Urban Planning and Development

DOI: 10.23968/2500-0055-2023-8-3-77-91

ANALYSIS OF URBAN TRANSFORMATIONS AND THEIR IMPACT ON THE COLONIAL URBAN FABRIC IN DJELFA (ALGERIA) USING SPACE SYNTAX TECHNIQUE

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Abstract

Introduction: The paper examines the urban transformations that Djelfa underwent over time, from its colonial inception to the present day, characterized by rapid demographic and urban growth as well as excessive consumption of urban space. **Purpose of the study:** We aimed to study the urban transformations of the city of Djelfa over time, provide a quantitative description of the urban and social characteristics that shape the built environment, and identify the city's most integrated (easily accessible) and secluded areas. **Methods:** We utilized the spatial syntax technique to analyze the stages of city development, which is based on modeling city maps into axial maps and quantitatively measuring various factors such as connectivity and integration (Rn). **Results:** We obtained significant results notably that the historical city center still maintains its importance in terms of easy access, interconnected axes, and chess layout that facilitated its expansion. Additionally, residential neighborhoods, isolated from the rest of the city, emerged at certain periods. Restructuring operations, such as the opening of Mohamed Boudiaf Square in the city center, contributed to increasing connectivity with its neighboring axes.

Keywords: Urban transformation, colonial city, spatial syntax, Djelfa, connectivity, integration.

Introduction

The city is the most complex urban pattern created by human thought, with distinct characteristics and features that define its historical identity as well as its social and cultural heritage. According to Kevin Lynch, The city may be looked on as a story, a pattern of relations between human groups, a production and distribution space, a field of physical force, a set of linked decisions, or an arena of conflict. Values are embedded in these metaphors: historic continuity, stable equilibrium, productive efficiency, capable decision and management, maximum interaction, or the progress of political struggle. Certain actors become the decisive elements of transformation in each view: political leaders, families and ethnic groups, major investors, the technicians of transport, the decision elite, the revolutionary classes (Lynch, 2008).

Intellectuals and historians have long considered the city to be an important field of scientific research for its social, economic, cultural, and political functions.

In this study, we will attempt to analyze the city of Djelfa at different time points, relying on Djelfa's population and housing statistics. In order to align the available demographic data with the urban transformations in Djelfa, we can rely on decennial census conducted to systematically acquire, record, and calculate population information. The United Nations (UN) defines the essential features of population and housing censuses as "individual enumeration, universality within a defined territory, simultaneity and defined periodicity", and recommends that population censuses be taken at least every ten years (UN Department of Economic and Social Affairs Statistics Division, 2008). We relied on these statistics as reference points in time to study the transformations that the city of Djelfa underwent. The delay in the last census was due to political reasons experienced by Algeria. However, we collected population and geographical data for the last period through our own sources (study offices). We utilized the Space Syntax technique to analyze the influence of the spatial structure on human behavior and economic movement within the system. Our goal was to answer the following question: What is the effect of these urban transformations on the urban fabric of Djelfa, with its colonial core?

To answer the question, we relied on two assumptions: that urbanization has affected the spatial structure of the city of Djelfa in terms of morphology and functionality, and that the spatial structure of the old urban fabric (colonial) has contributed to the city's modern morphological formation.

Materials and methods

Space Syntax

Space Syntax is a novel computational language proposed to describe the spatial patterns of contemporary cities. Syntax is a linguistic concept that refers to the relationships between different elements or the interactions between space and society. Urban planners can gain a better understanding of urban development and gather more ideas to help design new urban schemes by conducting structural analyses of the urban environment.

The patterns of human movement in the city can be analyzed using Space Syntax principles, primarily by considering the degree of integration and interconnectedness of urban spaces (El-Agouri, 2004). Bill Hillier and other researchers at the Bartlett Faculty of the Built Environment at University College London developed space syntax in the late 1970s and early 1980s as a morphological approach to the urban and social development of major British cities of the time. It then rapidly evolved during the 1980s and 1990s (Hillier, 1996) developing into a method to analyze the spatial formations of architectural objects and urban areas through the interpretation of social behavior, using various theories and techniques that resulted in several interpretative models of numerous social and spatial phenomena. Examples include social segregation, crime, business location, activities, and urban mobility (Hillier, 2005). In his paper, Hillier (1999) emphasizes this point and contends that if the spatial complexity variable cannot be controlled, its effects and consequences cannot be measured. In fact, urban research using the Space Syntax approach aims to bridge this gap by first addressing the problem of description, namely, how to accurately and consistently describe the physical complexity of the city in order to use it as a variable.

Space Syntax studies the composition of road networks and spaces across cities, analyzing the resulting attraction or separation characteristics that significantly impact the distribution of activities as well as users' behavior and, more specifically, mobility. Using modeling tools developed by the Space Syntax Laboratory (SSL), this composition can be compared to various statistical variables. It enables the assessment of the strength of its association with different factors, such as pedestrian and vehicle flows, property value, distribution of activities, and even crime (Perrin, 2001a). Space syntax theory offers useful tools to understand the logic of configurations through its engagement with social structure (Rahmane and Abbaoui, 2021).

They are used in land use planning, city planning, and transportation. Its scope has expanded in recent years to include archaeology, urban and human geography, as well as anthropology and the environment (Perrin, 2001b). Typical applications of space syntax include pedestrian modeling, urban crime mapping, road-finding processes in complex built environments, and analysis of other hidden spatial and social dimensions in the built environment. All these investigations tend to be based on the assumption that spatial patterns or structures have a significant impact on human activities and behavior in urban environments. Several empirical studies demonstrated the importance of spatial syntax for modeling and understanding urban patterns and structures (El-Agouri, 2004).

The space syntax technology has been used in numerous research projects. Hanson described the social and cultural implications of various plans to rebuild London (Hanson, 1989). In 1989, Miller used spatial syntax as a tool in the urban renewal process in Swedish cities (Miller, 1989). In the same year, Hillier and others attempted to predict spatial patterns of crime in urban areas. In 1984, Hillier and Hanson published a book entitled "The Social Logic of Space", which addressed the impact of spatial formation on social life and vice versa. The theory demonstrated how the arrangement of spaces influences users' behavior, thus determining the efficiency and suitability of the design for the activity (Elporolosy and Elfalafly, 2020). Peponis and colleagues investigated the functional role of building morphological structure (Peponis, 1993). In 1989, Mills demonstrated how the spatial structure of towns functions as a controlling mechanism for apartheid ideology (Mills, 1989). Besides, the relationship between urban morphology and movement patterns (primarily related to pedestrians) was extensively studied (Teklenburg et al., 1993).

Study area

The mandate of Djelfa, resulting from the 1974 administrative division, is located in the central part of northern Algeria, south of Algiers, between latitudes 33° 35' and 36° 12' north and longitudes 2° and 5° east. It is located in the center of the steppe highlands and covers a vast area of 32,362 km2, which is equivalent to 1.36% of Algeria's total area.

The Djelfa province occupies land stretching from north to south for more than 300 km, while its maximum width from east to west is only 150 km. This vast area borders nine other provinces: Medea and Tissemsilt in the north; M'sila and Biskra in the east; Ouargla and El Oued in the southeast; Laghouat and Ghardaia in the southwest; and Tiaret in the west.

Djelfa city's urban development

Colonialism is regarded as a mainly regional phenomenon because colonized societies needed space, raw materials, labor force, manufacturers, and consumers. Consequently, colonial cities were established in specific locations, such as transit areas or strategic zones. The primary objective of these cities was to oversee and control the respective

territories. During the first years of the colonization of Algeria, the colonizers established a network of cities in specific regions. The French policy aimed to secure the regions, attract European settlers, and establish the center of power. The colonial cities in Algeria were designed to recreate what existed in Europe at the beginning of the 19th century: a chess layout and the image of a Roman city (Amokrane, 2016). All of the old centers are characterized by a high density of buildings lined up along the streets and around the squares and monuments, and the lands are frequently of a special legal nature. However, the focus is on the square, which typically includes three elements commonly seen in French villages: the school, the town hall, and the monument. In this regard, Malverti stated that the colonial city centers are military cities, whose mission is to house the military forces, after which the urban neighborhood is planned (Malverti & Picard, 1988). Vacher (1997) defines the colonial city as a chessboard of straight streets, which delineate a group of land plots, often square in shape, in the city center, some of which are removed to make way for the most significant structures: the church, the town hall, the homes of merchants, and the wealthiest settlers (Vacher, 1997).

Djelfa's urban development has gone through several stages over time to give us the city we see today (Fig. 1). The city of Djelfa has a colonial origin (1852–1962), and its ancient nucleus serves as the center from which various expansions were launched. This occurred particularly after the demolition of the perimeter protective fence in 1960. As a result, the city expanded along the axis of National Road 1, which has remained one of the city's important spatial axes. This urban development has followed the same pattern as the ancient perpendicular nucleus, despite the emergence of other structured axes in subsequent periods of time, such as the National Road 46 axis east of the Mellah valley and the Ben M'hidi axis in the west. Algeria was subjected to French colonization from July 5, 1830, to July 5, 1962.

Digital modeling of Djelfa City

After finishing the urban schemes for each period with XDF extension, we converted these schemes into axial maps, which are defined as the minimum set of axial lines passing through each convex area (Turner et al., 2005). Depth is the measure of the shortest path from a specific root line to all other lines in the system (Turner, 2004). Let us perform an axial analysis with DepthmapX of the latest version 0.8.0, examining the most important metrics in this type of analysis (global and local measures) to accurately identify the transformations that have affected the spatial structure and their effects.

Depth Map is a multi-platform software developed to perform multiple spatial network analyses in order to explore the complexity of social behavior in a given built environment (Fareh and Alkama, 2022). After modeling and conducting complex calculations, the DepthmapX program utilizes the color spectrum of the spatial system axes to measure the strength or weakness of the factor. The colors used for this purpose are red, orange, yellow, green, light blue, and dark blue, representing varying levels of strength or weakness. The colors symbolize very strong, relatively strong, above average, medium, weak, and very weak relationships, respectively.

Due to the length of these studies and the time required to work on them, the visual and convex analysis of the Djelfa city will be the subject of future research.

Results and discussions

Connectivity

The value of connectivity is measured by the number of axes that are directly connected to each individual axis in the urban system, and an increase in the number of axes that are directly connected to each other indicates the high mobility provided by the space. Sukor and Fisal (2020) stated that connectivity is an important attribute to ensure high-quality public transit.

Djelfa before 1962

The city of Djelfa had 86 axes in its spatial structure. The axes that showed high connectivity, indicated in red on the axial map of the Djelfa city using the connectivity index before 1962 as shown in Fig. 2, were a single axial line intersected by 16 axes. This particular axis is represented by National Road 1, which marked the starting point of the colonial nucleus. Its significance lies in being the only existing landmark and serving as the only axis facilitating continuous movement from north to south. The orange axis to the east is parallel to this axis, but it is shorter and has a connectivity value of 14. As we move further away from the main axis, the connectivity values gradually decrease.

Djelfa in the period between 1962 and 1977

The number of axes in Djelfa increased to 574 (more than 6.5 times), as indicated by the development of several neighborhoods stretching from the northwest to the southwest and northeast of the Mellah valley.

The results of calculating the connectivity values at the city level, as shown in Fig. 2, revealed that Khemisti Street (the borders of the old nucleus) in the south had the highest connectivity value at the city level, with a value of 24. This value increased from 11 before 1962. Additionally, the connectivity of the axis of National Road 1 was 19, also showing an increase from 16 before 1962.

The reason for this difference in growth is the city's expansion to the east and west rather than to the north and south. Khemisti Street benefited from this expansion because it runs east-west, resulting

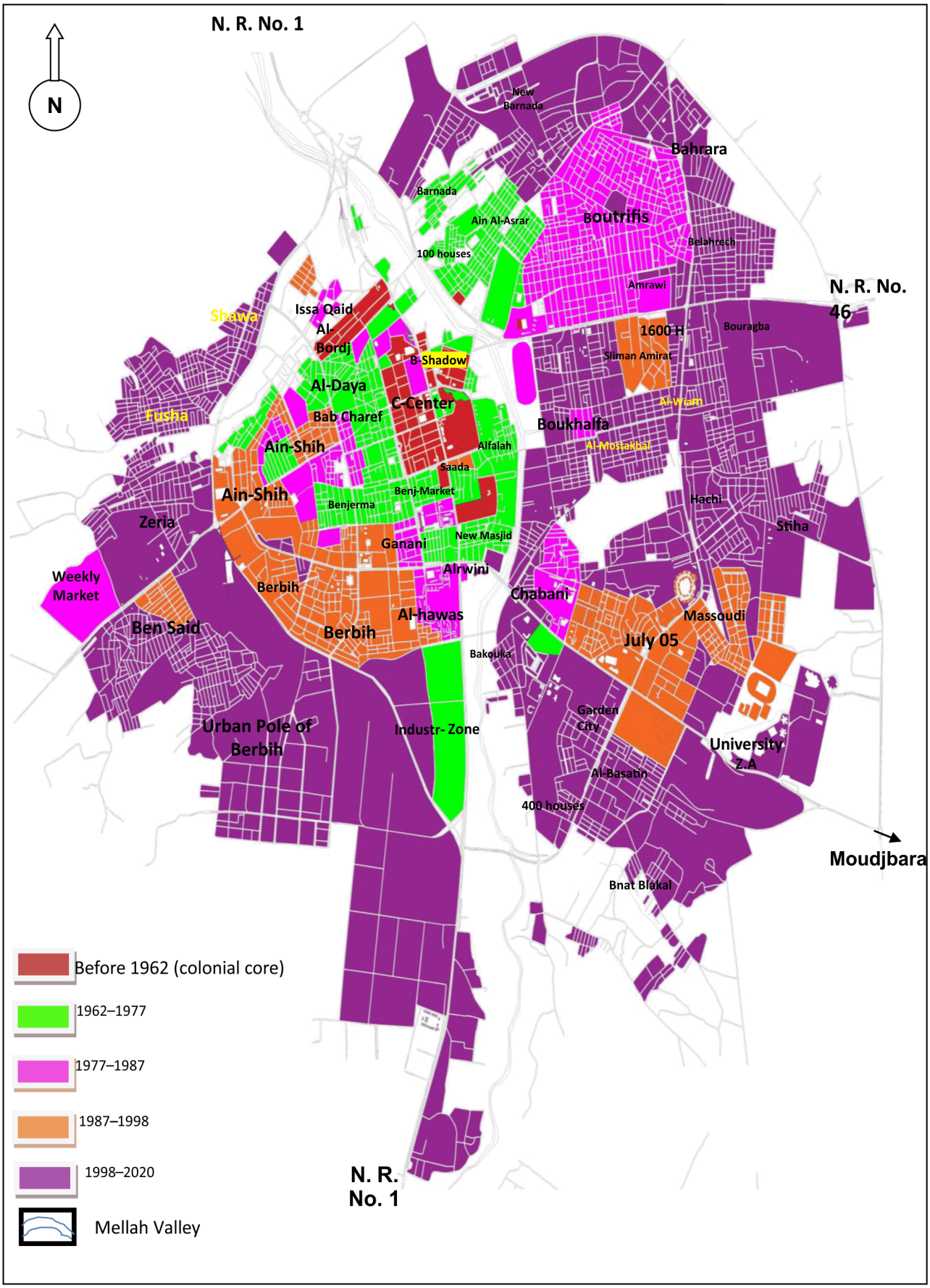

Fig. 1. Urban development of the city of Djelfa. Source: authors

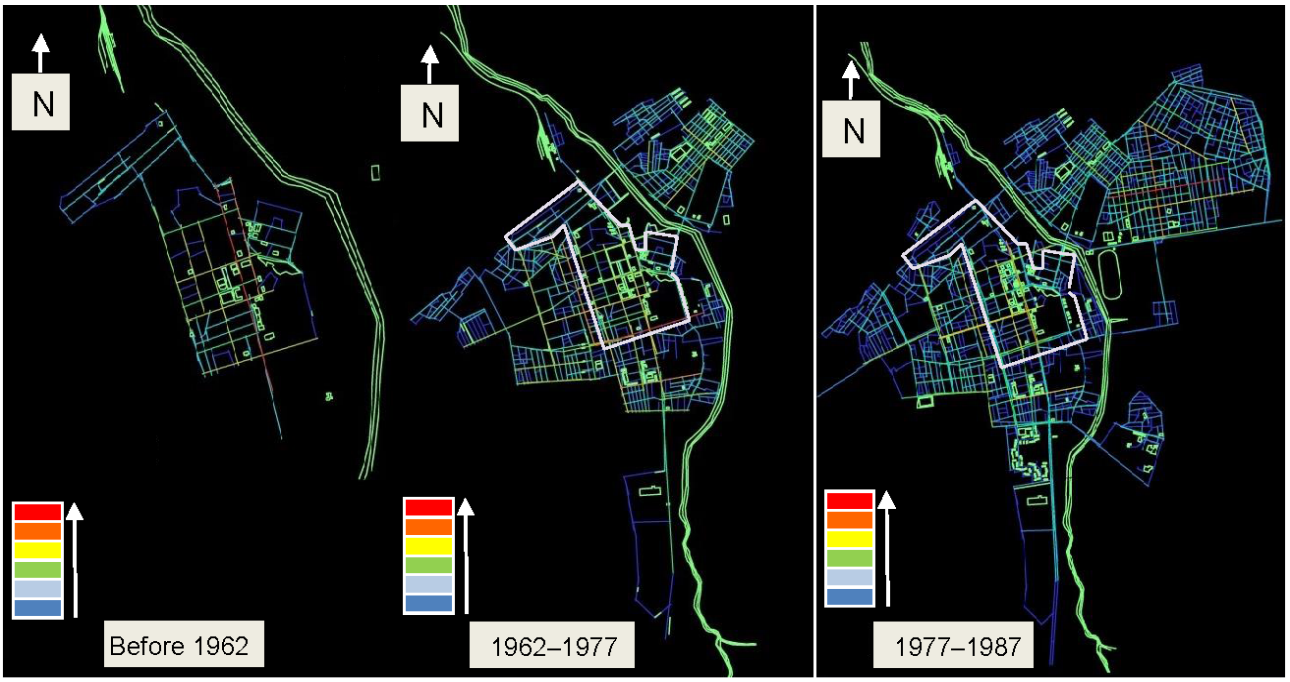

Fig. 2. Axial map of Djelfa before 1962, in 1962–1977, and in 1977–1987 (connectivity). Source: authors

in a higher number of intersecting axes and making it easily accessible from 24 streets that directly intersect it. The axial map, analyzed using the connectivity indicator, reveals that the old city center has most of the axes with high connectivity.

The new neighborhoods developed to the east of the Mellah valley demonstrate two perpendicular axes with the highest connectivity value. The intersection of these axes will later give rise to a significant commercial center in the area, known as the Al-Rahma Market.

Djelfa in the period between 1977 and 1987

The digital modeling of the Djelfa city for 1987 reveals some interesting findings. For the first time, the axis with the highest connectivity value shifted to the eastern side of the Mellah valley, specifically within the axes of the new expansions of the Boutrifis neighborhood. This axis has a connectivity value of 32, indicating its significant role in enhancing kinetic flexibility at this level. The axis that ranks second in terms of connectivity, with a value of 28, is perpendicular to it, and the axis that ranks third, with a value of 24, runs parallel to it at the system-wide level. These three axes with the highest connectivity index values, along with other axes with lower values, will help create the first nucleus of a secondary center for commercial activities in this neighborhood in the future.

The restructuring of the city center, along with the opening of Mohamed Boudiaf Square, considered the focal point of the vibrant city center, helped increase the values of the connectivity index of the adjacent axes, especially the northern axis (the AL-Ma'rad axis), which ends at the Sidi Nael axis. Its connectivity index increased from 14 to 20, making it one of the most important axes for movement and trade, connecting the city center with the previously somewhat isolated northern area.

The retreat of the Khemisti axis towards the south was a significant setback for the overall spatial system. This axis had a connection value of 24 in 1977, making it crucial in connecting different areas. However, it later became a less important axis with a connectivity value of 17. The reason behind this decline was the oversight in considering its continuity during the planning of new neighborhoods to the west. The end of the axis was blocked, which hindered its function of connecting sub-axes. This lack of connectivity weakened its fluidity and movement. That was a result of poor and random planning, with a lack of foresight.

Djelfa in the period between 1987 and 1998

This stage was distinguished by accelerated construction and the implementation of major housing programs, including:

- The establishment of a new urban residential area in the eastern part, represented by the July 05 district.
- The establishment of a new urban residential area in the western part, represented by the newly developed Ain Al-Shih neighborhood.
- Restructuring of Larbi Ben M'hidi Street by expanding it through the middle of the Ben Jerma neighborhood (demolition of about 200 m on both sides of the street) and extending it to the south to meet the Western bypass road (Algiers–Laghouat). Along with demolishing the western part of the Al-Bordj neighborhood to make way for Larbi Ben M'hidi

Street, the bypass road (Algiers–Laghouat) will be connected in its northern part.

The city of Djelfa experienced a significant expansion over a ten-year period, with the number of system axes increasing to 1801, which is about a third more than its original size. The axial map of the city, when analyzed using the connectivity indicator (Fig. 3), provides valuable insights into the changes in the city center, outskirts, and new neighborhoods, as well as the impact of urban interventions on the main axes.

The connectivity value of National Road 1 remains at 28, which is the highest in the city center and on the western side as a whole.

The axes of the old city center remained unchanged in their high or medium values from the previous period. As a result, both the center and the surrounding area were fully developed without any urban interventions that could disrupt the interconnectedness of the axes. It should be noted that the axis of the AL-Dhil AL-Jamil neighborhood in the city center did not witness any intervention made to enhance its connectivity and therefore keep up with the other axes in the city center.

The digital modeling of the Larbi Ben M'hidi axis revealed that it consists of a series of straight axes connected to form a circular line. The longest straight axis is 818.6 m long and has a correlation value of 21 (orange). It ranks second in terms of importance for the spatial network of the city. This area is where commercial activities are concentrated, providing kinetic fluidity and intersecting with the largest number of sub-axes. This relieves the pressure on the city center and facilitates travel from the center to the north and south of the city. The expansion in the south transformed the Ganani–Ben Jerma axis, which intersects it, into one of the most important axes with a value of 24. Despite having one blind end, this axis saw the flourishing of commercial activities and services. It includes a school for blind children, a municipal playground, and a court headquarters. It also intersects an important axis with a connectivity value 23, of which is the axis of the Ben Jerma market. This market is the heart of the western-south region, attracting movement and providing easy access from the side streets, thus reducing pressure on the old city center. The new urban residential area in the eastern part, represented by the July 05 district, seems to be an isolated block within the city. Most of the axes in this area have low connectivity (dark blue and light blue), making it difficult to move around. As a result, this area experienced significant isolation and became a predominantly residential area. The lack of axes with high connectivity and the collective housing character contribute to this isolation. However, there is a bridge across the Mellah valley that connects this area to the rest of the city.

The Boutrifis neighborhood continues to have the axis with the highest connectivity value (32), along with the previously mentioned axes. However, it is worth noting that the crossroads axis (horse racing area) is starting to emerge towards Bou Saada with a connectivity index value of 15. This is due to the construction activities in the area south of it, including the establishment of a neighborhood with 1600 housing units and the development of the first nucleus of the Boukhalfa neighborhood. Additionally, sub-axes are being opened that lead to this axis. In the future, this axis will undergo a transformation and will become the most important axis in connecting the Boutrifis neighborhood with the future neighborhoods due to its length, straightness, and central location among these neighborhoods.

Djelfa in the period between 1998 and 2020

The number of axes in this period increased to 4036, which is more than double the previous amount. The maximum value of the connectivity index at the system level is 32, and the minimum is 1, which is consistent with the values from the previous period. In addition, the average connectivity in the city's spatial system is 5.1, which is considered high given the size of the city. That is, on average, each axis in the spatial system is intersected by five other axes, indicating good kinetic fluidity in the city and providing the user with an average of five choices in their movements within the city.

When examining the axial map and the connectivity index values of the city of Djelfa during this period (Fig. 3), several noteworthy observations come to light. Firstly, the axes of the city center maintained their significance and even increased their values due to their connection with important axes in the new expansions. This facilitated easy access to the city center from different directions and enabled comfortable outward expansion towards the borders of the Mellah valley to the east and the Larbi Ben M'hidi axis to the west. Moreover, within this space, the facades of the sub-streets underwent transformations, giving rise to diverse commercial and service fronts. However, it is important to note that certain neighborhoods lack the presence of interconnected axes, resulting in a higher degree of privacy. One such example is the old tower neighborhood located north of the old city center. Built by local residents during the colonial period, it possesses a distinct character that prevented its streets from turning into bustling commercial areas, despite its proximity to the city center. Additionally, this neighborhood did not benefit from restructuring programs aimed at integrating it into the city center's activities.

The new neighborhoods that emerged on the far-western side of the city resemble a cord extending from the northwest to the southwest, following the path of the Western bypass road (Algiers–Laghouat). These neighborhoods include Hay Al-Sha'wa, Al-Fusha, Al-Zariah, Ben Said, and the Urban Pole of

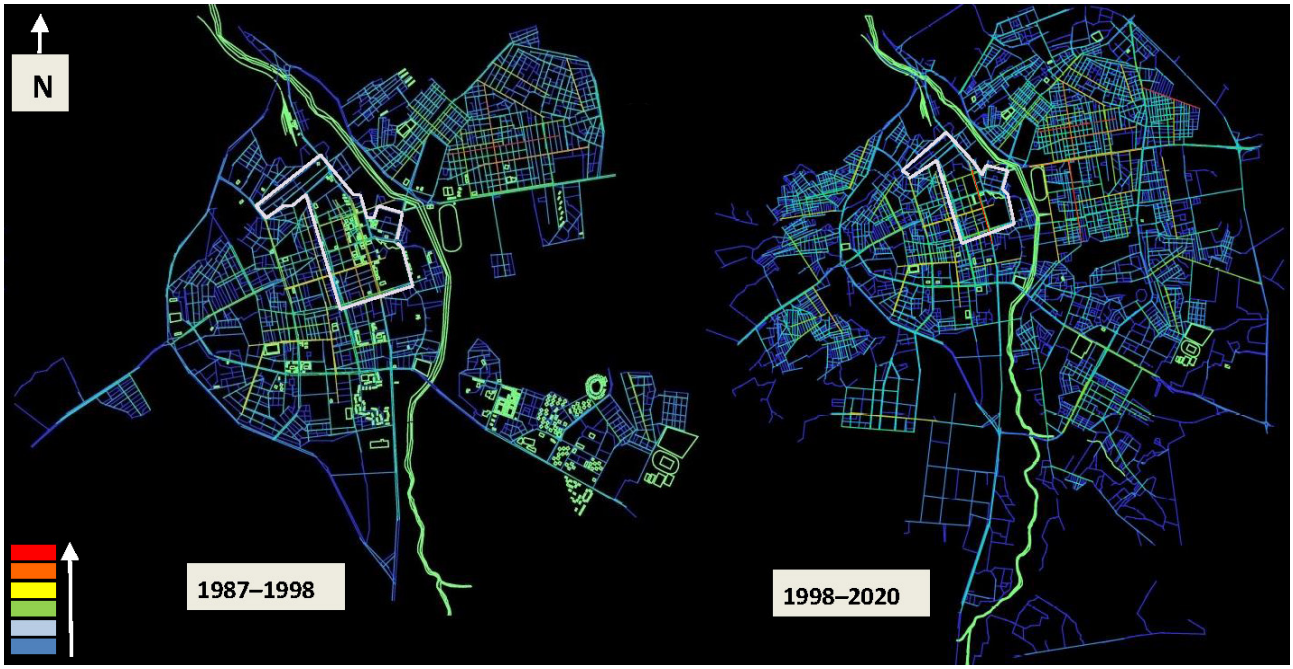

Fig. 3. Axial map of Djelfa in 1987–1998 and in 1998–2020 (connectivity). Source: authors

Berbih. These neighborhoods have a gradient in color and therefore differ in connectivity values. The axes with the highest connectivity values represent important axes within the neighborhood, where many streets converge. These axes provide kinetic fluidity as they represent public spaces within these neighborhoods. Next, there are less interconnected axes, which represent semi-public spaces. Finally, there are those axes that represent semi-private and private spaces within these neighborhoods. Since these areas are primarily residential, the number of axes with high connectivity values within one neighborhood is limited. Regarding the planned territorial divisions that were established in the mid-1990s, the main axis is located in the middle of the neighborhood. Numerous sub-axes branch out from it, creating a sense of balance within the neighborhood. This is in contrast to the illegal neighborhoods of Al-Fusha, Al-Zariah, and Ben Said, which grew and developed unnoticed by the authorities. Their status was later settled under the law of 08/15. These neighborhoods were planned spontaneously, with privacy in mind, leaving the important hubs on their borders impermeable to their fabric. Then the new pole emerged in Berbih, which was a planned residential neighborhood. It should be noted that the most significant axis situated in this neighborhood has a connectivity value of 21. This important axis is located in the middle of the neighborhood and extends from east to west. A large part of collective housing adjacent to it does not face it, and there are no ground-floor shops that benefit from the significance of this axis. The exception being a few shops located in its far west. This important axis, which provides good mobility, has not been utilized up to now and will not be utilized in the future due to the type of housing adjacent to it (collective housing). It is impossible to open shops at its level. This axis, which would have represented a commercial pole, attracts various commercial and service activities and saves the residents the trouble of traveling long distances. This reduces the need for mechanical transportation, which in turn minimizes energy waste and decreases air pollution.

The emergence of significant shifts in the spatial structure of the eastern side, particularly in the new neighborhoods, can be observed. The spatial axes of these neighborhoods follow the same planning and direction as the axes of the Boutrifis neighborhood. These neighborhoods were planned as public plots designated for individual private housing. This planning facilitated the formation of several important axes within the heart of these neighborhoods. They are characterized by high connectivity, and the biggest beneficiary of these planned expansions is the axis of National Road 46. Its connectivity value increased from 15 in the period of 1987–1998 to 27 in this period because it benefited from 12 new axes that intersect it. As a result, it became an important link between the city center and such neighborhoods as Boutrifis, Boukhalfa, Al-Mostakbal, Suleiman Omairat, Al-Wiam, Hashi, and Bahrara. This is due to the significant kinetic fluidity that it provides.

Global Integration Index (Rn)

Djelfa before 1962

The axial map that represents the global integration index for the city of Djelfa before independence (Fig. 4) shows that most of the axes

of the colonial core, which represent the streets where the colonists lived, are axes with high integration values. Where the axis colors range from red to orange to yellow to green, these are the streets that represent the axes that can be reached with the fewest number of steps. It is clear that the areas with low integration, which can only be reached with the greatest number of steps, appear isolated from the rest of the urban fabric. The axes that appear on the map in dark blue are axes located in the Al-Bordj neighborhood, which is inhabited by locals. A distinction between the residents of these neighborhoods is observed. The average global integration of the spatial structure of the urban fabric is 1.35, indicating a high level of integration. The National Road 1 axis has the highest integration value of 2.38, while the Al-Bordj district's sub-axis has the lowest value of 0.67.

Djelfa in the period between 1962 and 1977

The average global integration is 1.14, indicating a high level of integration within the spatial system as a whole. However, this value slightly decreased compared to the period before independence (1.35). This decline resulted from the city's expansion beyond the boundaries of the initial colonial core and the development of eastern and western neighborhoods in the Mellah Valley. The axial map displaying the global integration index (Rn) for the city of Djelfa (Fig. 5) shows that the areas exhibiting high integration, represented by red, orange, and yellow colors, are primarily located in the city center. This leads to the conclusion that the historical city center remained unaffected by the expansions, maintaining its prominence. Notably, axes such as the Emir Abdelkader axis, the AL-Ma'rad axis, the Sidi Nael axis, the city center–Bab Al-Charef axis, and the old post office–Ben Jerma axis, all appear in red. These axes denote the commercial and kinetic significance of the city center in relation to the outskirts. In contrast, the new neighborhoods on the outskirts of the city are depicted in blue due to their lack of global integration. This indicates their great depth, which makes it difficult to access them from other areas, particularly the Zahaf neighborhood, 100 houses, and the northern part of the old Ain Al-Shih neighborhood.

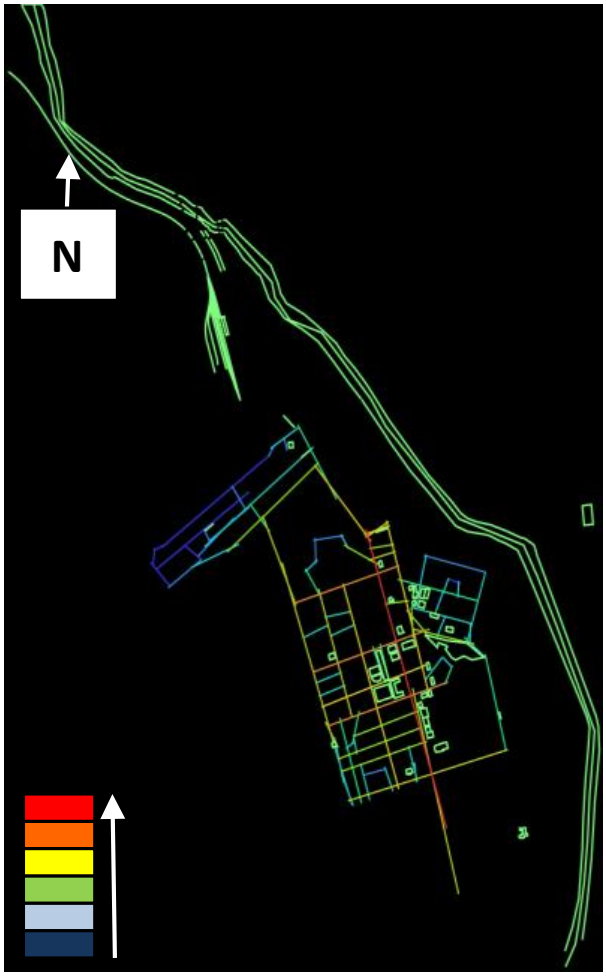

Fig. 4. Axial map of Djelfa before 1962 (global integration (Rn)). Source: authors

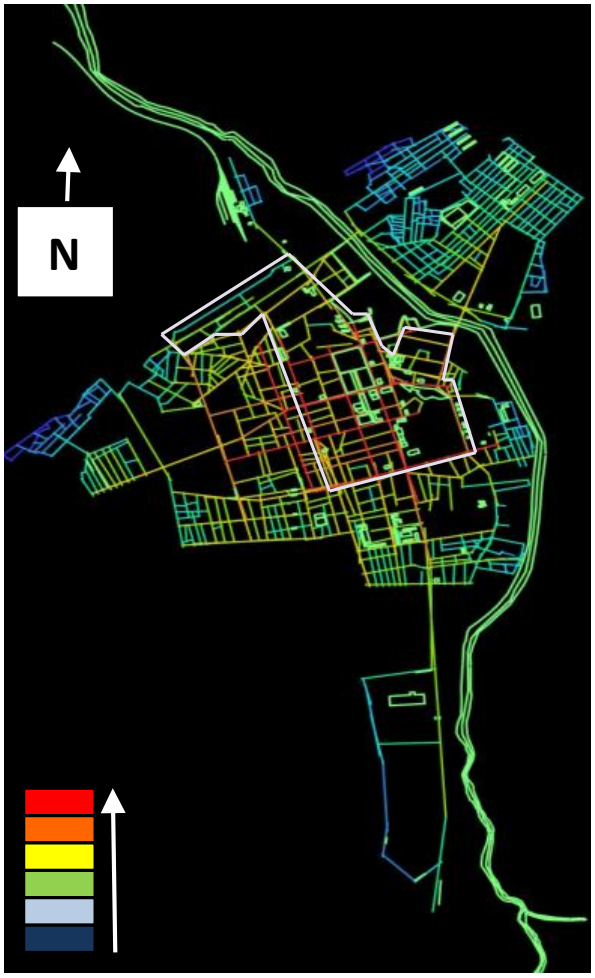

Fig. 5. Axial map of Djelfa in 1962–1977 (global integration (Rn)). Source: authors

Djelfa in the period between 1977 and 1987

The average global integration for the entire spatial network of the system is 1.02. This value suggests that integration is at its lowest level. However, when we examine the axial map representing global integration (Rn) for the city of Djelfa from 1977 to 1987 (Fig. 6), we can see that there is a concentration of important axes with high integration depicted in red. These axes are primarily located in the colonial center of the city and were expanded through the restructuring process of the city center, which involved the opening of Mohamed Boudiaf Square on the site of old dwellings. This contributed to raising the global integration of the AL-Ma'rad axis to its highest value within the entire spatial system, up to 1.61. It is worth noting that this was accomplished while the city's size nearly doubled compared to the previous period.

Global integration, even if it had lesser value, extended to most parts of the city, particularly the newer ones like the Boutrifis neighborhood on the eastern side of the Mellah valley. Its connection with the Ain Al-Asrar neighborhood contributed to raising the integration of the latter, which had previously experienced low global integration. This connection increased the number of axes that can be accessed from any other axis with the fewest number of steps and thus reduced its isolation. The Al-Bordj neighborhood endured isolation and lack of connectivity within the previous period. However, the emergence of the Issa Al-Qaed neighborhood to the north, and the expansion of the Al-Daya neighborhood to the southwest, along with their connection to Al-Bordj through various spatial axes, contributed to its transformation. It went from being an isolated neighborhood lacking movement to becoming a neighborhood that shows remarkable recovery, acting as a link connecting the Al-Daya and Ain Al-Shih neighborhoods in the west, the Ain Al-Asrar and Boutrifis neighborhoods in the east, and the Issa Al-Qaed neighborhood in the north with the city center in the south. This is evident in the colors of the structured axes (yellow and green).

Djelfa in the period between 1987 and 1998

We note that the average global integration (Rn) decreased to 0.82 after being 1.02 in the period of 1977–1987. This value indicates that the spatial system as a whole is not integrated and is characterized by depth. It means that moving from one axis to another requires many detours, thereby increasing the difficulty of movement. By analyzing the axial map displaying the global integration index (Rn) (Fig. 7), we can identify the reason for this decline. We can see that the city expanded during this period, with its size increasing by approximately one-third. The growth includes the development

Fig. 6. Axial map of Djelfa in 1977–1987 (global integration (Rn)). Source: authors

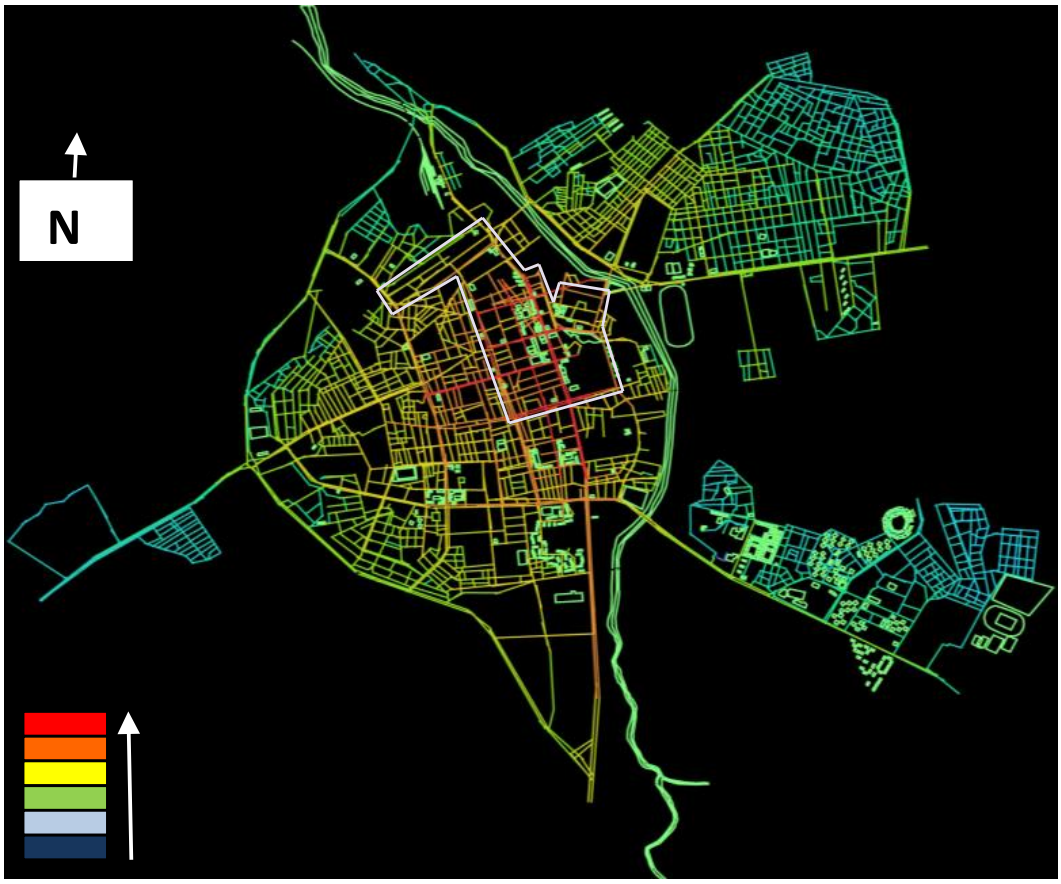

Fig. 7. Axial map of Djelfa in 1987–1998 (global integration (Rn)). Source: authors

of a new urban residential area in the eastern part represented by the July 05 neighborhood. Despite its large size, this neighborhood is isolated and connected to the rest of the city only through one axis, which is the July 05–Al-Ruwaini axis.

Most of the affected neighborhoods are displayed on the axial map showing the global integration index (Rn) in yellow. This indicates their highly acceptable integration, as they transformed from semi-private areas to semi-public areas. These neighborhoods can now be accessed from every axis in the city's spatial system, with an average number of steps. With adequate pedestrian and vehicle traffic, these neighborhoods can potentially evolve into an extension of the city center and serve as an outlet when it becomes saturated in the future.

Regarding the city center, it witnessed significant transformations. Its most important spatial axes are marked in red, and they are the most well-integrated axes within the overall spatial system. These axes are the least deep, which makes them the easiest to access with the fewest number of steps. These axes witness intense movement, whether by pedestrians or vehicles, because they represent areas that provide high liquidity. On the other hand, we have observed the expansion of the historical city center beyond its original borders in the west, reaching the Larbi Ben M'hidi axis. The restructuring and extension to the north and south, highlighted in red, facilitated the movement of both pedestrians and vehicles, particularly after its connection to several important axes originating from the city center in the west and leading towards it. Furthermore, the global integration index (Rn) of most of the sub-streets that flow into it increased, attracting more commercial and service activities. Consequently, these streets transformed from semi-public spaces to bustling public streets, further enhancing the city center's appeal. The old one serves as an outlet to the west, as well as a means of relieving pressure from pedestrians and vehicles. No urban intervention was made on the eastern side of the old city center to repair the damage caused by blocking the ends of the beautiful AL-Dhil AL-Jamil axis. As a result, the latter neither contributed to the flow of pedestrians and vehicles nor attracted substantial activities in line with the city center's level. Consequently, it became a mere back street for parking vehicles.

Djelfa in the period between 1998 and 2020

The average global integration index (Rn) for the city of Djelfa in the period of 1998–2020 was low, decreasing from 0.82 in the period of 1987–1998 to 0.74. This suggests that the city lacks integration and is dominated by depth. A user had to take many detours to reach other axes in the city, but when looking at the axial map displaying the

global integration index (Rn) (Fig. 8), we find some interesting observations:

The global integration index (Rn) accurately shows us the most integrated areas within the space system, which can be accessed with the least number of steps. These areas are the historical (colonial) city center, with its highly integrated axes (in red) and the adjacent neighborhoods.

The variation in colors, evident in the axial map of the global integration index, provides us with an accurate understanding of the kind of space and its position in relation to the city's overall spatial system. The color gradient is as follows: red and orange represent public spaces; yellow and green represent semi-public spaces; light blue represents semi-private spaces, and dark blue represents private spaces. The red and orange axes, representing the most integrated spaces in the spatial system that can be reached with the fewest number of steps, are located in the historical city center and the adjacent axes. The city center expanded southward with the National Road 1 axis to the northern border of the industrial zone. To alleviate pressure on this axis, a west-east axis parallel to the Al-Ruwaini–Shabani axis was opened, with a bridge over the Mellah valley connecting the southwest and southeast of the city. This intervention greatly increased the integration of this axis. Furthermore, a bridge connecting this axis with the crossroads of July 05, Shabani, and Al-Ruwaini had a significant impact on its integration, transforming it from weak to strong (red color). This axis attracted intense movement, which will likely affect the future land occupation and the diversity of activities on this axis.

The Larbi Ben M'hidi axis remains on the western side as a dividing line between the expanding city center and the semi-private and private areas. In other words, at this stage, the city center did not extend beyond the north-south axis of Larbi Ben M'hidi, particularly on its northern side, unlike its southern side, which saw a slight expansion along the Al-Hawas–Ain Al-Shih axis.

The neighborhood of July 05 is still considered isolated in relation to the spatial system of the city in this modern period. Unlike the Shabani neighborhood, which benefited from its association with the Ben Tiba neighborhood and transformed most of its main axes into public and semi-public areas, access to it requires the fewest number of steps within the entire spatial system. However, the July 05 neighborhood is isolated and failed to benefit from the expansion of the Ben Tiba and Al-Mostakbal neighborhoods to the north. This is due to a natural obstacle, namely a forest located to the north, which prevents the neighborhood from connecting with the new neighborhoods with good global integration.

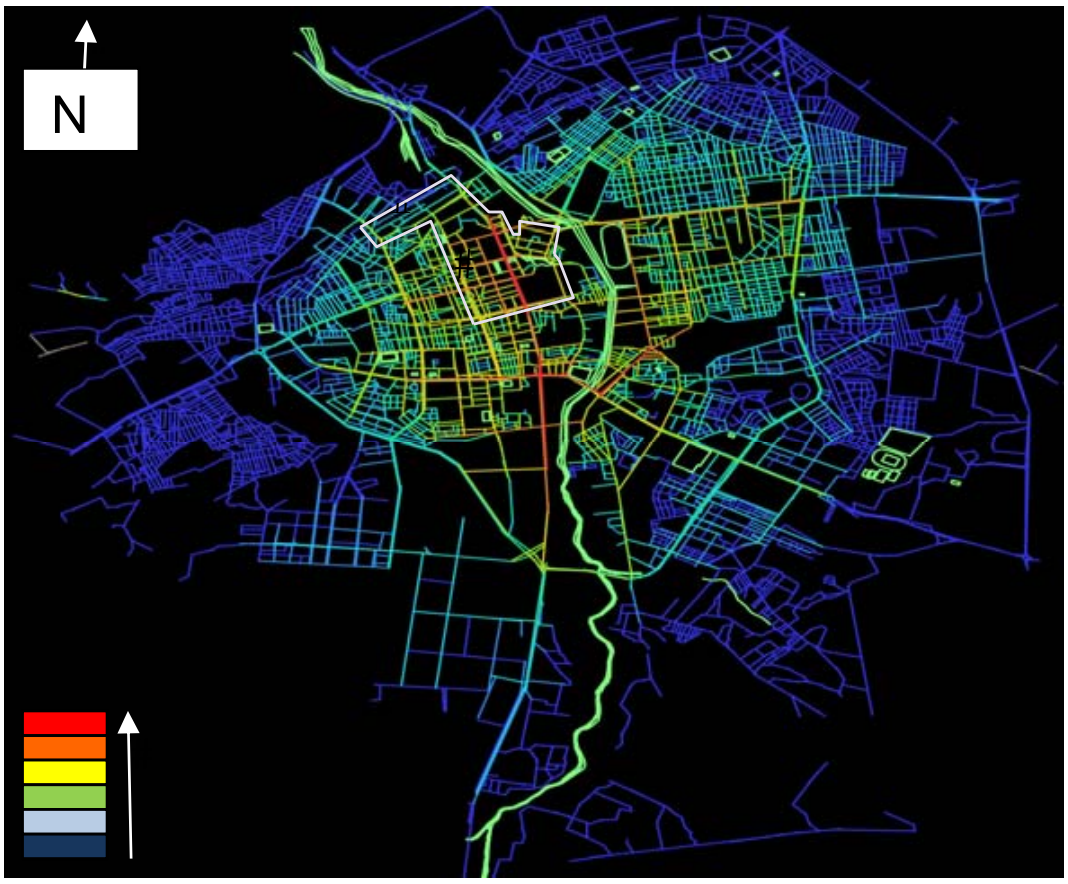

Fig. 8. Axial map of Djelfa in 1998–2020 (global integration (Rn)). Source: authors

Conclusions

Djelfa before 1962 (before independence)

The number of axes in its urban fabric was 86, with an average connectivity of 4.13. This means that each axis intersects with four other axes. The highest value was estimated at approximately 16, which was carried by National Road 1 (Algiers–Laghouat or Emir Abdelkader later). This road is considered the first point of reference on which the initial nucleus of the city was established. With an average global integration (Rn) of 1.35, the ancient Al-Bordj neighborhood, inhabited by local residents, is the least integrated in the entire urban fabric and therefore isolated from the spatial structure as a whole.

Djelfa in the period between 1962 and 1977

During this period, the number of its axes increased to 574, with an average connectivity of 5.1. The Khemisti axis became (within the limits of the colonial nucleus) the highest in terms of connectivity, reaching 24, as the city expanded on the western side. This expansion benefited this axis. During this period, the historical city center maintained its status and remained unaffected by the new expansions. This is confirmed by the average global integration (Rn), which had a value of 1.14. The axial map indicated that areas with high global integration were concentrated in the city center.

Djelfa in the period between 1977 and 1987

During this period, the number of axes in the urban fabric of the city of Djelfa increased to 1127, which is approximately twice as many as in the previous period. This indicates that the city doubled in size. Additionally, the average connectivity index of the city increased to 5.5, which is the highest among all the periods studied. The higher connectivity axis further shifted towards the eastern side. This period witnessed the emergence of new axes with high connectivity, particularly in the Boutrifis neighborhood. However, other axes experienced a decline in connectivity due to their inability to keep up with the city's expansion, poor planning, discontinuity as the Khemisti axis in the city center, and the restructuring of the city center. The opening of Mohamed Boudiaf Square also played a role in increasing the connectivity index of the nearby axes, particularly the AL-Dhil AL-Jamil axis. The average global integration (Rn) during this period was the lowest at 1.02. (An Rn value below 1 indicates that the city is not integrated, meaning it has a significant level of isolation.) Even in this period, the most easily accessible (with the fewest number of steps) and integrated axes can be found in the colonial city center.

Djelfa in the period between 1987 and 1998

During this period, the number of axes in the urban fabric of the city of Djelfa increased to 1801, which accounts for about a third of the city's size in the previous period. The average connectivity index is 5.3, meaning that each axis in the spatial system intersects with approximately five other axes. This value is considered good, as it indicates that the spatial system of the city remains coherent despite its expansion and growth. By examining the axial map of Djelfa displaying the connectivity index, we can make important and accurate observations regarding the city center, the outskirts, and the new neighborhoods. However, the average global integration index (Rn) decreased to 0.82, indicating that the overall spatial system of the city is not well-integrated. This means that reaching desired destinations within the city requires traversing numerous streets. The reason for this decline is due to the emergence of a new urban residential area in the eastern part, represented by the July 05 neighborhood. Despite its large size, it is isolated and not well connected to the city, except through a single axis (July 05–Alrwini axis).

Djelfa in the period between 1998 and 2020

During this period, the number of axes in the spatial system of the city of Djelfa increased to 4036, which is more than twice. This period was characterized by significant demographic growth and rapid reconstruction. The city also witnessed significant transformations, with an average connectivity index of 5.1, which is considered high. Given the size of the city, this indicates good fluidity and suggests that users have an average of five transportation options available to them. The analysis of the connectivity index has revealed some important observations. Firstly, the axes of the city center have maintained their values and have become even stronger due to their connection to important axes in the new expansions. This connectivity allows for easy access to the city center from various directions, and enables the expansion of the city towards the Mellah valley in the east and the Larbi Ben M'hidi axis in the west. However, it is worth mentioning that the average global integration index (Rn) decreased to 0.74, indicating that the city as a whole lacks depth and integration. This means that users often have to navigate through multiple depths to reach different axes within the city. Nonetheless, when we examine the axial map displaying the global integration index (Rn), we can clearly observe a gradation of spaces. The most integrated spaces are public areas, followed by semi-public areas with moderate integration. In contrast, semi-private areas have lower integration, while private areas are isolated and situated deeper within the spatial system.

From all of the above, it becomes clear to us that analyzing the city using the spatial syntax methodology has helped us reveal the important transformations that the city witnessed from its colonial inception to the latest stage. The morphological composition of the first colonial nucleus with its chess layout center and the continued expansion of the city greatly

contributed to the distinction of the city center as a commercial center. This expansion also allowed the city to grow beyond its original borders. The high connectivity and integration indices further indicate the ease of movement and accessibility from different parts of the city. The results also showed that the restructuring and construction of Mohamed Boudiaf Square greatly affected the adjacent axes and led to an increase in traffic and commercial activities, especially along the AL-Dhil AL-Jamil axis. However, they also revealed that the illegal and unplanned neighborhoods, such as Al-Fusha and Ben Said, faced significant isolation due to their limited connectivity and integration with the rest of the city. Commercial activities are driven by the most interdependent axes and integrated areas, which highlights the influence of the spatial structure on human behavior.

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ИССЛЕДОВАНИЕ ГОРОДСКИХ ПРЕОБРАЗОВАНИЙ И ИХ ВЛИЯНИЯ НА КОЛОНИАЛЬНУЮ ГОРОДСКУЮ ЗАСТРОЙКУ В ДЖЕЛЬФЕ (АЛЖИР) С ПОМОЩЬЮ ПРОСТРАНСТВЕННОГО СИНТАКСИСА

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Аннотация
Введение: В данной статье рассматриваются городские преобразования Джельфы, которым подвергался город с момента его формирования в качестве колонии до настоящего времени, характеризующиеся стремительным демографическим ростом и урбанизацией, а также обширным использованием городского пространства. **Цель работы:** Исследование городских преобразований Джельфы в динамике и количественное описание городских и социальных характеристик, формирующих застройку; определение наиболее интегрированных (легкодоступных) и уединенных районов города. **Методы:** Для анализа этапов развития города мы использовали методику пространственного синтаксиса, которая основана на моделировании карт городов в виде схем осей и количественном измерении ряда показателей, таких как связанность и интегрированность (Rn). **Результаты:** Были получены значимые результаты, в том числе следующие: исторический центр города по-прежнему сохраняет свое значение с точки зрения доступности, увязанных осей и шахматной планировки, которые способствовали его расширению. Кроме того, в определенные периоды появились жилые кварталы, изолированные от остальной части города. Деятельность по перестройке, в частности, открытие площади Мохамеда Будиафа в центре города, внесла вклад в увеличение связанности соседних осей.

Ключевые слова: городские преобразования, колониальный город, пространственный синтаксис, Джельфа, связанность, интегрированность.