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Spatial syntax analysis of colonial urban morphogenesis: Insights from a Mediterranean case study

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ABSTRACT

BACKGROUND AND OBJECTIVES: The Mediterranean city of Oran, located in Algerian coastal territory, experienced extensive morphological modifications through the sustained influence of Spanish and French colonial activities. Its strategic position attracted successive occupations that left visible traces in the urban form. This study analyzed how spatial structures evolved under these colonial regimes and how political and strategic decisions shaped Oran's urban morphology. It also sought to explain the mechanisms through which these transformations occurred and how they continued to affect the city's organization.

METHODS: Historical maps from 1736 and 1927 were used to analyze space syntax, measuring global and local network integration, choice, and intelligibility. The syntactic results were combined with the urban decoding principles developed by Caniggia and Maffei to provide historical context to the morphological shifts. These years were chosen because they represent turning points in Spanish and French urban planning strategies.

FINDINGS: The integration value of Plaza Mayor in 1736 was 0.61, confirming its role as the central hub under Spanish rule. In 1927, the highest integration value shifted to Place d'Armes (0.66), reflecting the French strategic repositioning of the city's core. This shift led to urban fragmentation and a reduction in intelligibility in certain areas. Despite modernization efforts, peripheral zones maintained low integration values, confirming persistent spatial segregation.

CONCLUSION: The research established how colonial rule directly influenced the spatial layout of the city and demonstrated that spatial syntax is an effective tool for analyzing historical urban development patterns. The results contribute to urban heritage

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INTRODUCTION

Throughout history, the Mediterranean coastal city of Oran in Algeria (Fig. 1) has undergone extensive urban changes due to the influence of political powers, military interests, and colonial administration. The city of Oran was founded by Andalusian traders in the 10th century, after which it attained strategic importance because of its geographical advantages, leading to extended conflicts among various powers through the centuries (Lespes, 1938). The Spanish rule of 1732 to 1792 established Oran as a fortified urban center by designing a defensive urban plan for territorial dominance. The Plaza Mayor emerged as the city's nerve center, concentrating social, commercial, and administrative functions within a compact and highly centralized structure. The French administration (1831–1962) transformed the city when it applied Haussmannian principles for urban development. The city's new layout with broad streets and public squares, and neighborhood districts shifted urban areas away from Plaza Mayor to the new Place d'Armes and the connecting avenues (Kettaf, 2013). Spatial syntax analysis serves as the methodology to explore morphological changes by allowing researchers to measure urban network accessibility and connectivity and spatial comprehensibility (Hillier and Hanson, 1984; Karimi, 2012; Psarra, 2009). This paper analyzes the syntactic values of Oran during 1736 and 1927 to understand how political events, along with military

activities, affected urban development patterns and relationship dynamics within the city structure. Similar methodologies have been successfully applied in other colonial urban contexts. Atakara and Allahmoradi (2021), for instance, combined space syntax with GIS to examine the spatial transformation of Famagusta, highlighting the method's ability to detect historical patterns of spatial centrality and urban restructuring in Mediterranean port cities affected by successive colonial regimes. The results provide a detailed reading of Oran's spatial evolution, revealing how the city transitioned from a closed and defensive layout to a more expansive yet fragmented system. This research also highlights the potential of spatial syntax as a tool not only for understanding historical urban dynamics but also for guiding contemporary strategies of urban heritage preservation and planning. This study aims to analyze the spatial transformations of Oran's urban fabric during the Spanish and French colonial periods, using spatial syntax as a methodological framework. The chronological evolution of the city's spatial expansion is illustrated in Fig. 2. The research was conducted in 2024, based on historical map analysis and spatial modeling applied to the city of Oran, located on the northwestern coast of Algeria.

MATERIALS AND METHODS

The spatial syntax developed by Hillier and Hanson (1984) was used to examine the

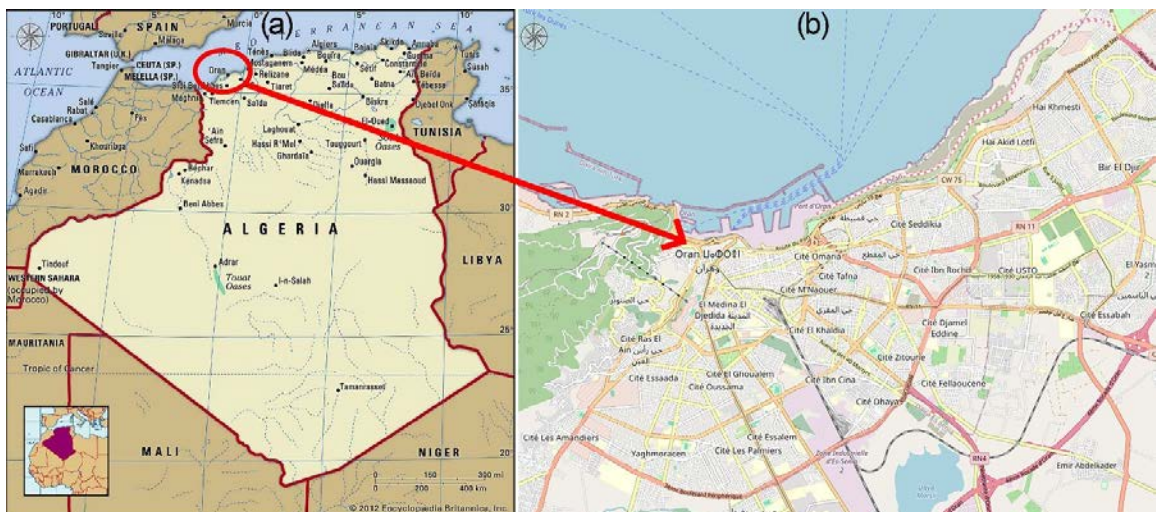


Fig. 1: Location of (a) Algeria and (b) Oran. Sources: (a) Encyclopædia Britannica, (b) OpenStreetMap.

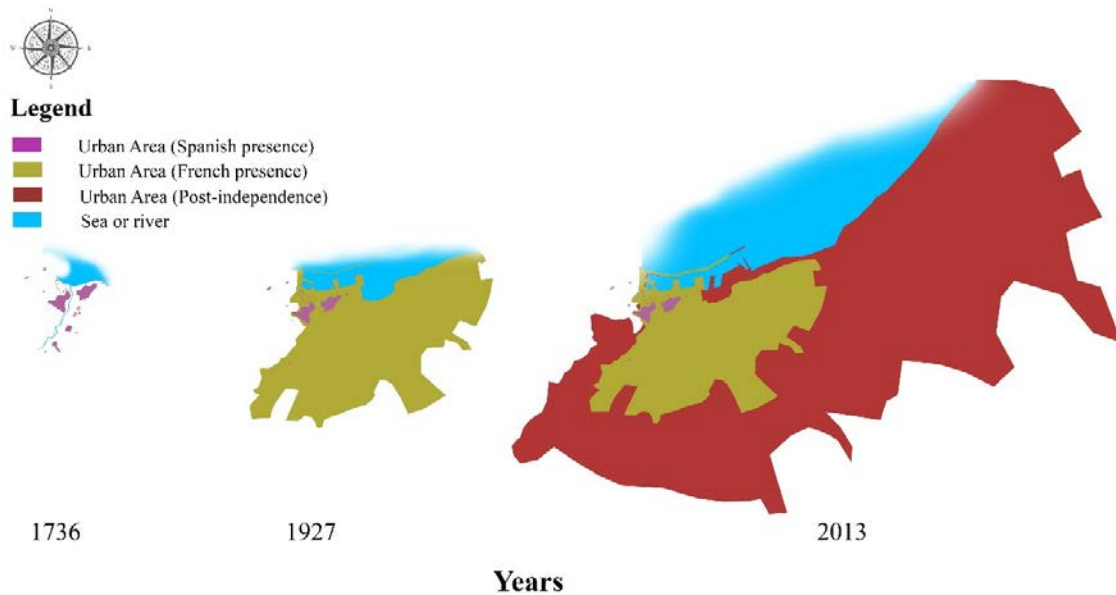


Fig. 2: Chronological and historical growth of the city of Oran (Source: The authors).

morphological structure of Oran, as this methodology analyzes spatial relationships along with their effects on urban dynamics. Spatial syntax provides excellent capabilities to study how various spatial arrangements influence accessibility and centralities throughout history (Hillier and Hanson, 1984; Turner et al., 2005; Karimi, 2012; Psarra, 2012). Axial maps were generated using the software Depthmap10 to measure street integration and connectivity, following the methodological recommendations of Turner et al. (2005). This method has also been applied in Algerian cities such as Annaba to assess urban accessibility and syntactic coherence (Laouar and Mazouz, 2017). This analysis made it possible to visualize the most and least integrated areas, along with the key connections within the urban fabric. The historical maps were adapted and georeferenced to ensure spatial accuracy. The historical maps were georeferenced using QGIS software. Twelve fixed control points, such as fortifications, churches, and other prominent urban landmarks identifiable on both historical and current maps, were selected to ensure reliable alignment. This process resulted in a mean root mean square error (RMSE) of less than 6 meters, which is considered acceptable for urban-scale morphological analysis (Rumsey & Williams, 2002). This research analyzes two historic stages:

1736, representing urban stabilization following Spanish reforms, and 1927, reflecting French planning and city expansion. These dates were selected due to their historical significance and the reliability of the available map sources. The 1736 map (Fig. 3) derives from Spanish archives, whereas the 1927 map (Fig. 4) originates from French colonial cadastral records.

Spatial metrics analyzed:

- *Global Integration (Rn)*: Measures the accessibility of each space relative to the entire system, identifying the most and least accessible areas.
- *Local Integration (R3)*: Evaluates accessibility within a limited radius, revealing secondary centers of activity.
- *Choice (HH)*: Highlights the most frequently used paths, indicating the most likely movement corridors.
- *Synergy and Intelligibility*: Examines the relationship between local and global integration, assessing the structural coherence and spatial legibility of the network (Griffiths et al., 2010; Hillier and Hanson, 1984).

The choice of a radius of 3 (R3) for the local integration analysis follows the methodological recommendations of Hillier (1996). This radius is particularly appropriate for capturing pedestrian

Spatial syntax in colonial urban morphology

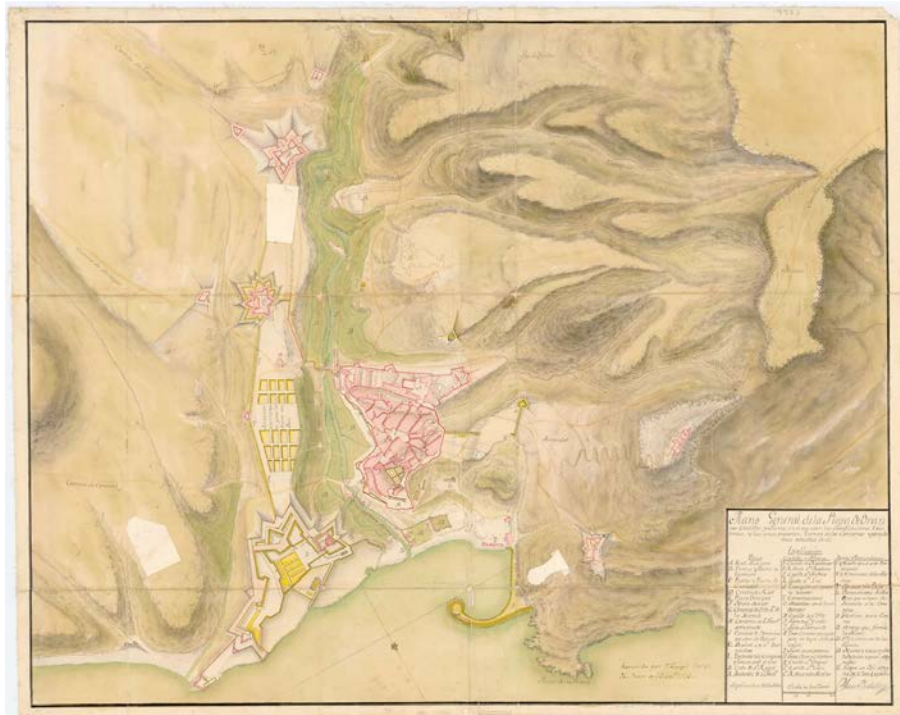


Fig.3: General Plan of the Plaza de Oran, its Castles and Forts of 1736, showing the existing Fortifications and those proposed for the Contours and most notable places (Source: Archivo General Militar de Madrid)

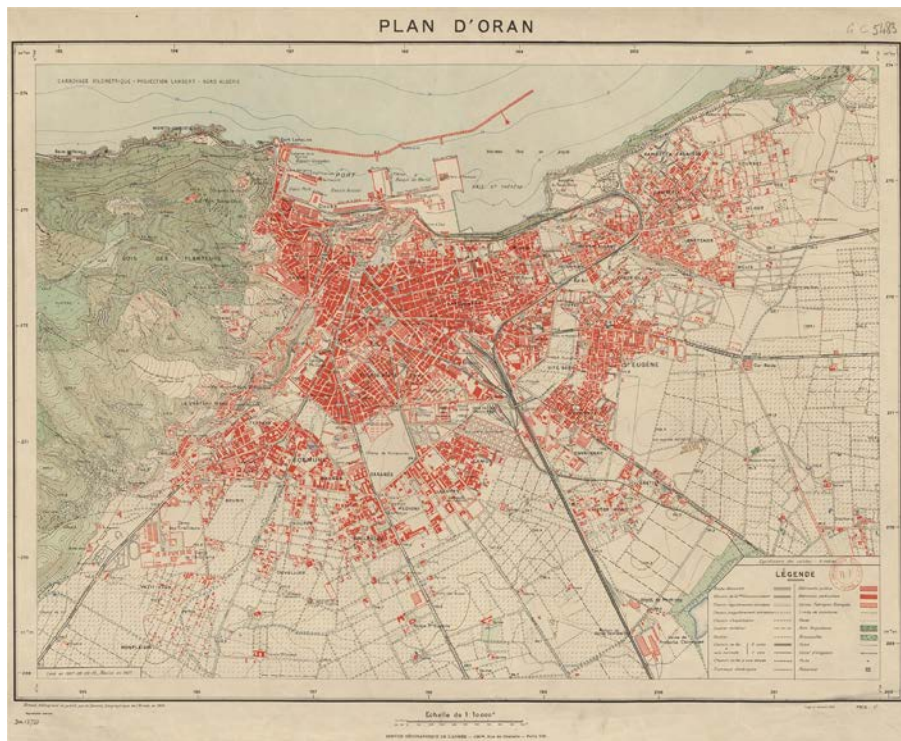


Fig. 4: Map of Oran. Surveyed 1907-08-09-10. Revised in 1927 (Source : Bibliothèque nationale de France)

mobility and neighborhood accessibility patterns in historic Mediterranean urban cores. According to these authors, a radius of 3 highlights the spatial structures that most directly shape everyday routes and social interactions, while still providing a focused, localized perspective and avoiding dilution by broader citywide trends. This approach has been widely adopted in urban morphological studies using space syntax.

Analytical framework: In addition to the spatial metrics, the urban decoding theory of [Caniggia and Maffei \(2001\)](#) was employed to interpret spatial transformations over time. This theoretical lens enabled the contextualization of urban fabric evolution in broader social and historical dynamics.

Limitations of the methodology: While spatial syntax provides a rigorous analysis of urban morphology, it has limitations. This limitation has been further explored in recent studies highlighting issues related to axially, scale, and network curvature ([Pafka et al., 2020](#)). For instance, it focuses on the configuration of built space without directly accounting for socioeconomic dynamics or land use. The methodology becomes stronger when used with historical and cartographic information for studying urban evolution. This methodology made it possible to monitor the spatial alterations of Oran and their influence on the current urban arrangement. The combination of quantitative spatial analysis and historical interpretation provides valuable insights for urban planning and heritage conservation.

State of the art

The study of urban morphological changes through spatial syntax has gained considerable attention in recent decades, especially for understanding the historical evolution of cities with complex colonial pasts. Research developed by [Hillier and Hanson \(1984\)](#) continues to find broad usage for understanding how urban spatial configuration influences social interaction, movement patterns, and the emergence of centralities. In the Mediterranean region, various studies demonstrate how military, political, and economic factors transformed spatial city layouts. For example, [Griffiths et al. \(2010\)](#) analyzed the evolution of British colonial cities, showing how spatial syntax reveals patterns of centrality and segregation over time. [Baruah et al. \(2021\)](#), in a large-scale comparative

study of 318 African cities, showed that colonial rule has kept different cities looking different even today. Their study found that cities with Francophone colonial histories tend to exhibit more compact development and grid-like street patterns, whereas Anglophone cities are characterized by greater urban sprawl and less regular layouts. The results highlight that the structure of African cities today is mainly shaped by colonial planning. According to [Çelik \(1997\)](#), the French colonial power imposed spatial control as well as social segregation through their urban planning practice in North African cities. [Njoh \(2008\)](#) suggests that although French policy promoted assimilation in theory, in practice it relied on urban separation based on socioeconomic and cultural divisions. This approach led to urban layouts that physically separated European settlers from indigenous populations, reinforcing social hierarchies and control mechanisms within colonial cities. [Wright \(1991\)](#) shows that urban planning in French colonies served to control space and also influence the culture. She argues that the design of colonial cities served to symbolize and reinforce the authority of the colonizers, often through the implementation of European architectural styles and urban layouts that contrasted sharply with indigenous forms. This approach laid the foundation for colonial beliefs to appear in city design. Beyond control and segregation, colonial urbanism also served symbolic and morphological functions, with long-lasting implications on urban form. Several scholars have examined how colonial powers imposed their ideologies through urban design, leading to enduring spatial patterns. Comparative studies of colonial urban morphology further confirm these patterns across various urban contexts ([Belova and Carlotti, 2021](#)). For instance, [Mowla \(2000\)](#) discusses the establishment of dual city systems favoring colonial interests, resulting in segregated urban forms. [Bannerj \(2022\)](#) analyzes the visual and morphological aspects of colonial cities, highlighting how design choices reinforced colonial dominance. Additionally, [Chiaradia \(2019\)](#) emphasizes the role of urban morphology in understanding the evolution of colonial urban forms. Historical research on Oran's development between Spanish and French rule comes from the perspectives presented by [Lespes \(1938\)](#), [Kettaf \(2013\)](#), [Alonso Acero \(2003\)](#), and [Benkada \(2019\)](#). During the Spanish era, [Alonso Acero \(2003\)](#)

and Benkada (2019) recorded Spanish defensive urban planning strategies; whereas, Lespes (1938) and Kettaf (2013) studied the French territorial growth and implementation of new city design principles. This French design was inspired by the Haussmann model. Moreover, the integration of spatial syntax with historical urban theories, such as the urban decoding theory of Caniggia and Maffei (2001), has proven valuable for interpreting the layered transformations of historical cities. Karimi (2023) points out that representation of urban morphology with space syntax supports an analytical, evidence-based look at complicated urban systems. With this approach, understanding spatial arrangements becomes easier by relating them to urban society, economics, and cultural life, especially in cities with a long history of social division. This combination allows for a more nuanced reading of how spatial configurations both shape and are shaped by political power, social practices, and historical contingencies. This aligns with recent efforts to establish systematic, quantitative classifications of urban form for comparative historical analysis (Fleischmann et al., 2021). The results of the spatial syntax analysis can also be interpreted through the combined lens of Urban Decoding and postcolonial urbanism theories. The typological reading proposed by Caniggia and Maffei (2001) allows for the identification of persistent morphological invariants within Oran's fabric, revealing how certain street alignments and centralities established during the Spanish period were adapted, rather than completely replaced, under French colonial planning. When juxtaposed with postcolonial urbanism perspectives (Çelik, 1997; Njoh, 2008; Wright, 1991), these findings underscore how spatial configurations not only responded to functional and strategic needs but also materialized the colonial agenda of control, segregation, and symbolic domination. In this sense, the shifts in centrality from Plaza Mayor to Place d'Armes can be read both as a typological transformation and as a political act embedded in the broader discourse of colonial governance. This dual reading deepens the understanding of Oran's urban morphogenesis by bridging physical form analysis with socio-political interpretation. Despite the advances in the field, few studies have applied spatial syntax specifically to Oran, leaving a gap in the literature that this research seeks to fill. By bridging historical analysis with

quantitative spatial metrics, this study contributes to a deeper understanding of Oran's urban evolution and provides a methodological framework that can be applied to other cities with complex historical trajectories.

Case study presentation

The city of Oran, located on the northwest coast of Algeria, approximately 150 km from the Spanish coast, is a Mediterranean city whose strategic location and distinctive topography have shaped its urban development over the centuries (Lespes, 1938). To the west, the city is bordered by the Murdjajo Mountain, while the Ras el Ain ravine and the Oued Rehhi structure part of the natural landscape, directing urban expansions towards the east and south (Bounoua et al., 2009). Oran's history is characterized by successive phases of growth tied to different dominations: the Spanish period (1732–1792), French colonization (1831–1962), and the post-independence era (1962–present) (Lakjaa, 2008). Each phase left visible traces in the urban structure, shaping three distinct systems: the historic Spanish core, the planned French zones, and the post-independence extensions. The Spanish Period (1732–1792): During the Spanish occupation, Oran developed as a compact, fortified city. The Plaza Mayor served as the single meeting point between all urban functions, including administration and religion, along with commerce. Urban developments during this period concentrated into dense fabric while the street layout stayed narrow and curvaceous because of defense requirements. The Alcazaba, together with other fortifications, established an enclosure of the city that produced low global integration according to syntactic analysis by Lespes in 1938. This configuration mirrors that of other fortified Mediterranean cities, such as Ceuta and Melilla, where defensive structures constrained internal expansion (Berriane, 2016). The French Period (1831–1962): French colonization brought significant transformations. Planners adopted a planning model inspired by the Haussmannian model to establish wide boulevards and a grid-like arrangement for the city as they moved central areas towards new connected locations (Kettaf, 2013). The construction of Place d'Armes as the new city center overtook the Plaza Mayor, and the primary boulevards linked critical infrastructure such as the port and train

- *Global Integration (Rn)*: Reflects the degree of global accessibility of a space about the entire urban network (Hillier and Hanson, 1984).

- *Connectivity*: Measures the number of direct connections a given axial line has with others, revealing the local density of connections (Turner et al., 2005).

- *Local Integration (R3)*: Evaluates accessibility within a limited radius, useful for identifying secondary centralities and areas of high local activity (Griffiths et al., 2010).

- *Intelligibility*: Analyzes the correlation between local connectivity and global integration, providing insights into the spatial legibility of the urban system for users (Jiang et al., 2000).

The adopted methodology enables a detailed evaluation of spatial transformations in Oran from 1736 to 1927, which reveals strategies for urban centrality development. Comparing Spanish defensive patterns against French colonial administration principles becomes possible through studying axial maps over different periods of time. This approach is consistent with broader analytical perspectives that use spatial syntax to trace morphological evolution and centrality structures in historic urban contexts (Karimi, 2023; Yamu et al., 2017).

1. Modeling the City of Oran during the Spanish Period

During the second Spanish occupation between 1732 and 1792, Oran's urban architecture displayed a complex system that resulted from defensive requirements and Spanish military base needs. The date 1736 was chosen because it indicated a period of stability after Spanish urban reforms in 1732, when the main military and civil infrastructures that defined the city's spatial configuration were consolidated (Tinthoin, 1956). During this period, the Plaza Mayor served as both the social and economic hub and operational center that directed the development of the old town region (Lespes, 1938). The streets in Oran formed a radial-concentric pattern that spread out from Plaza Mayor through winding passes which led to gateways, including Puerta de Tlemcen and Puerta del Canastel. This structure favored defense and territorial control, allowing rapid military mobilization in case of attack, but it limited internal expansion and created an urban environment with low navigability. This structure favored defense and territorial control, allowing rapid military

mobilization in case of attack, but it limited internal expansion and created an urban environment with low navigability. Military engineers from Spain applied Vauban defensive principles to reinforce the fortifications by readjusting the urban plan to achieve maximum oversight of the central area (Benkada, 2004). However, this closed configuration directly impacted spatial intelligibility, creating a network with high local integration around the plaza but low global integration towards peripheral areas. To better understand these dynamics, axial maps were generated using Depthmap10, enabling the analysis of the syntactic properties of the urban system. The study quantitatively assessed the levels of global and local integration, as well as choice and connectivity, to produce visual representations illustrating how military control influenced citywide distribution and separation. The historical processes and spatial developments revealed how the city of Oran changed its form and helped clarify the spatial boundaries that limited growth within the old town's area.

1.1. Global Axial Accessibility: Global Integration (Rn)

The global axial accessibility analysis based on the Global Integration metric (Rn) demonstrates that Oran's 1736 urban structure revolved centrally around the Plaza Mayor area. The results of the axial map generated with Depthmap10 (Fig. 6a) show that global integration values range from a minimum of 1.191 to a maximum of 3.005. The Plaza Mayor area stands as the city's central hub because it possesses the maximum integration value at 3.005 within the urban fabric. The most integrated axes are those connecting the Plaza Mayor with the main access gates: the Puerta de Tlemcen and the Puerta del Canastel. A survey of the Plaza Mayor reveals an integration value of 2.771 while connecting commercial and religious sections, which establishes this central space as an administrative center and gathering point, and marketplace. The integration levels diminish rapidly across areas farther from the center. For instance, the axial lines near the garrison and the Alcazaba present values below 1.5, limiting their connection to the rest of the city. The defensive strategy implemented through fragmented zones enables important core areas to maintain high integration while limiting the access of vulnerable sectors to potential attacks. Fig. 6 clearly illustrates that the Plaza Mayor was the node with the highest

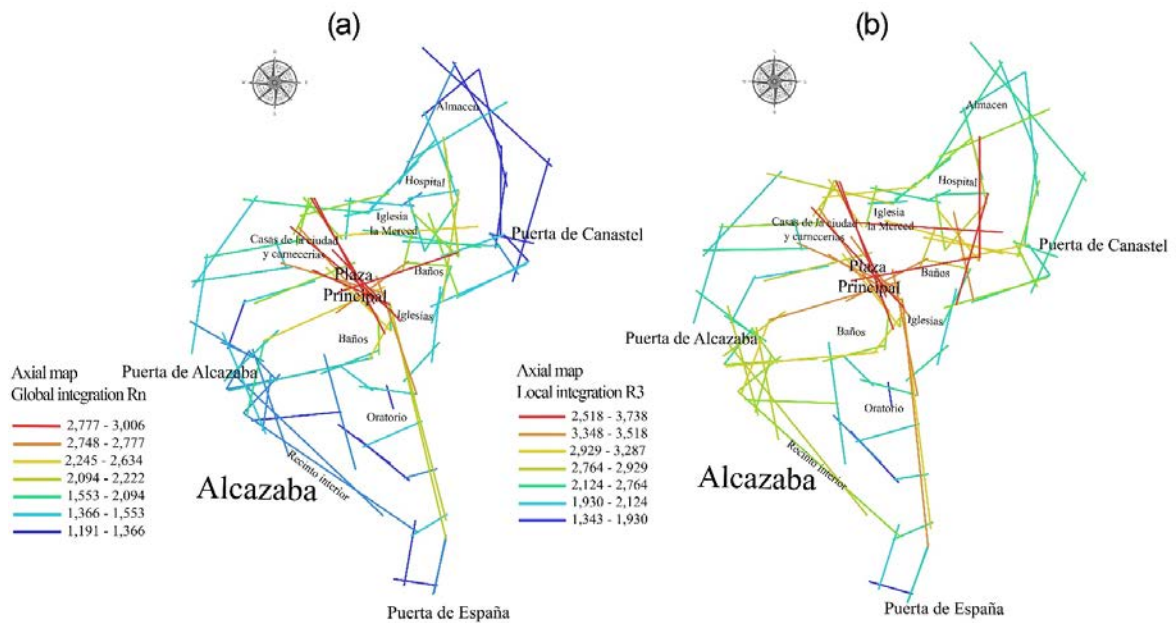


Fig. 6: (a) Global integration Rn map of the city of Oran in 1736 (Spanish period), (b) Local integration R3 map of the city of Oran in 1736 (Spanish period). Source: The authors

global integration, acting as the structural heart of the city. However, this extreme centrality, combined with low integration in peripheral sectors, reveals a city designed more for protection than organic expansion, which conditioned its morphological evolution until the French occupation.

1.2. Local Spatial Accessibility: Local Integration (R3)

The local integration metric (R3) enables spatial accessibility analysis, which shows central node vicinity relationships at brief distances to reveal Spanish-era secondary central patterns and social and functional city dynamics. According to the results obtained through axial maps generated with Depthmap10 (Fig. 6b), local integration values range from 1.443 to 3.738, with an average of 2.741. The Plaza Mayor remains the point with the highest local integration values (3.738), reinforcing its dominant role in organizing urban space. This high local integration indicates that the Plaza was not only the city's global structural center but also concentrated immediate connections, facilitating the convergence of multiple streets that articulated daily urban life. The corridors linking the Plaza Mayor with commercial and religious areas show high local

integration values, meaning these spaces were easily accessible for residents on short trips, fostering the concentration of economic and social activities around the Plaza. For example, streets connecting the Plaza Mayor with the main church and the market had values above 3.2, positioning them as key axes of local interaction. However, residential areas farther from the center experienced a significant drop in local integration values. Areas near the fortifications, with values below 1.8, reflect an urban structure where peripheral sectors were relatively isolated from the main social dynamics, reinforcing internal segregation within the city (Hillier and Hanson, 1984). This low local integration correlates with the city's military function: areas near the walls and garrisons were designed for control and surveillance rather than social connectivity. Additionally, spatial synergy — the relationship between global and local integration — shows an average value of 0.708, indicating that the most locally integrated areas also tended to be well connected globally. However, this synergy broke down in the most peripheral areas, creating spatial discontinuities that affected the internal cohesion of the urban fabric. Ultimately, the analysis of local integration reveals that Oran, during the Spanish

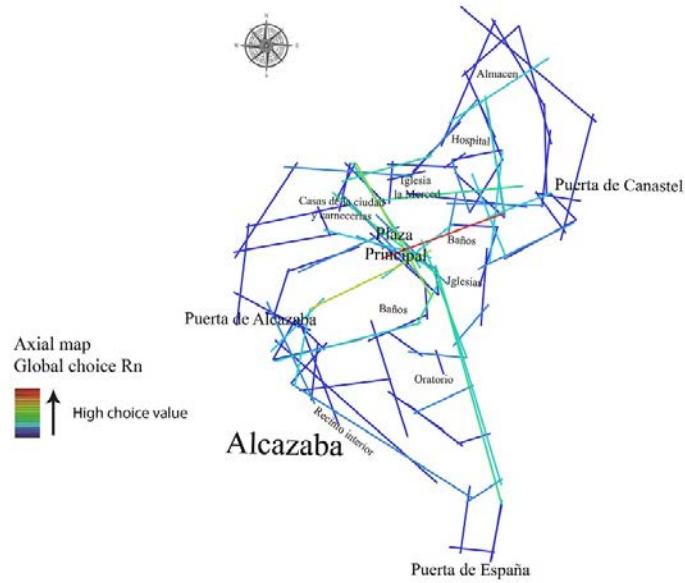


Fig. 7: Rn global choice map of the city of Oran in 1736 (Spanish period). Source: The authors.

period, functioned as a highly centralized city around the Plaza Mayor, with a declining integration structure towards the peripheries. This pattern reinforced the Plaza’s role as the epicenter of urban life but also limited the possibility of developing secondary centralities, consolidating an urban model where defense and extreme centralization defined the city’s morphology.

1.3. Global Choice HH: Rn

The analysis of global choice (HH) using radius n (Rn) helps identify the most frequently used urban corridors within Oran’s Street network in 1736, revealing the strategic axes that channeled movement through the urban fabric. This metric is essential for understanding how certain spaces functioned as preferred routes, not only due to their integration but also because of their ability to attract both spontaneous and planned movements. Depthmap10 results show that the main street between Puerta de Tlemcen and Plaza Mayor features the peak global choice value of 655.566 (Fig. 7). This indicates that this route was the most heavily traveled and essential for the city’s circulation structure. The average choice value across the urban network stands at 15.205,2 and shows how movement flows distribute throughout the area. The main connection artery traversed the

old town heart to enable internal movement and access to significant urban areas (Lespes, 1938). Additionally, several streets holding choice values between 10.500 and 12.800 connected the Plaza Mayor to the central religious and administrative buildings, including the main church, together with the governor’s residence. This configuration confirms that the city was structured to concentrate movement flows around spaces of power and control, reinforcing the extreme centrality of the urban core. The analysis shows that locations situated near military premises, along with peripheral residential districts contain the weakest choice values, which lie under 2.000. This low choice reflects the deliberate intention to keep certain areas isolated from the main flow, likely to protect sensitive sectors or restrict access to strategically important areas. The research demonstrates that the main corridors serve as the fundamental network backbone, yet fail to produce noteworthy extra connectivity centers. According to Hillier (1996), the urban network of Oran used its design to steer residents towards Plaza Mayor through its single targeted destination rather than dispersing traffic throughout the urban areas. The global choice analysis demonstrates that the Spanish era Oran maintained a centralized hierarchical system for the optimization of security and control over the

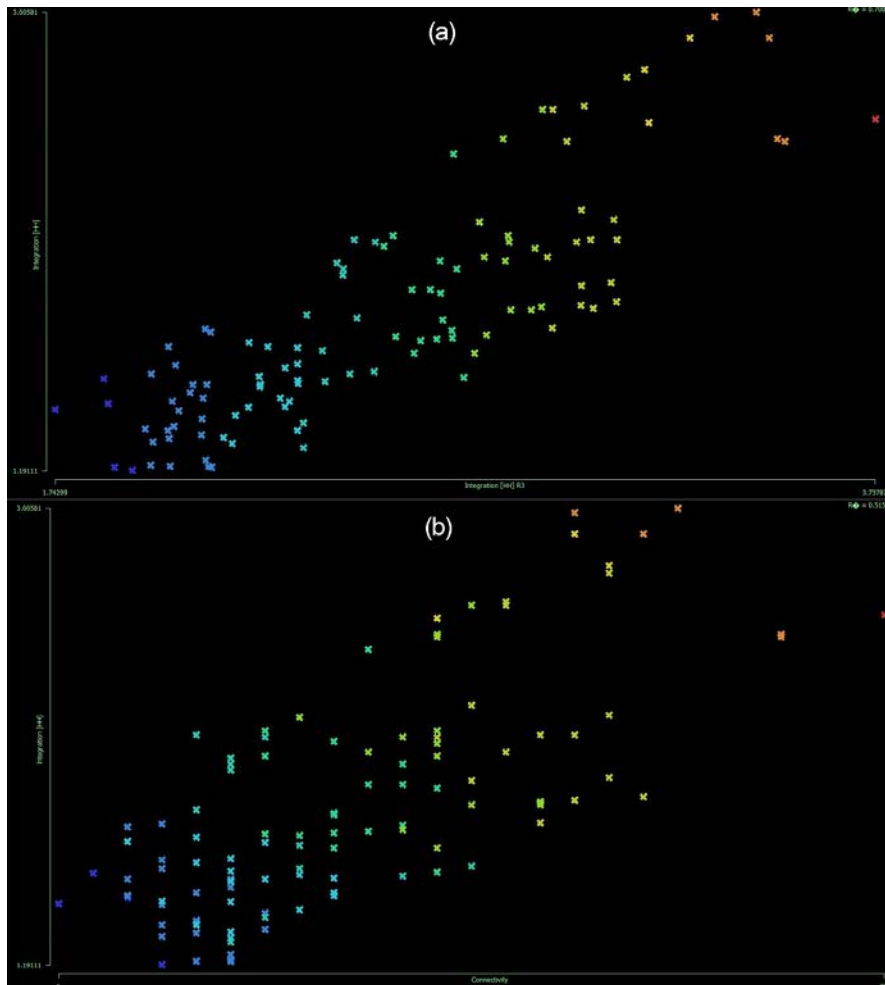


Fig. 8: (a) Synergy diagram, (b) Intelligibility diagram of the city of Oran in 1736 (Spanish period). Source: The authors.

territory. While this configuration was functional from a defensive perspective, it limited the diversification of urban routes, likely affecting the fluidity of daily movement and shaping the city's morphological evolution.

1.4. Synergy and Intelligibility

The assessment of synergy alongside intelligibility yields essential insights into structural city network coherence in Oran during 1736 because it demonstrates how local and global integration patterns influenced spatial organization and functional arrangements of the city. The outcomes from Depthmap10 analysis demonstrate a moderate link between local and global integration, with a city-wide synergy average of

0.708 (Fig. 8a). The urban core exhibited a substantial amount of synergy, which confirmed that the Plaza Mayor and its main corridors served as the most interconnected areas both at a local and global scale. The Plaza Mayor thrived as a primary hub because its spatial organization enabled all these functions while improving access for internal movement and social and commercial operations (Hillier and Hanson, 1984). However, the intelligibility of the urban system presents a low average value of 0.515, reflecting that Oran's Street network was difficult for users to comprehend, especially outside the central core. The narrow and winding streets of the old town, designed to maximize defense, fragmented the urban network and reduced the ability of inhabitants to intuitively

orient themselves (Jiang et al., 2000). The presence of militarized characteristics throughout the city led to extensive disconnections between the main urban traffic and outlying districts. The scatter plot (Fig. 8b) demonstrates this disconnection because it shows Plaza Mayor and its immediate axes maintain a strong link between integration and connectivity, but areas adjacent to the military fortifications show remarkably low values of intelligibility. The data reveal that Oran placed its functional Civic heart center at its core, while its defensive forts separated and dispersed the peripheral areas. The outcomes from the synergy and intelligibility research demonstrate that Oran operated as a centralized network with hierarchical organization through which military logic achieved superiority over spatial clarity. While the high synergy in the center reinforced functional cohesion, the low global intelligibility limited the fluidity of movement and restricted the city's ability to adapt to growth needs or diversify urban activities.

2. Modeling the City of Oran during the French Period (1927)

During the 131 years of French colonization, which spanned from 1831 to 1962, Oran experienced a complete reorganization that incorporated modern urban design concepts derived from the Haussmannian model. The plan of 1927 shows that the city reached substantial growth beyond its Spanish fortifications by introducing broad boulevards and open squares as well as structured street organization to achieve better urban mobility and connective functions (Tinthoin, 1956). The colonial administrative and commercial, and military requirements led to urban restructuring, which moved the center of city activity to new hubs of activity. The Place d'Armes became the central hub that displaced the former power base of the Plaza Mayor while new main boulevards linked residential zones with public buildings and transportation facilities, including the railway station and harbor (Kettaf, 2013). However, the modernization efforts of colonial urbanism created new spatial fragmentation due to the segregationist nature, where new European districts remained better integrated, but expansion zones for indigenous people underwent limited connectivity (Çelik, 1997). This duality between modernization and exclusion is reflected in the syntactic analyses, which reveal how planning decisions affected the city's spatial

structure. Through spatial syntax, the evolution of Oran's Road network in 1927 was examined about the needs of the colonial administration, focusing on global integration patterns, the formation of secondary centralities, and the effects of urban expansion on spatial cohesion. This approach made it possible to understand how the superimposition of Spanish and French urban systems produced a complex morphology marked by tensions between continuity and historical rupture.

2.1. Global Spatial Accessibility: Global Integration R_n

The analysis of global accessibility through the integration metric (R_n) reveals how French urban expansion transformed Oran's spatial structure in 1927. Unlike the Spanish period, characterized by extreme centrality around the Plaza Mayor, the new colonial road network redistributed integration patterns, shifting the functional center towards the new boulevards and the Place d'Armes. According to the results obtained with Depthmap10 (Fig. 9a), global integration values range from 0.218 to 1.502, with an average of 0.912. The street with the highest global integration is the Boulevard Seguin (now Boulevard Emir Abdelkader), with a maximum value of 1.502. This axis, which connects the former Spanish city with the French expansion areas, became a structural backbone, linking the main urban activity hubs. The Place d'Armes also shows high integration values (1.373), reflecting its function as the new nerve center. This square not only concentrated administrative and commercial functions but also acted as a convergence node for the main urban arteries, facilitating connections to key infrastructures such as the train station and port. In contrast, areas near the old Alcazaba and the districts designated for the indigenous population show significantly lower integration values (0.218 - 0.5). This low integration reveals the persistence of spatial segregation dynamics, where peripheral areas remained marginalized from the main circulation flows, limiting their access to urban services and perpetuating the inequalities inherent in the colonial model. The global integration map thus presents a city with a more open structure than during the Spanish period, but with a shifted centrality towards new colonial power spaces. This spatial reorganization optimized connectivity in European sectors while reinforcing the functional separation of marginal

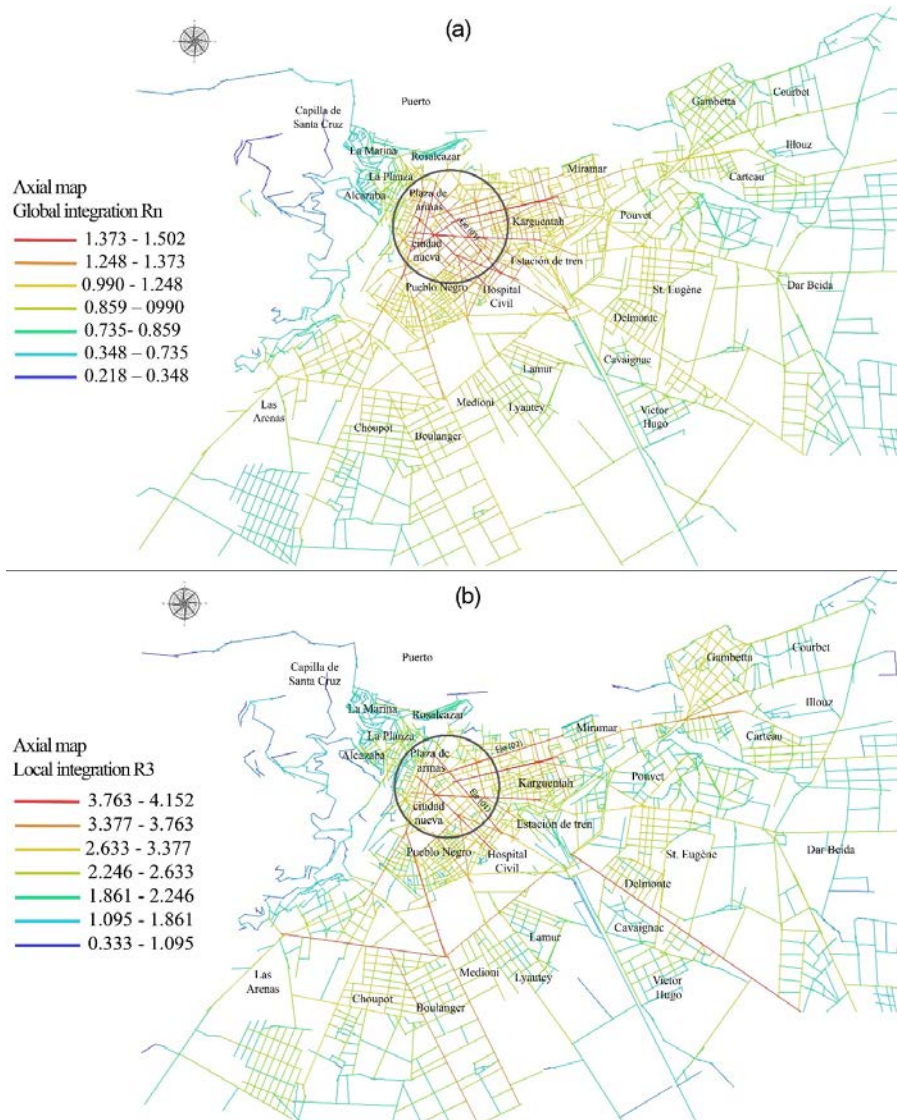


Fig. 9: (a) Global integration Rn map, (b) Local integration R3 map of the city of Oran in 1927 (French period). Source: The authors.

areas, shaping a fragmented urban landscape in terms of integration.

2.2. Local Spatial Accessibility: Local Integration R3

The analysis of local integration (R3) shows how Oran's urban network distributed secondary centralities during 1927 through a study of transportation accessibility in short distances, which identified locations for daily interactions. This metric is key to understanding how French expansion affected not only global connectivity but

also local spatial dynamics. According to the results obtained with Depthmap10 (Fig. 9b), the calculated local integration values span from 0.312 to 2.893 with an average of 1.421. Most areas with high local integration are located near the Place d'Armes (2.893) and the Boulevard Seguin (2.672), which form the main urban boulevards. These spaces, combining high local and global integration, functioned as hubs of intense commercial and social activity, facilitating movement and reinforcing their role as key functional centers of the city. The area surrounding markets,

together with public facilities and administrative spaces, demonstrates high local integration value measurements between 2.3 and 2.6. The high local integration levels experienced a rapid decline throughout peripheral areas as values dropped below 0.8, specifically within indigenous resident segregated neighborhoods. The contrast between high and low local integration areas highlights the inherent tensions of colonial urbanism: while European sectors were designed to maximize internal connectivity, indigenous neighborhoods remained spatially isolated, with less integrated local networks that limited opportunities for interaction and access to urban services. Local integration in 1927 reveals a polarized spatial structure: main corridors and central squares functioned as high-accessibility nodes, while peripheral areas remained highly disconnected, perpetuating the spatial inequalities characteristic of colonial planning. A spatial disconnection between urban centers and peripheral zones has been observed in Monastir, where configuration analysis illustrated functional separation patterns (Bouzgarrou et al., 2019). While the syntactic analysis reveals persistent spatial segregation and fragmentation, particularly between the historic center and peripheral districts, these dynamics are closely linked to the socio-economic and political history of Oran. The analysis of population distribution in the two periods studied, as discussed by Benkada (2019), when compared with space syntax results, shows that areas with higher spatial integration were primarily occupied by European settlers, whereas local populations were relegated to less integrated and often marginalized neighborhoods. This hierarchical spatial organization can largely be explained by the mechanisms of colonial control, which aimed to reinforce domination over urban space through the selective distribution of accessibility and resources. Although this study focuses on the Spanish and French periods, these findings help clarify how the legacy of colonial spatial organization has contributed to shaping the urban structure and inequalities that still characterize Oran today.

2.3. Global Choice HH: Rn

The global choice (HH) analysis through radius n (Rn) determines the main urban corridors that people most often use to travel extensive distances across the city plan. The measurement helps determine

the French expansion's impact on preferred route optimization throughout strategically important areas of the city. Depthmap10 results in Fig. 10 show global choice values spanning 300.421 to 18.745,3 across the urban fabric, while the most important values emerge between the Place d'Armes and port districts and the train station. Boulevard Seguin represents the avenue with the greatest global choice value, reaching 18.745,3, which makes it the most important long-distance transport artery. The Place d'Armes displayed a choice value of 16.213,7, which served as a focus where traffic from throughout the city united to link European neighborhoods with commercial zones and main entry and exit routes. The square maintained such a high choice value because it served both as an important transportation intersection and a prominent social center throughout the urban fabric. On the other hand, the indigenous population areas located in the periphery demonstrate minimal choice activity (800 - 2.000) due to their disconnected status from the citywide movement system. This spatial segregation limited opportunities for interaction with the more integrated sectors, perpetuating the social barriers imposed by colonial planning. The analysis thus reveals a road network that prioritized main corridors to maximize colonial movement efficiency, while keeping certain areas on the margins of the mobility network. This spatial hierarchy reinforced a highly centralized urban model, where high-choice streets strengthened power dynamics and spatial control over the city.

2.4. Synergy and Intelligibility

The analysis of synergy and intelligibility made it possible to assess the structural coherence of Oran's urban network in 1927, revealing how local and global accessibility patterns were articulated and to what extent French colonial expansion improved or fragmented the city's spatial legibility. The urban network's average synergy value based on Depthmap10 analysis in Fig. 11a measures 0.612, which shows a moderate relationship between local and global network aspects. During the Spanish era, the urban network exhibited superior synergy levels than in the French era since French development fostered global integration through new districts but disrupted network continuity via spatial segregation. The Place d'Armes, along with the principal boulevards, exhibits the greatest synergy values

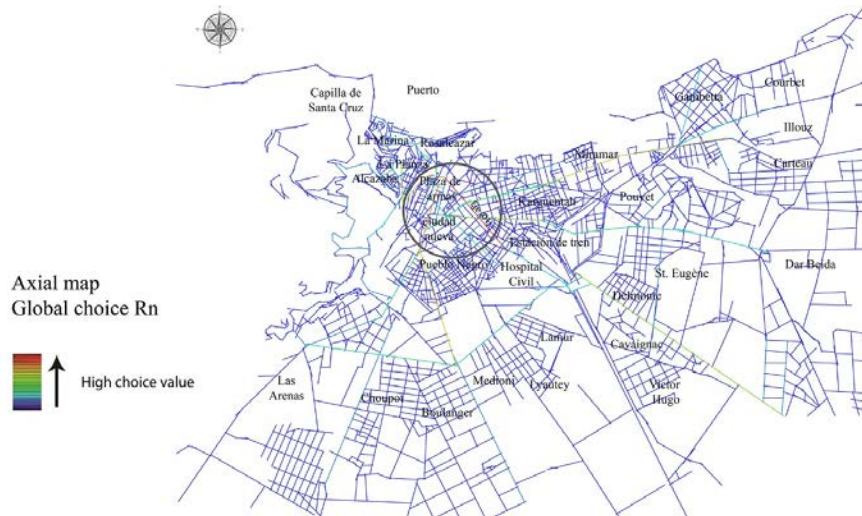


Fig. 10: Rn choice map of Oran in 1927 (French period). Source: The authors.

as their accessibility reaches 0.75 and above. The formation of spatial coherence enhanced the plaza's position as the city's functional center, along with better movement possibilities. However, even though connectivity improved, network comprehension was below average at 0.492, which demonstrated that users found it challenging to understand the city, particularly in outlying zones. The urban segregation in areas with below-0.3 intelligibility isolated neighborhoods, resulting in decreased inhabitants' integration potential into urban systems. Fig. 11b demonstrates this structural divide as the main axes show integration and connectivity correlation, but peripheral areas exist outside the trend because of colonial planning segregation. This lack of intelligibility reveals the limitations of the imposed urban model, which prioritized circulation efficiency for colonial sectors at the expense of overall system cohesion. The moderate synergy, along with low intelligibility, shows that French planning achieved efficient connectivity but introduced significant spatial divisions in the urban fabric. By 1927, Oran had become a divided city that received better roads yet continued to perpetuate its spatial social differences. The results of the synergy and intelligibility evaluation for 1927 are presented in Fig. 11.

The spatial syntax analysis of Oran reveals not only technical shifts in network integration and centrality but also spatial consequences of colonial governance.

The contrast between Spanish defensive compactness and French expansionist rationalization demonstrates how political agendas were embedded in spatial decisions and manifested through measurable urban patterns. Similar patterns of morphological shift from compact colonial cores to fragmented postcolonial expansions have also been documented in cities such as Dhaka, where spatial syntax analysis highlighted these transitions (Ahmed et al., 2014; van Nes and Yamu, 2021). Similar trends have been observed in other colonial or postcolonial cities, where planning decisions reflected power structures and shaped urban accessibility. In North African cities such as Algiers or Tetouan, studies have shown how colonial urbanism created fragmented networks with distinct zones of centrality and exclusion (Çelik, 1997; Cermasi and Psarra, 2013). These patterns often persisted long after colonization, influencing the spatial logic of modern urban development (Anguelovski, 2016). The findings of this study also resonate with recent work emphasizing the potential of spatial syntax in supporting heritage-oriented planning. The method provides a robust framework for diagnosing structural discontinuities and identifying historically rooted inequalities in urban space (Karimi, 2023; Van Nes and Yamu, 2021). By bridging spatial analytics with urban history, this research contributes to a growing body of literature that promotes evidence-based strategies for integrated urban transformation. The

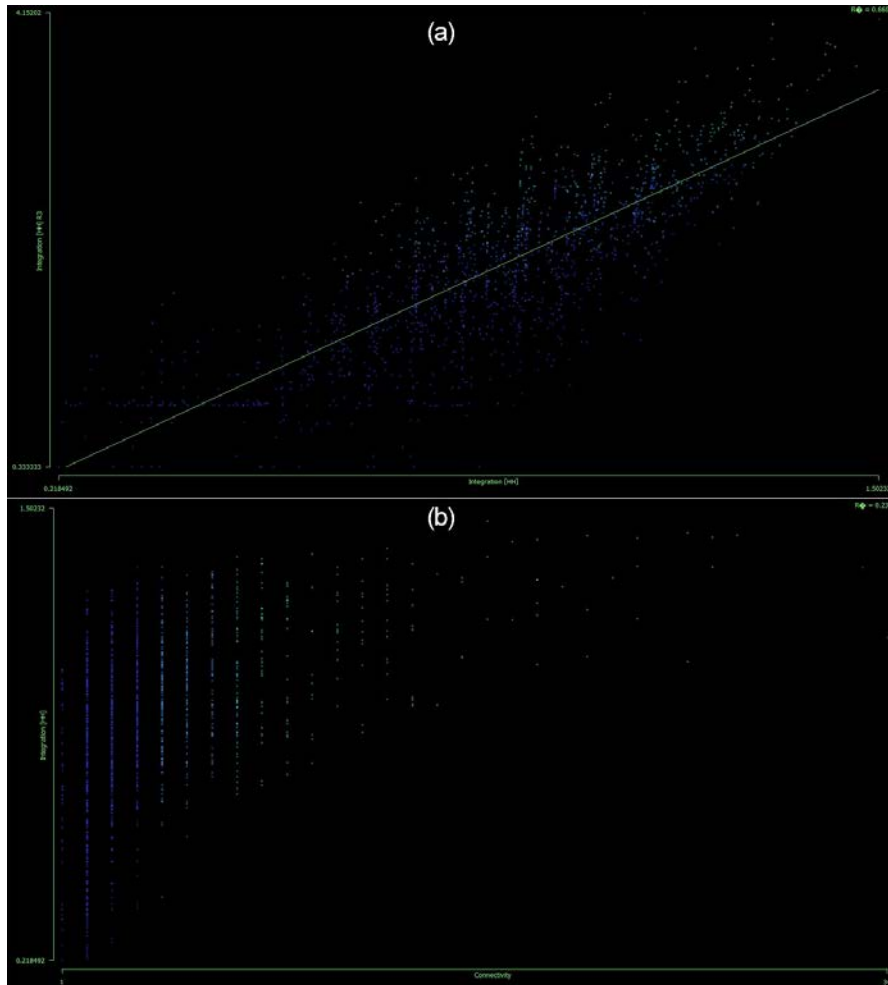


Fig. 11: (a) Synergy diagram, (b) Intelligibility diagram of the city of Oran in 1927 (French period). Source: The authors.

findings of this research provide concrete pathways for preserving Oran's urban heritage and mitigating spatial inequalities inherited from the colonial period. The high syntactic integration observed around the Plaza Mayor in 1736 and the Place d'Armes in 1927 can be leveraged to revitalize these areas within heritage conservation and enhancement strategies. For instance, incorporating the Plaza Mayor and its historical axes into a priority heritage zoning framework could reinforce its role as a cultural and tourist hub, while improving connections with peripheral neighborhoods. Moreover, space syntax methods can be employed to identify the most marginalized areas and propose targeted inclusive planning interventions, in line with the approaches suggested by [Van Nes & Yamu \(2021\)](#). This may include

developing pedestrian linkages, upgrading public spaces, and introducing new economic activities in low-integration sectors. In this way, the syntactic analysis moves beyond a purely historical diagnosis to become a decision-support tool for guiding urban policies toward balanced heritage valorization and the long-term reduction of socio-spatial disparities.

CONCLUSION

Spatial syntax analysis of Oran has made it possible to understand the morphological and functional changes that occurred during Spanish and French rule. The results reveal two contrasting urban models, each shaped by spatial logics adapted to the strategic and political needs of their respective historical periods. In 1736, during Spanish colonial rule, Oran

became an enclosed and fortified city with its center of all activities around Plaza Mayor. The high global and local integration of this space reflected its role as the sole functional epicenter, while peripheral areas remained segregated to optimize military protection. This structure resulted in high synergy in the center but low intelligibility, making orientation difficult and limiting organic expansion opportunities. The city of Oran experienced extensive redevelopment during the French occupation of 1927 through reforms that centered on the Place d'Armes and the newly built boulevards. Global integration was redistributed, improving connectivity in European sectors, while global choice consolidated main corridors as circulation arteries. However, low intelligibility and fragmentation in peripheral neighborhoods reveal how colonial planning perpetuated spatial inequalities, reinforcing physical and social barriers in the city. Oran's morphological evolution illustrates how urban planning decisions, shaped by military, political, and colonial imperatives, have left a lasting imprint on the city's structure. Spatial syntax proved to be a valuable tool for visualizing these dynamics, offering both quantitative and qualitative insights that link spatial configurations to systems of power and control. Beyond historical understanding, this methodology provides a meaningful basis for rethinking urban heritage preservation and rehabilitation strategies, while supporting greater spatial cohesion in future planning interventions.

AUTHOR CONTRIBUTIONS

Nidal Abdenaceur Labdaoui contributed to data collection, conceptualization, and drafting of the manuscript. Ana María Esteban Maluenda provided academic supervision and critically reviewed the manuscript. Alberto Ruiz Colmenar contributed to the writing process and provided supervisory support throughout the research.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, they have witnessed all ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy.

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ABBREVIATIONS (NOMENCLATURE)

<i>GIS</i>	Geographic Information System
<i>HH</i>	Global Choice (High-High) metric in Space Syntax
<i>R3</i>	Local Integration (Radius 3)
<i>RMSE</i>	Root Mean Square Error
<i>Rn</i>	Global Integration (Radius n)
<i>SIG</i>	Système d'information géographique

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