Space Syntax: a Method for assessing the urban policies in Ain M'lila city

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Abstract:

Since its establishment, the city of Ain M'lila has implemented various urban policies to manage its urban space. These policies were aligned with the country's urban agenda and employed different laws and plans. The objective of the administrators of Ain M'lila was to guide urban growth and ensure controlled urban development. However, all of these urban policies fell short of their intended goals and instead gave rise to a host of problems. Furthermore, these policies facilitated the city's expansion in multiple directions through the creation of new neighborhoods. A significant contributing factor to this failure was the lack of an evaluative tool.

This study aims to assess the diverse urban policies that Ain M'lila city has undergone by employing space syntax as a novel approach. This theory enables the creation of axial maps and facilitates visual and quantitative comparisons by calculating syntactic measures.

Key words: Space syntax, urban policies, syntactic measures, Ain M'lila.

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1. Introduction:

Algeria has experienced rapid urban growth, which has been largely resulting from mass migration from rural areas to cities, both before and after independence, this situation has led to numerous urban challenges such as housing crisis caused by natural population growth and migration[1], which has resulted in an increased demand for housing, public facilities, and infrastructure. To control its urban growth, Algeria has implemented various urban policies aimed at addressing these challenges such as Master urban plan (PUD), Master Plan for Planning and Development (PDAU) and the Land Occupation Plans.

The observer of these urban policies can indeed realize that many of them have not achieved their objectives and have been deemed failures. There may be several reasons for this, including the mismatch between the urban policies and the urban, social, and economic realities of the country. Some urban policies may be incompatible with the needs and aspirations of the population, leading to their lack of acceptance or effective implementation. Regular and ongoing evaluation of urban policies is necessary to assess their success and identify problems and

necessary improvements to better achieve their goals, where the results of the latest general census of population and housing in 2008 are indicative in this regard: 70% of the population resides in the main urban areas, 16% in secondary urban areas, and the remainder in rural areas. Furthermore, nearly 66% of the population lives in a city, and the number of urban agglomerations increased from 211 in 1977 to 751 in 2008[2].

To assess the effectiveness and efficiency of urban policies (plans), reliance on traditional methods (spatial analysis), which are time-consuming and prone to errors, is no longer sufficient. Consequently, with the advent of the technological revolution, alternative means have been found, and perhaps the most prominent among them is "space syntax", which is a collection of methods and modelling techniques for architectural and urban spaces[3]. Its objectives are to build a theoretical and methodological framework for studying the form of the city and the functioning of space, its analysis techniques, and their statistical comparison with empirical social data[4].

So, from a scientific perspective, there have been numerous studies that have utilized space syntax theory, particularly in the field of urban planning. However, despite the effectiveness of spatial analysis in assessing urban expansions, there is a lack of evaluation within the context of urban policies tools. This has prompted us to undertake research in this area.

2. Materials and methods:

2.1. Space syntax:

This theory formulated by Hillier in 1975 introduces a comprehensive set of technical models aimed at analyzing spatial configurations, with a particular focus on societal aspects. Over the past two decades, space syntax has been known as an alternative computational language that is used to describe spatial patterns of modern cites and analyzes the topological relationships of settlement spaces[5]. This theory encompasses a diverse range of methods that enable the quantitative description of spatial organizations and their intricate connections to social activities. By highlighting the pivotal role of mobility in urban dynamics, it investigates the syntactic relationships among subspaces within a defined system and characterizes the system through detailed descriptions within a morpho-mathematical approach.

2.2. Space syntax and assessing urban policies:

The space syntax analysis is an analytical approach that can be utilized across various design levels. It starts from analyzing the smallest spatial units, such as individual rooms, and extends to the examination of apartments, buildings, neighborhoods, districts, and even entire cities[6]. Spatial syntax, in a broader context, focuses on relational characteristics and "extrinsic" properties. These include connectivity, the local position of a space within the system, and the global relationship of the space in relation to all other elements of the system[7], indeed, spatial syntax plays a crucial role in the effective evaluation of urban policies. The organization, connectivity, and structure of spaces within an urban or architectural environment can have significant impacts on the functionality, accessibility, and user-friendliness of that space.

2.3. Axial map:

The axial map is an alternative representation of urban networks to measure the level of accessibility which is defined as "spatial integration"[8].However, the axial line-based space syntax comes from the fact that axial lines do not exist in reality: it is a concept to represent small-scale spaces[9], The axial map of interconnected and accessible lines can be analyzed using both topology and mathematical graph theory. This analysis involves obtaining three syntactic measures: integration (global and local), which identifies the most visible and accessible spaces, connectivity, which indicates visual connections between different spaces in the city. The DepthMap© 10 software is often used for this purpose, with a visibility analysis radius of (n) for global analysis, (3) for local analysis and for the connectivity.

2.4. Syntactic measures:

One of the methods used in space syntax analysis is the visibility graph analysis (VGA) witch defined as graphs of simple inter-visibility information in a spatial layout, translated into edges to other nodes that are distributed over a regular and dense grid of possible observation points[10]. It focuses on analyzing open spaces. It involves measuring connectivity and integration to analyze the data, so it helps to assess the urban policies of cities and it provides a quantitative analysis of urban spaces and spatial development properties.

- **global integration (Rn):**

The global integration index measures the mean depth of an axial line[11], it is a normalised measure of distance from any space of origin to all others in a system[12]. It measures the ease of reaching that space from any other space in the overall spatial arrangement. It is an important measure of spatial syntax[13]. The measure of integration is a static global measure. It indicates the extent to which a space is integrated or segregated from the system.

- **Local integration:**

The local integration is portrayed as blend estimations of axial lines at the radius 3 (root notwithstanding two topological steps from the root), which can be used to show up a concentrate picture of integration[14], in fact, the minimum value is obtained for the most integrated line while the maximum value is obtained for the most segregated line[15].This measure explores more localized structures and aims to identify the emergence of secondary centralities within a given city.

- **Connectivity:**

Connectivity measures the number of immediate neighbors that are directly connected to a space. This is a static local measure[16].

2.5. Study area:

Ain M'lila is a medium-size city [2], It is located in eastern Algeria specifically in the northwest of the province of Oum El Bouaghi, It was created by a government decree issued on November 28, 1874 as a center of a mixed municipality (Ain M'lila). The city was promoted as a district

during the colonial period and was initially attached to the stat of Constantine in 1957. Subsequently, in 1974, it was reattached to the stat of Oum El Bouaghi.

Ain M'lila city enjoys a strategic location at the intersection of the two national roads. One of which is N°. 03, it connect the province of Constantine to the province of Batna, and the national road No. 100 which links the province of Mila to the province of Oum El Bouaghi, where the two roads intersect in the city centre (fig: 01).

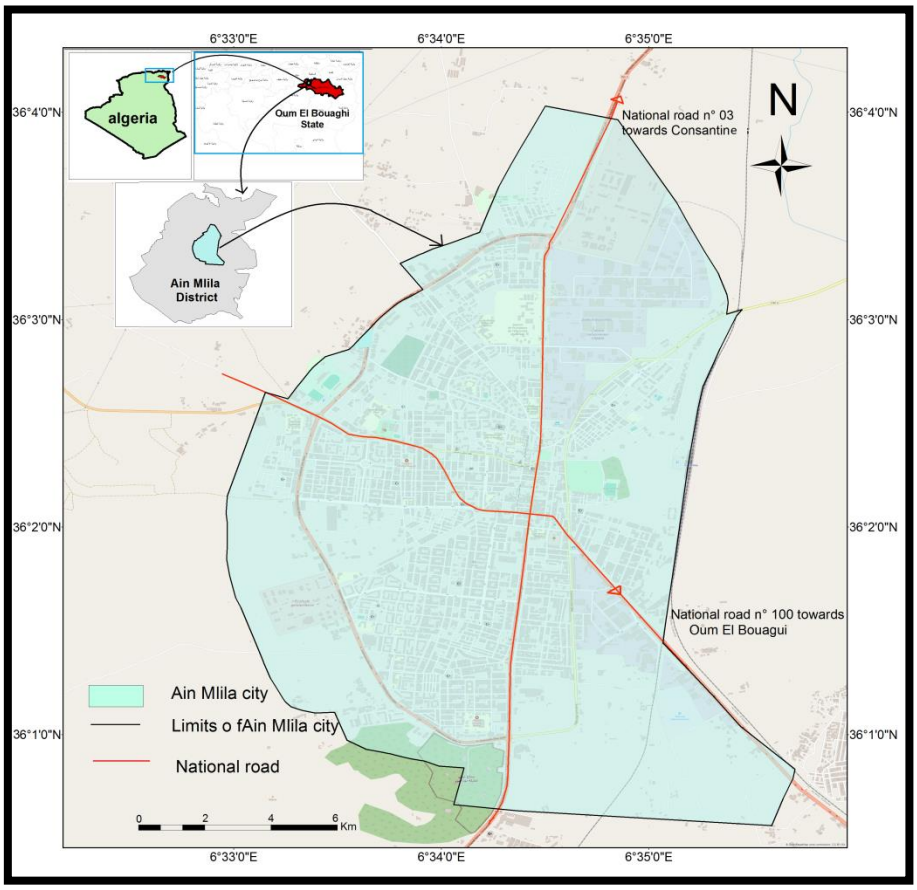

Fig 1: Study area in WGS 1984 UTM projection, Zone 32S

Source: Prepared by the researchers based on the revision of

the master plan for preparation and reconstruction 2004 + aerial photos using the Arcgis10.8 software.

2.6. Urban policies in the city of Ain M'lila :

Ain M'lila city benefited from several urban plans. Its main objective was to control its urban growth. Below is an overview of the city of Ain M'lila's urban policies , **Fig 2.**

- Urban policy before independence (1962):

Ain M'lila's urban policy started with a designated neighborhood for Europeans in the city center. It was to the left of National Road No. 3, This neighborhood served as the city's first nucleus. It later became the city's center..

- **Urban policy After Independence (1962-1977):**

In the face of various urban problems, the city of Ain M'lila after independence was managed through various decrees, laws issued at the time (vacant properties, agricultural revolution...) [17]and economic scheme: the Triple Scheme (1967-1969) and the First and Second Quaternary Scheme (1970-1973 and 1974-1977)[18], Additionally, the city experienced an unplanned and haphazard expansion of the colonial nucleus due to waves of immigration. This led to an expansion on the western side of the city[19].

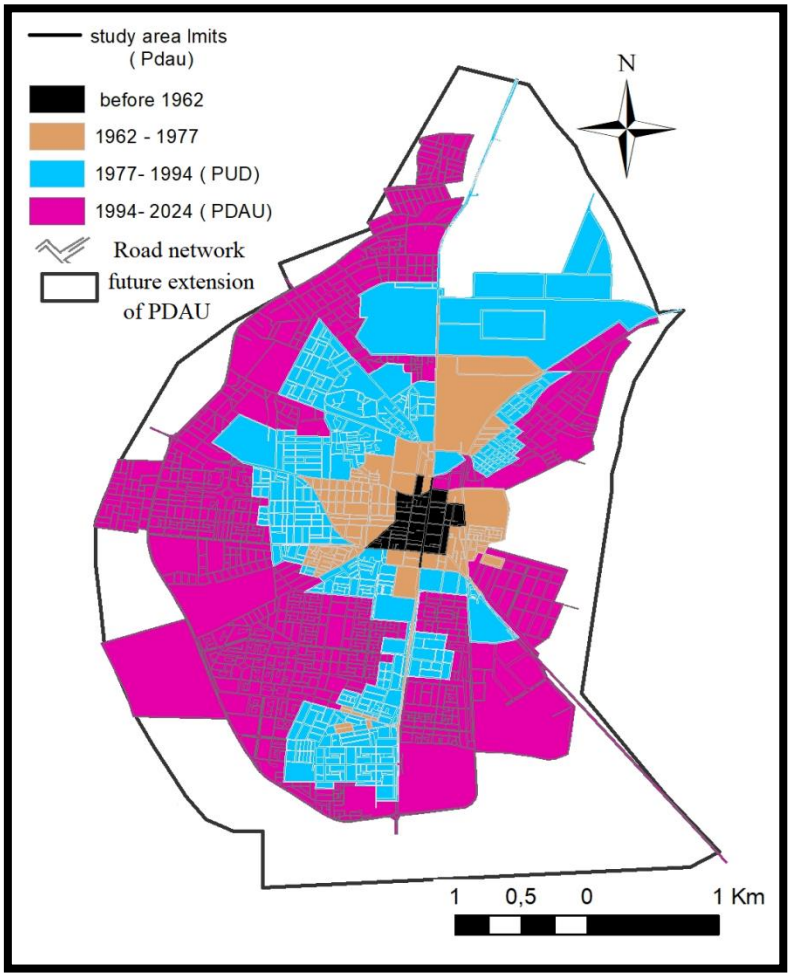

Fig 2: urban policy in Ain M'lila city and its spatial development

Source: Prepared by the researchers based on:

- Map of colonial core of Ain M'lila city [20]
- The urban master urban plan 1977.
- revision of the master plan for preparation and reconstruction of Ain M'lila city 2004
- fieldwork, 2022.

- **Urban policy between 1977 and 1991**: application of Urban Master Plan (PUD) :

In response to the worsening urban issues in the city of Ain M'lila, including the housing crisis, inadequate public facilities and services, and unregulated construction on the city's outskirts, which encroached upon valuable agricultural lands, the city received the first urban study with

the implementation responsibility entrusted to the National Fund for Urban Development, Constantine Regional Branch CADAT.

As result, the urban expansion during this period was characterized by a notable emphasis on planning and organization. It was primarily characterized by the adoption of a semi-circular model on the western side, which incorporated a diverse range of housing types including both individual and collective units.

- **Urban policy between 1991 and 2024:** period of Master Plans for Preparation and Reconstruction PDAU.

The city of Ain M'lila benefited from the first master plan for preparation and reconstruction (1994). It replaced the urban master plan. it sets out basic principles that are different from those of the targeted urban master plan, which are mainly represented in the rationalization of the city's urban space use through the application of building and reconstruction laws.

The plan of 1994 did not achieve the set goals due to the rapid growth of the city. As a result, this review was undertaken with the aim of developing an effective long-term urban tool for the city. The revision of the master plan for preparation and reconstruction in 2004, which is still in effect,

The urban development of Ain M'lila during this phase was characterized by linear expansion on both sides of National Road N°. 03. However, it was particularly intensive on the western and northern sides. During this period, private contributions played a significant role in the urban development .

2.7. **Methods:**

To achieve the objectives of the study and verify the hypothesis that refers to the contribution of space syntax theory as a quantitative language in assessing the spatial development of the city of Ain M'lila, a descriptive-analytical approach was adopted, and a combination of software tools was used in this research, namely ArcGIS 10.8 and DepthMap© 10.

The research begins with identifying the urban policies (plans) that have been occurred in the city of Ain M'lila since independence by utilizing multiple sources of data, such as aerial imagery and maps obtained from various administrations…

As well as field surveys, subsequently, a database was created using ArcGIS 10.8software to document the evolution of the city's structure.

The maps were then exported to Depthmap©10 software in an appropriate format (DXF) for conversion and analysis. Among the space syntax analysis methods, the axial maps analysis is used.

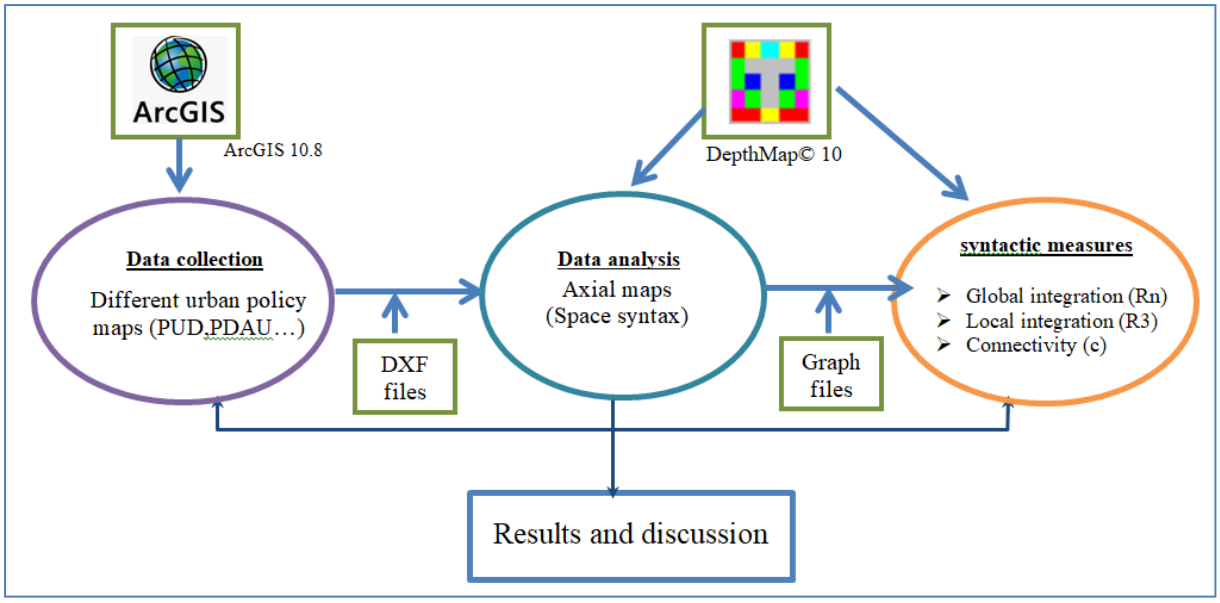

Fig 3: Flowchart of the methodology for assessing the urban policies of the City of Ain M'lila.

Different axial maps show a gradient of colours ranging from blue to red, indicating the areas from most segregated /disconnected to most integrated /connected respectively.

According the axial maps analyses, which include quantitative measures such as global integration (Rn), local integration (R3) and connectivity (C) we formed table 1 as follow:

Table 1: Summary table of syntactic measures during various urban policies in Ain m'lila city.

Urban policy	Global integration (Rn)			Local integration (R3)			Connectivity (C)		
	moy	min	max	moy	min	max	moy	min	max
Before 1962	1,89	1,12	3,52	2,03	1,22	3,75	4,30	2	16
1962-1977	1,50	0,68	2,53	2,59	0, 94	4,76	10,45	1	51
1977-1994 (PUD)	1,45	0,81	2,50	2,53	0,70	4,70	8,79	1	60
1994-2024 (PDAU)	1,45	0,64	2,50	2,74	0,70	5 ,13	10,24	1	97

3. Results and discussions:

The axial maps of Ain M'lila's urban polcies were generated using the DepthMap© 10 software. Once the syntactic properties were calculated, Depthmap assigns a color range from blue (low values) to red (high values).

3.1. Urban policy in Ain M'lila city before independence:

Fig 4(a) represents the axial map of Ain M'lila city before independence, using the measure of global integration (Rn). The results indicate that the values range from 3.52 for the most integrated axes to 1.12 for the least integrated spaces, with an average value of 1.89. The most integrated axe is (X1) which parallels road to National Highway 3 (X2) marked in red, which separates the colonial structures from the residential area. It is worth noting that this area witnessed the first public facilities being established in the city of Ain M'lila, part of the city represents urban centrality (colonial nucleus).

The results remain consistent regardless of local integration (R3), as the axe (X1) maintains its position as the most locally integrated space during this period, with values ranging between 3.75 and 1.22 for the larger spaces, Fig 4(b).

Meanwhile Fig 4(c) and Table 1 show that the values of connectivity range from 2.16 for the most connected spaces to 2 for the least connected spaces, with an average of 4.30. This aligns with the length of the axis and the degree of usage correlation. The axis (X1) remains the most connected space in the city due to the urban policy during this period.

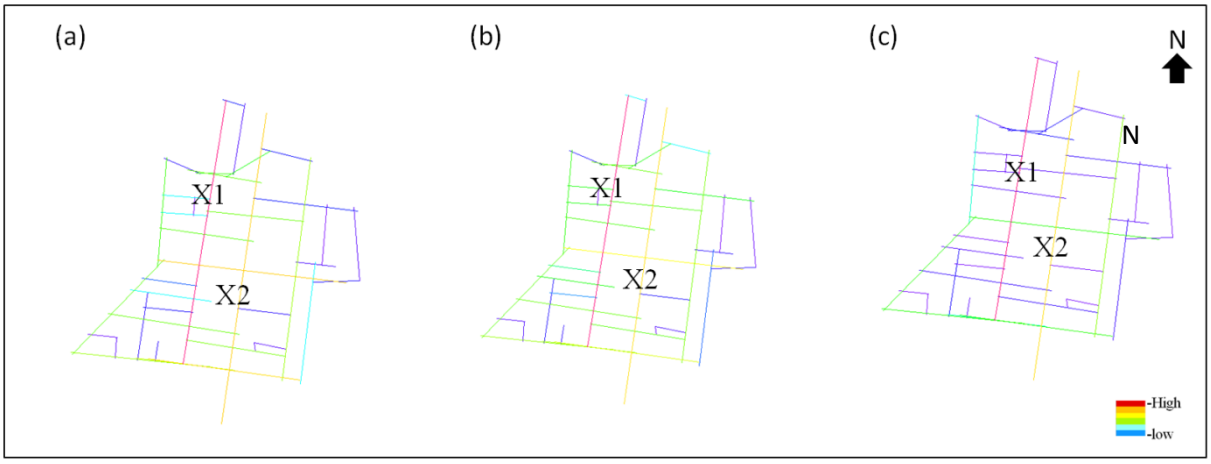

Fig 4: Axial Maps : (a) global integration (Rn), (b) local integration (R3) and (c) connectivity in Ain M'lila city before independence, (Depthmap©10). Source: authors, 2024.

3.2. Urban policy in Ain M'lila city after independence (1962-1977):

The quantitative results of the global integration, as shown in Table 1 range from 0,69 to 2,53 with a decrease in the enclosed area compared to the previous period. This is due to the emergence of new axes resulting from urban policy after independence related to the extension of colonial core. Additionally, a prominent network with a blue color indicates the presence of secluded spaces with less integration into the urban fabric of the city, particularly in the eastern,

southern, and southwestern parts of the city. These areas consist of neighborhoods that formed in a chaotic manner in the period immediately following independence.

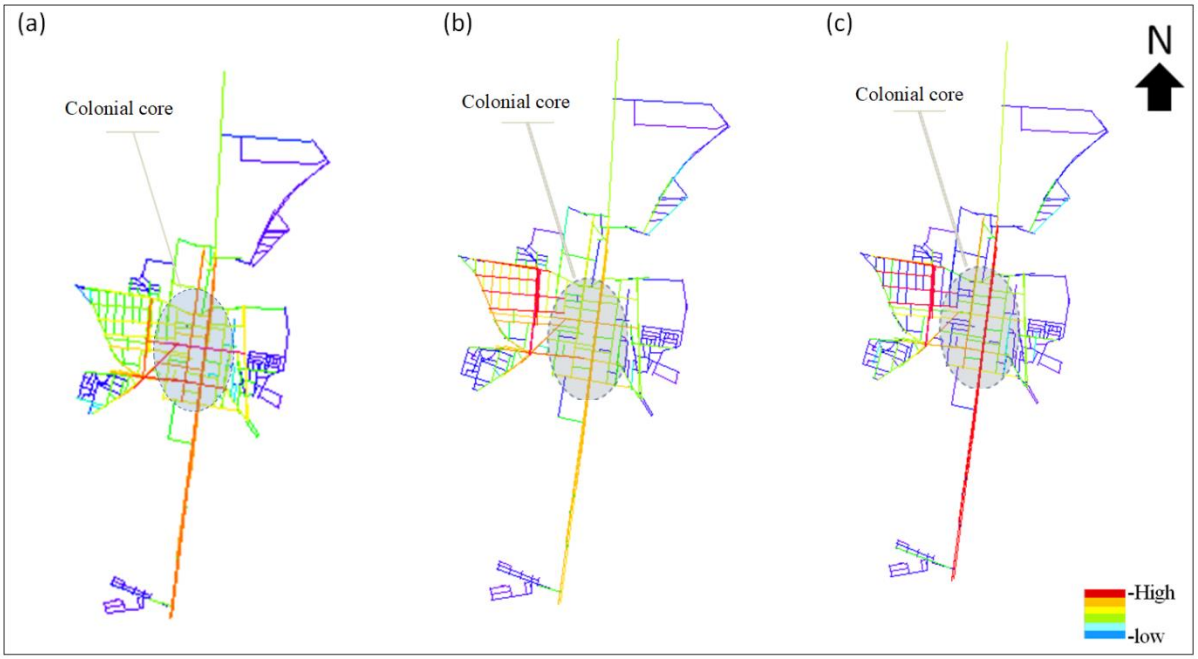

Fig 5: Axial Maps : (a) global integration (Rn), (b) local integration (R3) and (c) connectivity in Ain M'lila city 1962-1977, (Depthmap©10). Source: authors, 2024.

As for the values of local integration (R3), they range between 4.76 as the maximum value for the most integrated areas and 0.94 for the secluded areas, (table 1). There is a difference in the concentration of the red network compared to the global integration, with the more integrated areas located in the western part of the city, specifically in the downtown area fig 5 (b). This can be attributed to the urban policy and organized division of these areas, connecting them harmoniously with the surrounding spaces. Meanwhile, the neighborhoods continue to suffer from marginalization, which explains the difference in the lower and upper boundaries of the local integration values compared to the previous period.

Fig 5 (c) represents the axial map of connectivity in the city of Ain M'lila during this period, where the value of the most connected areas nearly tripled. The highest values of connectivity are concentrated predominantly in the colonial nucleus, represented by the color red, and decrease as we move away from it towards the surrounding areas of the city. This is in line with spatial growth, where the rate of connectivity takes on its lowest values in those areas.

3.3. Urban policy in Ain M'lila city by the PUD (1977-1994):

Through the axial map of fig 6(a) and Table 1, it can be observed that the boundaries of the global integration range from 0,81 to 02,50, indicating the dominance of the red color in the colonial core network (), reflecting the centrality of this space, gradually decreasing towards the periphery where the presence of the blue color indicates less integration.

There have been changes in local integration (R3). However, significant local integration can be observed in the municipal neighbourhood, Belle vue "inferieur", indicating apparition of secondary centrality within the city as shown fig 6(b).

Regarding the connectivity map of the implemented urban policy during this period, several areas suffering from poor connectivity can be observed, especially within the neighborhoods, which inevitably affects their integration into the urban fabric. The eastern part of the city remains less connected (in neighbourhood: Khonfri and Regaizi) due to the presence of the railway as a constraint on spatial development. fig 6(c).

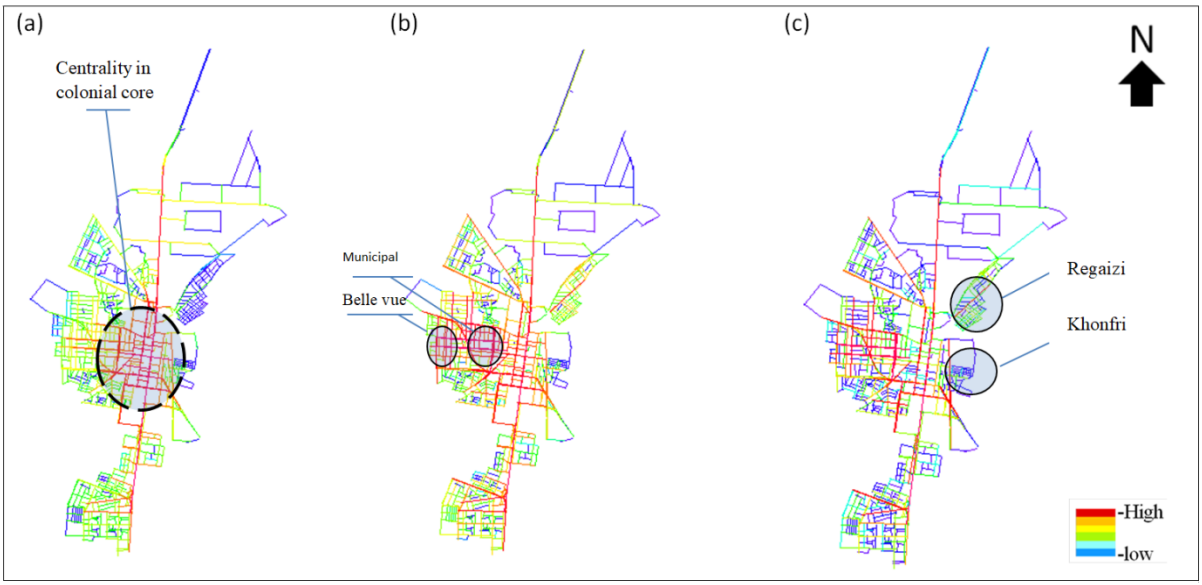

Fig 6: Axial Maps : (a) global integration (Rn), (b) local integration (R3) and (c) connectivity in Ain M'lila city of PUD, (Depthmap©10). Source: authors, 2024.

3.4. Urban policy in Ain M'lila city by the PDAU (1994-2024):

The axial map of global integration (Rn), fig 7(a), shows an expansion in the red network, indicating increased integration in the southern and western areas, and to a lesser extent, the eastern part of the city, significantly, the blue color prominently emerges in the neighborhoods surrounding the city, such as the following neighborhoods: Mazouz, El Hanaa, and Essaada, ZAD. These regions consist of individual housing (sleeping quarters), and their low integration values of 0.81 indicate its seclusion.

Regarding local integration (R3), we observe a convergence in the results with the global integration of the city, indicating expansion in the most integrated areas, adjacent to the previous period's expansions, and the emergence of seclusion areas in the surrounding neighborhoods (Rn) , fig 7 (b).

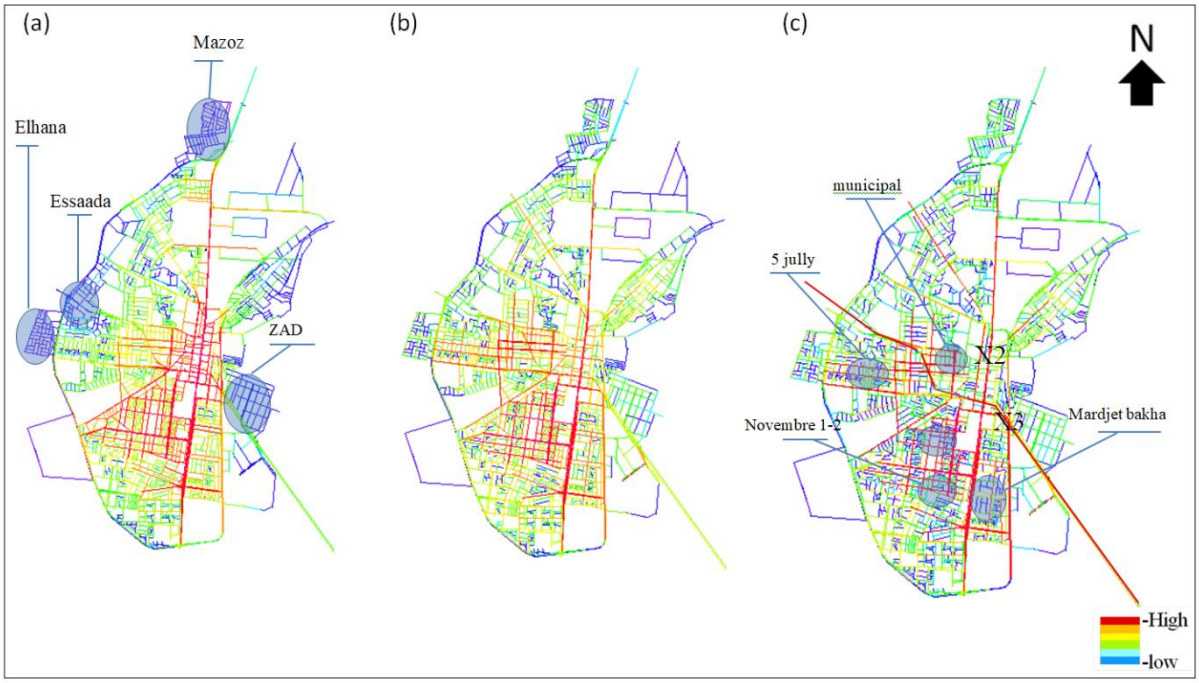

Fig 7: Axial Maps : (a) global integration (Rn), (b) local integration (R3) and (c) connectivity in Ain M'lila city of PDAU, (Depthmap©10). Source: authors, 2024.

Furthermore, from fig 7(c), which represents the axial map of connectivity, and Table 1, we can observe an increase in the global average value compared to the previous period, reaching 10.24. This corresponds to the spatial expansions that occurred during this period, along with a higher upper value of 97, explaining the rapid spatial development in the city. The red color is concentrated in the central areas of the city, such as the the neighborhoods: Municipal, Belle vue, 5 July, November 1-2, and Mardjat Bkha. These areas are located along National Road No.3 (X2) and National Road No.100 (X3), providing easy accessibility. In contrast, the surrounding neighborhoods, represented by the blue color, exhibit lower connectivity rates, and these areas formed secondary centrality in the city.

4. Conclusion:

The urban policies implemented by the city of Ain M'lila have allowed for its spatial development in all directions, particularly through the creation of several neighborhoods, especially in the western part of the city, such as: municipal, 5 July, Esaada, and Elhana. The Space Syntax theory as a scientific approach was employed in this research, using the DepthMap© 10 software, aimed to evaluate various urban policies in the city of Ain M'lila. The study relied on axial maps resulting from quantitative analysis. Based on the results, we concluded that:

- The colonial core of Ain M'lila maintained its importance due to easy access and interconnected axes, as well as its chess layout that facilitated its expansion. Additionally, it contains a significant proportion of facilities and amenities.

- The global integration value of the city has declined as a result of the expansions it has undergone, specifically the expansion of the colonial core in all directions, particularly during the

PDAU period. There has been a continuous increase in the establishment of connectivity resulting from the creation of various axes that have followed regular forms.

- These expansions, along with the urban plans and policies, have led to the centralization of the city's core. Secondary centralities exist in the adjacent and existing expansions along the two national roads 100 and 3. This has created marginalized and isolated areas, especially in the surrounding areas of the city, indicating a lack of clear policies or a failure to create a balance and integrate the new areas into the city.

Therefore, it is necessary to establish policies that deal with all the spaces of the city as whole and not as separate parts, and to utilize modern techniques such as the space syntax program.

This indicates the existence of an urban policy imbalance, especially considering the lack of public facilities in these neighborhoods. Meanwhile, the more integrated areas are concentrated in the central areas of the city, extending primarily from the colonial core and the surrounding neighborhood expansions. These areas have easy access and are characterized by the concentration of public amenities, so space syntax provides an effective quantitative indicator for analyzing and exploring the urban policies and spatial development of cities as well as many issues, such as urban safety, mobility, urban centralities, and even environmental issues. The modeling results of urban spaces using this method can be compared and combined with different variables to assess the strength of their correlations.

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