category has an area of 56.65 km², accounting for 35% of the municipality's total area, characterized by steep mountainous forest areas in the south and agricultural lands in the northwest.
- **Poor Construction Category**: This category encompasses a total area of 27.27 km², which is 17% of the municipality's total area, characterized by steep slopes and distance from urban areas.

Conclusions.

Based on the findings, addressing the issue of urban saturation in alignment with the principles of urban sustainability relies on the rational use of land by promoting vertical expansion instead of wasting space through horizontal sprawl. This can be achieved through the adoption of sustainable urban planning that balances population growth with the availability of resources and infrastructure, while enhancing environmental and social sustainability.

Furthermore, enforcing strict policies and regulations to organize building and construction permits is essential to ensure that urban expansion occurs legally and systematically. This is particularly important for Tebessa, which suffers from unregulated housing developments in the south and southeast areas of the city, such as El Jarf and El Mizab neighborhoods.

The utilization of vacant urban pockets within the city could significantly improve land use by converting them into residential areas to replace deteriorated housing, which accounts for 5% of the city's housing stock. Alternatively, these areas could be used for economic projects, such as commercial centers, which would create job opportunities and stimulate the local economy, especially given the high unemployment rate in Tebessa.

The implementation of these proposals requires a serious commitment from the state, institutions, and individuals to ensure the sustainable growth of urban areas in Tebessa, as well as to protect the environment and improve the well-being of its residents.

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