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Evaluation of the Main Properties of the Urban System by the Correlation between the Method of Space Syntax and the Empirical Approach of Kevin Lynch. The Case of Bejaia City in Algeria

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Abstract. Inscribed in the field of reflection inherent to the city as a socio-physical space. This paper aims at highlighting the main syntactic properties of the socio-urban system of Bejaia city. Our methodological choice is based on the corroboration and correlation between two innovative methods dedicated to the characterization of socio-urban spaces. On the one hand, the technique of the "all Line Analyses" relating to the space syntax aims at allowing the interpretation of the relations between the social and the urban. On the other hand, a questionnaire survey with a targeted sample whose aim is to draw up the image of the city as perceived by its inhabitants. The results obtained can be used as analytical support for future research on the city of Bejaia, while constituting a decision support tool for urban managers.

Key words: Mental image of the city; axial modeling; space syntax; urban system; all line analyses.

INTRODUCTION

The city, a complex space, in perpetual mutation, lends itself to metamorphosis. It is a privileged place for wandering, meetings, and cultural mixing (Menegaldo, 2007). Considered as living organisms (Peñalta Catalán, 2011), they are dynamic complex systems (Bettencourt and West, 2010), and our understanding of how they evolve is still severely inadequate (Batty, 2008). As an organism, they must breathe easily, having as a barometer a good permeability irrigating the urban spaces of the city by providing its users with a safe and secure atmosphere (Attar, 2019). The organization of the city by the creation, transformation, and management of its urban system, remains a confluent worksite open to multidisciplinary reflection. In his general theory of urbanization, Cerdá (1867) considers the chessboard pattern to be the guarantor of certain social equality, and according to him, it ensures the homogeneity and regularity of the urban system. According to Sitte (1889) who was very critical of the dogma of orthogonality and symmetry of cities, this form of isotropy suppresses the city's historical and cultural substratum. According to him, the city should be approached place by place through the sensitive experience and its aesthetic implications, giving particular importance to the layout of squares.

Faced with the amplification of the effects of industrialization on socio-urban spaces, the first half of the 19th century was marked by two distinct models of urbanism. A progressive model that rejects all the artistic heritage of the past, to submit exclusively to the laws of a "natural" geometry with rationalism dominated by the idea of progress. Also, a culturalist model that attempts to integrate the community and cultural values resulting from the history of modern societies, and does not reject the aesthetic and morphological lessons of historical urban ensembles (Choay, 1965). Both models were controversial, especially by the urban planning philosopher Jacobs (1961). In her book entitled "The death and life of great American cities" she claimed that the public spaces derived from the modernists' "city in the park" notion, were one of the main reasons for the rising crime rate, she proposes instead an urban eye on the street approach through the reconsideration of public squares and street furnishings.

Whether cognitive, empirical, or normative, the urban methods and approaches that have succeeded one another over time reveal a relational interaction between human behavior and the urban environment. It is therefore essential to

have a precise tool to build a complete and verifiable theory allowing an efficient representation and characterization of urban space.

With the advent of computers in the 1960s, urban studies have experienced a new boom (Jormakka, 2007). In this regard, Christopher (1977) proposed an innovative alternative to produce projects or to improve a city, through a generative grammar able to propose solutions to each problem encountered during the design; the sum of solutions revealed forms a language that Christopher called "A pattern language" hence the title of his work. This approach allows non-specialists to understand architectural or urban options and then to make informed decisions (Jormakka, 2007).

By the way, the book entitled "The image of the city" published by Lynch (1960) is an essential reference for innovation in urban visualization systems; it proposes an empirical approach to the mental representation that city dwellers make of their city (Orillard, 2014). According to him, relationships are woven between elements and human beings, which gives the "imagibility" of the city. According to Kevin Lynch's methods, urban imagibility is a result of visual form perception and social significance conceptualization (Gulick, 1963). However, cities that are viewed as systems for making connections and generating encounters have often grown to isolate people, resulting in anonymity; this can lead to spatial segregation, social inequalities, or unequal access to services and infrastructure (Hillier, 2016). Noting this, and based on the neo-empiricists mentioned, Hillier and Hanson (1984) developed the method of spatial syntax differing from their predecessors in the importance given to the concept of mobility in the functioning of a city, and in the advancement of computer science that allowed the development of modeling tools (Laouar and Mazouz, 2017). It is a method of analysis, which represents and quantifies aspects of spatial pattern based on the geometry of the environment (Penn, 2003; D'Acci, 2019).

The space syntax is based on the use of computer techniques to analyze the configuration of urban space (Ratti, 2004). "One of the major purposes of space syntax is to understand the influences of spatial configurations on social life" (Oliveira 2016, p. 124). Jormakka says to this comment "according to the inventors of spatial syntax, social relations can always be reduced to spatial relations and vice versa, both being dependent on configurations that refer either to people or spaces" (Jormakka, 2007, p. 45). Although it is not a panacea, the space syntax is a potential and fruitful answer for the deciphering of socio-urban configurations.

In this research work, we have chosen as a case study the city of Bejaia in Algeria, a medium-sized city that, like many Algerian cities, suffers from a multitude of obvious urban dysfunctions involving socio-spatial segregation. Following the little works that we have counted about the urban system of this city and on its future, we judged it opportune to proceed to its analytical evaluation, to obtain an efficient diagnosis for any eventual decision of urban intervention. This is why our methodological choice was to combine the technique of the axial map, based on the spatial syntax approach, and the empirical approach of Kevin Lynch. It will be a question of proceeding to the numerical modeling of all the cities of Bejaia, before exporting it towards the software "Depthmap" to carry out the syntactic simulations able to enlighten us on the main properties of the configuration of the urban system. It is in particular a question of evaluating the global integration of this system, knowing the quality of the global and local intelligibility, and defining the air of the centrality of the city. Once this quantitative analysis has been carried out, it becomes necessary to evaluate its content by confronting the results obtained with a survey carried out in the field using targeted questionnaires. Through this survey, we aim to get a better understanding of the reality of the socio-urban setting, by getting closer to the mental image of the city as perceived by its users.

The obtained results will be the object of support of reflection for other future researches inherent to the urban landscape and the socio-spatial environment of Bejaia city.

METHODOLOGY

Presentation of the Case Study (Bejaia City)

Bejaia, formerly Bougie, is an Algerian municipality located on the Mediterranean Sea, 181 kilometers east of the capital Algiers. Resulting from the administrative division of 1974, the Wilaya of Bejaia is organized in 19 Daïras (The Daïra is a subdivision of the wilaya in the Algerian territorial administration that includes several Communes), six of which are coastal (Souk El Tenine - Aokas - Tichy - Béjaia - Adekar - Akfadou) and 52 Communes. It is located in the north of the country, overlooking the southern shore of the Mediterranean. With its 177 988 inhabitants at the last census of 2008 (RGPH, 2008), Bejaia is in terms of population the largest city of Kabylia (Kabylia is a historical region located in

northern Algeria, east of Algiers. Land of densely populated mountains is surrounded by coastal plains to the west and east, to the north by the Mediterranean, and to the south by the high plateaus.). It is equipped with an important road network made up of four national roads that serve it; its urban perimeter extends on a surface of approximately 3000 Hectares. Bejaia has all the infrastructures of service and communication necessary to the good functioning of a city. It is equipped with a bus station, a railway station, a maritime station, an airport, and a port.

Gaid (2008) in describing the city of Bejaia had written, "The golf of Bejaia, on the edge of which the city rises in an amphitheater, offers the aspect of a vast lake surrounded by a curtain of mountains with capricious profiles. Exceptional from a strategic point of view, the site of Bejaia will be constraining for the urban development of the city (Figs. 3, 4). The region of Bejaia was the cradle of several rich and diversified civilizations that have marked its territory for several millennia. This is due to the following reasons: the particular configuration of its roadstead (Féraud, 2001); its defensive relief that shelters it from the prevailing winds of the north and west; its strategic position and its openness to the Mediterranean Basin; its immeasurable tourist potential and its commercial mediation between Europe and Africa. At the same time, these characteristics make the city of Bejaia a source of conflict that will earn it incessant attacks from within and without.

The current city is made up of a historic core to the north, which rises like an urban hill 150 meters above the plain. It also consists of a set of planned urban entities geometrically occupying the central zone of the urban perimeter known as "the plain". A series of informal urban extensions on a capricious relief with steep topographic slopes, encircle the plain in a horseshoe shape (Figs. 1, 3). However, the urban evolution of the city of Bejaia seems to be doubly determined by its eventful history but also by its topography, which largely explains its development (Benazzouz, 2009) (Fig. 1).

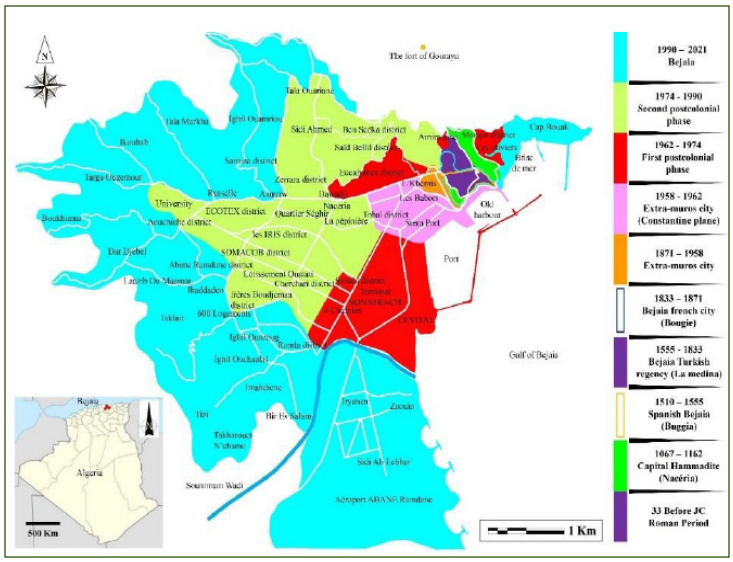


Figure 1. Urban evolution of Bejaia city

Figure 2. Photos of Bejaia city

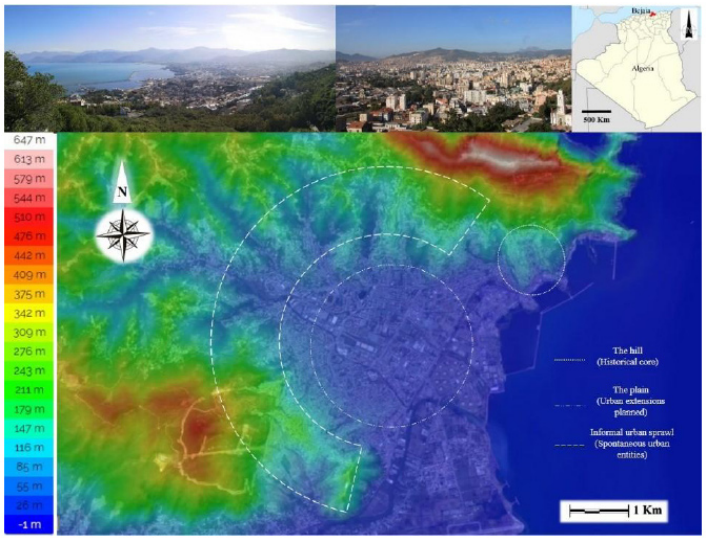


Figure 3. Topographical map of Bejaia. Source: (http://fr-fr.topographic-map.com) Treated by Authors (2021)

Figure 4. View on the city of Bejaia

Methodological Principle

Initiated by Bill Hillier and Julienne Hanson at the Bartlett, University College of London, in the early 1980s, the spatial syntax is an approach that focuses on the analysis of spatial configurations of architectural objects and urban spaces. Considering the influence of spatial morphologies on the distribution and frequentation of spaces, it aims to allow the interpretation of the relationship between the social and the urban (Hillier, 1996; Matejcek and Pribyl, 2020). In other words, spatial syntax establishes a significant correlation between the topological accessibility of routes and phenomena such as pedestrian and mechanical frequentation, orientation, security against vandalism and incivilities, location of shops and activities, etc. (Mazouz, 2013 apud Porta et al, 2006). Its use provides a framework for combining logical analysis in city space planning with traditional spatial perception. Space syntax is a mode of thinking that is solely based on spatial ontology. (Chen, 2017).

Concerning urban space, a route is divided into sequences corresponding to the different modifications of the visual field (Allain, 2004). It is accepted that an urban sequence is composed of ahead of the movement, a body of the movement, and then another head of movement (Hammou, 2010). The sum of the different urban sequences forms a mobility network in the form of a grid, which is made up of vertices and lines (Kerboul, 1997). The vertices are the spaces that mark the end of one linear route and the beginning of another; they are urban spaces that imply a strong social

interaction. Based on this, spatial syntax considers that the choice of people to take a particular route is conditioned by the physical and visual permeability of the space that ensures accessibility, and that convex spaces are best suited to the level of vertices since they maximize inter-visibility in space. The lines between the vertices are the supports of our path, which is of dynamic order; they must be straight as much as possible to ensure a visual permeability between two vertices. It is this discursive reasoning that makes the concept of the axial line the fundamental basis of urban syntactic analysis, and where convexity and axiality go hand in hand to form our experience of space (Hillier, 1984), an axial line that runs through many spaces makes the urban system shallow and accessible. The sum of interconnected axial lines, detected from a given spatial system, forms an axial map. Once established, this map allows the modeling of different urban configurations by using topology and mathematical graph theory. The complexity of the calculations will be spared by the computer (Hillier et al, 1987) which will reveal important indicative values such as, the depth of the system, its connectivity, and its integration (Hillier, 1993). The specialized software of the spatial syntax having the capacity to measure the least variations of the spatial morphology, give us numerical results of output (Output) which can be visualized in the form of graphs or the form of maps, with a beam of degraded colors as an indicator of the various syntactic measures obtained (Laouar and Mazouz, 2017).

Integration is the most important property of the urban grid, and is defined as the path requiring the minimum number of directional changes, and passing through the maximum number of nodes. It expresses the degree of spatial accessibility of a street relative to others belonging to the same city (Van Nes, 2021). Winding or segmented urban routes reduce the integration values of the system hence the importance of the concept of depth, each directional change needed to join two distinct urban spaces is called a depth step. A depth step means a direct accessibility relationship between two spaces. It is also necessary to measure the number of lines directly connected to a depth step of each line belonging to the axial map. All these static local measures are expressed in a connectivity map, which reveals the urban entities best served by the road network. According to Hillier (1998), "An integrated urban space tends to draw other spaces in the system back to itself" (Hillier, 1998, p. 36). The syntactic approach also addresses the concept of control and the concept of choice. According to Mokrane (2011), the first is a dynamic local measure of the extent to which a given space controls access to other surrounding spaces. While the second represents the probability for a space to be chosen among others as a route by a walker (Mazouz, 2013).

Another measure, known as the second degree, but which is not lacking in relevance, is that of intelligibility, which seems to take up quantitatively the notion of legibility developed in the work of Kevin Lynch. The system is qualified as intelligible when each space having good connectivity at the local level is at the same time integrated into the whole system, which thus becomes legible from its constituent parts. The intelligibility is a ratio between the measure of integration and connectivity, which is calculated in each space and represented in a diagram. A correlation coefficient R2 is calculated, if it is greater than 0.50, the resulting scatterplot will approach a 45° line and the system is said to be intelligible. If R2 is less than 0.50, the system is said to be unintelligible. (Mokrane, 2011).

In this research, we will proceed to the modeling of the entire city of Bejaia. Using Autocad© software, and based on several cadastral plans updated by the latest Google Earth satellite images, the resulting digital map will be exported to the spatial syntax software Depthmap©. We will start our modeling by generating the axial map that will be translated into measurable indicators. In our present investigation, we will limit ourselves to the analysis of the connectivity, the global integration (HH) of the city, the average depth of the system, and its intelligibility. We will then focus on local integration with three, five, and seven depth steps to detect possible peripheral centralities.

Once the properties of the urban grid are highlighted, a verification of the conformity between the distribution of the important facilities in the urban space and the global HH integration map is necessary. The superposition of the two maps will shed more light on the effective integration of the system, and it will allow us to detect possible boundaries and barriers to urban growth, which generate spatial discontinuities and considerably reduce the quality and proper functioning of the urban system.

The second stage of our investigation consists of evaluating the content of the quantitative analysis mentioned above, by confronting the results obtained with a survey conducted in the field using targeted questionnaires. It is about revealing the image of the city by the method of Kevin Lynch whose thesis has been widely cited in urban planning, social science, and environmental psychology research (Banai and Rapino, 2009; Morello and Ratti, 2009; Pocock et al, 1978). Lynch's work sparked a slew of follow-up research (de Jonge, 1962; Evans et al, 1981; Francescato and Mebane,

1973; Goodey, 1971; Gulick, 1963), His legacies prompted renewed interest in cognitive-environmental planning and design (Mondschein and Moga, 2019; Vale and Warner, 1998).

Through this survey, we aim to get a better understanding of the reality of the socio-urban setting, by getting closer to the mental image of the city as perceived by its users. This survey will be concluded by a synthesis map containing all the information related to the quality of the urban space of the city of Bejaia, in terms of permeability, integration, urbanity, legibility, and intelligibility. For this qualitative analysis to be credible, we sent a pre-established questionnaire to 300 people randomly selected among the inhabitants of the city of Bejaia. For this purpose, we prepared a map with the Oued Soummam, which crosses the city from south to southwest, the emblematic Fort Gouraya (The name of Gouraya would come from the Vandals who would have made Bougie their first capital. In their language. Goura means mountain. This mountain takes its name from a marabout, Lalla Gouraya, who was buried there. The Gouraya fort occupies the highest summit with a dominant view on the city (680 m); it is located right north of Bejaia (Féraud, 2001, p. 25)) (Fig. 2), the harbor jetty, and the boundary between the city and the sea (Annex 1). We then asked the interviewees to reproduce their image of the city of Bejaia on the pre-established support, their drawings had to contain the smallest details concerning; the districts, the edges, the paths, the nodes, and the landmarks of the city (These are the elements of the city used in Kevin Lynch's empirical approach (Lynch, 1960)). A quick map that we asked the respondents to draw as a quick description of the city of Bejaia. They were also asked to mention the urban entities in which navigation is easy, and where one can easily find one's way, as well as the places that they do not frequent or that they consciously avoid. To make all the expected drawings easily usable, we asked the interviewees to use the same symbols proposed in the graphic support (Annex 1).

The superposition of the maps thus obtained gives rise to the collective image that the inhabitants of Bejaia city have of their city. This synthesis map allows us to identify possible problems inherent to the structure of the urban system and its integration, to the visual form of the city, to its legibility and intelligibility. In addition, this map reveals the current centrality area of Bejaia city. All these properties relating to the configuration of the urban space revealed by this map will be compared to the results obtained by the syntactic simulations during the quantitative analysis. The correspondence between the two analytical approaches will allow us to define with more precision the spatial configuration of the urban system of Bejaia city.

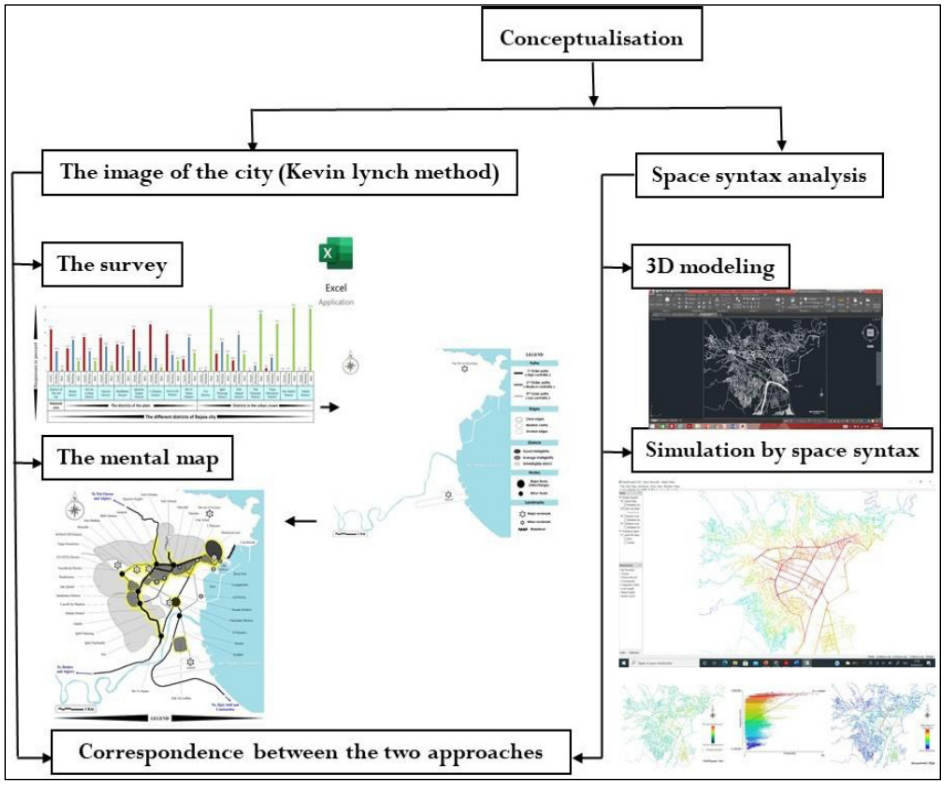


Figure 5. Methodological framework

RESULTS AND DISCUSSION

We will first present the results revealed by the syntactic simulation of the axial map, before moving on to the results of the questionnaire survey conducted among a sample of inhabitants of Bejaia city.

Results of the Syntactic Analysis Revealed by the All-Line Analysis Technique

The syntactic simulation through the axial map and the technique (all Line Analysis) applied to the city of Bejaia, provides us with an efficient diagnosis of the structure and spatial configuration of the urban system of the city. The axial map of the Bejaia city includes 6098 axial lines of various lengths, which is immediately considered as a high number compared to an average city whose urban perimeter is around 30 square kilometers.

Connectivity, Permeability, and Route Choice

The connectivity map gives us information through a cluster of colors on the connectivity of each axis belonging to the system, from the most connected in red to the least connected in blue, whose values are mentioned in "Table 1". We will only mention the axes with a high degree of connectivity (Figure 6), which appear in red on the map as follows:

- The B axis is called "Freedom Street" with 39 connections at one-step depth.
- The C axis is called "Route des Aurès" with 36 connections at one-step depth.
- The A axis is called "Boulevard Soummam" with 34 connections at one step of depth.
- The D axis is called "Boulevard Krim Belkacem" whose connectivity varies between 13 and 31 connections to a step of depth.
- The national road 09 (RN9) with 20 connections at one-step of depth.
- The L axis is called "Boulevard Lieutenant Ferdjallah Mohand Oulhadj" with 17 connections at one-step depth.

We note that all these axes are located in the lower part of the city, known as "the plain", and whose road system is a simple grid. The further away from these axes, the more the connectivity of the other axes of the system decreases. This implies a heterogeneous physical permeability within the city. The district of L'khmis is thus the best-connected and most permeable urban entity of the system, followed by "Quartier Seghir" and the area of "Sid Ali Lebhar". We also note that in these urban entities that enjoy a good physical permeability, the road system is in simple mesh forming balanced and medium-sized blocks, this spatial configuration offers a varied choice of routes for the benefit of pedestrian and mechanical mobility. The city's peripheral entities thus appear to lack this quality.

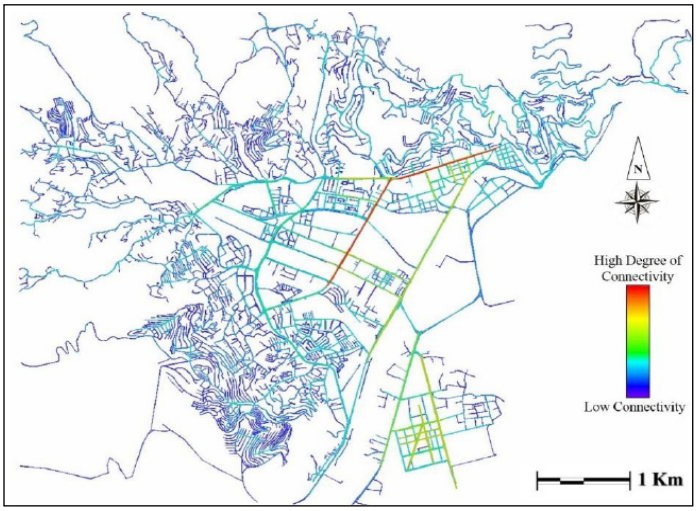


Figure 6. Axial map (all line analysis): Global connectivity of Bejaia city (Dephtmap©)

Integration, Depth and Definition of Potential Centrality Area

According to the results from the syntactic simulation, the inherent map of the global HH integration at radius n (Fig. 6), reveals an integration kernel in the shape of a crushed glove or a deformed bicycle wheel (Hillier, 1989). This core

consists of the axes "A, B, C, D, F, H, I, J, K, T" which are almost all located around the periphery of the plain area with integration values as high as 0.82. However, we can classify these structuring axes of the city into two categories. The first category is furnished by a linear built-up system densified and animated by commerce, which makes it an important place for pedestrian and mechanical traffic, and thus gives it the qualification of streets rather than roads. It is around these axes that the centrality area of the city is drawn. This category includes the axes (B: Freedom Street, D: Boulevard Krim Belkacem, T: Street Boudechicha Tahar, K: Road Boukhiama). A second category corresponds to roads of great vehicular flows, it includes the axes (A: Boulevard Soummam, C: Route des Aurès, F: Rue Boumdaoui Nacer, J: Boulevard Boudechicha Tahar, H, I). we can consider it as a potential centrality zone.

Around these structuring axes, a first ring from the north to the southwest of the city appears in orange with average integration values that do not exceed 0.49. This urban area is made up of a dominant tree-based road system with a few looped systems included inside. A second ring surrounds the first one on sloping terrain, with low integration values equivalent to 0.14, it is mainly constituted by a tree-like road system and appears on the map with shades of green and blue. The map of local integration (radius 3), reveals an urban entity that stands out with its good integration that appears with an orange color tending to red (Figure 7), it is the recent urban area of Sid Ali Lebhar located south of the city whose system is checkerboard constituting a secondary centrality.

We also note the eccentricity of the historical core of the city about the global integration core, which is not consistent with the generic model of the cities studied by Hillier (2001) in which the historical core has strong integration values. We find an explanation for this in Ratti (2004), who criticized the syntactic method for its inability to take into account the relief and three-dimensionality associated with urban systems. Figure 3 shows us that the relief and morphology of the site housing the historic core of the city are the reasons for its partial separation from the global integration core. Similarly, for all the urban entities of the upper city, where the integration values were very low, the relief of the site converts the grid-like road system of the lower city into a tree-like system that follows the contour lines in the upper part of the city. However, the most segregated areas revealed by the global integration analysis at radius (n) are revealed again in the local integration maps at radius 3, 5, and 7. They have in common their purely residential character assimilated to dormitory towns. This urban reality is confirmed by the values of the mean depth (Mean Depth), as well as the mean depths R3, R5, and R7, which increase as one moves away from the integration core towards the upper part of the city (Table 1).

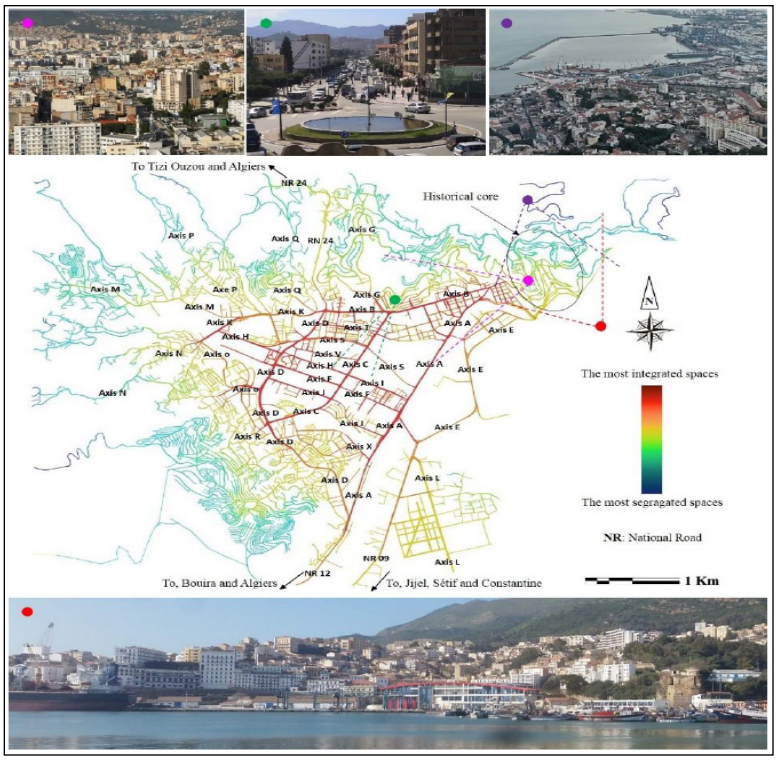


Figure 7. Global integration [HH] at a radius n of Bejaia city (Dephtmap©)

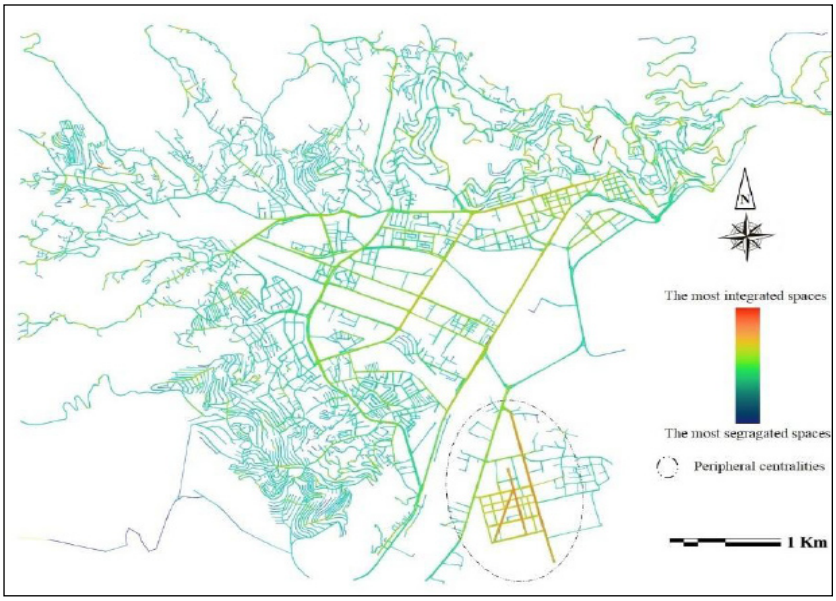


Figure 8. Local integration [HH] at a radius R3 (Dephtmap©)

The Integration Network and the Distribution of Magnets Between Discrepancy and Conformity

We note a certain concordance between the distributions of facilities concerning the overall integration core of the city, whereas the entire urban ring around the plain is devoid of urban facilities apart from the historic core to the north, which enjoys an important variety of magnets. However, many anti-urban facilities are grafted onto the most important axes of integration, occupying very large areas such as security facilities (military barracks, gendarmerie, etc.). A third of the city is also occupied by an industrial zone that practically empties the overall integrated system of its supposed urbanity (Fig. 8). The axes confined to this zone are converted into urban corridors furnished with long walls of fences on both sides, limited to ensuring important mechanical mobility. The same goes for the port, which now constitutes a physical barrier between the city and the sea. This configuration considerably reduces the effect of centrality in the city, whose area spreads from the historic core, through the first extensions extra-Muros before embracing the perimeter of the lower city linearly. The urban area of Sid Ali Lebhar in the south, which constitutes a secondary centrality in the city, is an area both disconnected and enclosed from the core of global integration of the city, and which enjoys at the same time a certain functional autonomy because of the various urban facilities it has. The situation of this entity between the sea in the East, Oued Soummam from North to South-West, and the airport ABANE Ramdane in the South (Fig. 1), only accentuates the enclavement of this urban area.

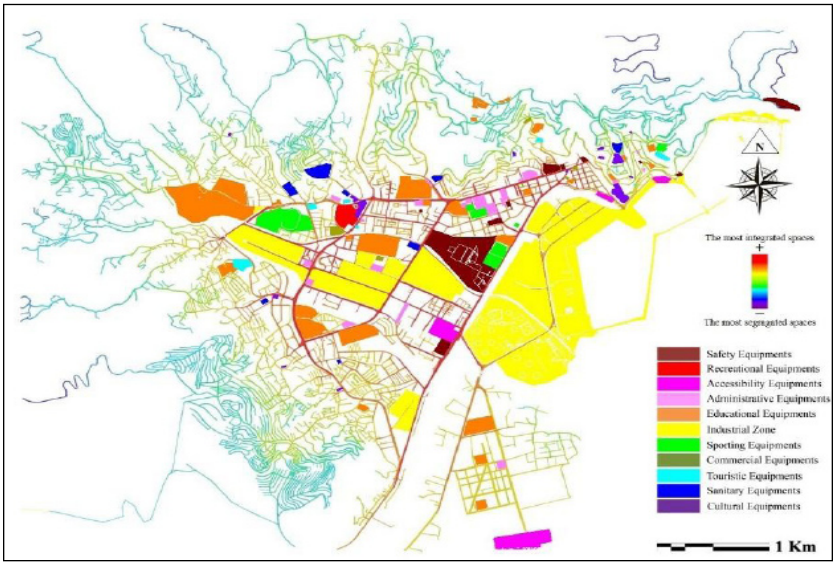
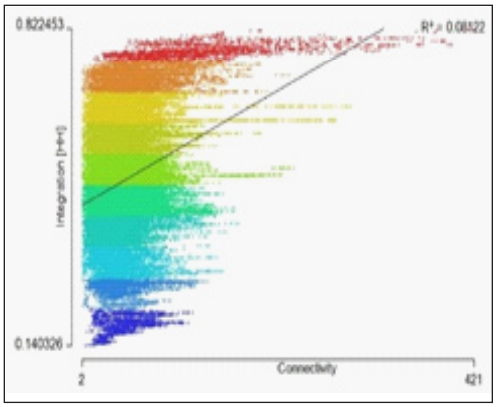


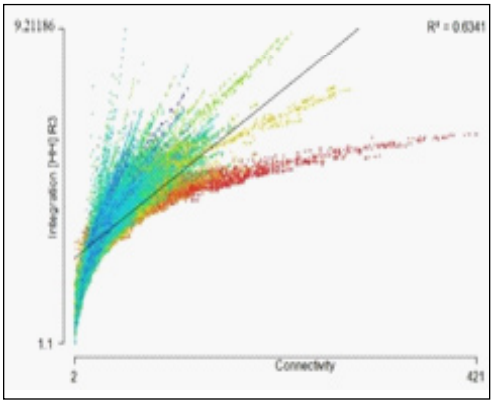
Figure 9. Distribution of urban equipment around the global integration system of Bejaia city

Intelligibility and Legibility of the Urban Structure

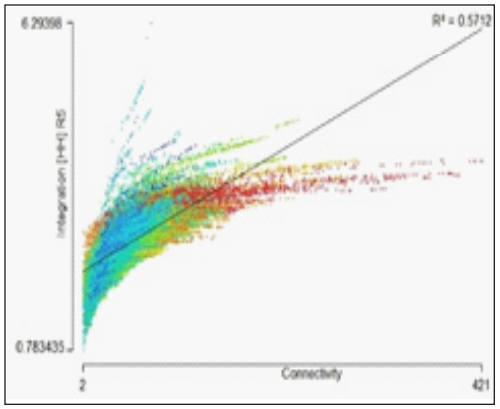
Concerning the global intelligibility of the system, graph 1 reveals a correlation coefficient R2 of 0.081 with a scattered cloud of points meaning that the system is very little intelligible. Graphs 2, 3, and 4 give us information on the local intelligibility at three, five, and seven depth steps, whose R2 correlation coefficients decrease considerably with the multiplication of the depth steps. This implies relatively good readability and intelligibility at the local level limited to each urban entity, but which is progressively lost and becomes more confusing as soon as we move to a higher level encompassing a larger number of urban entities.



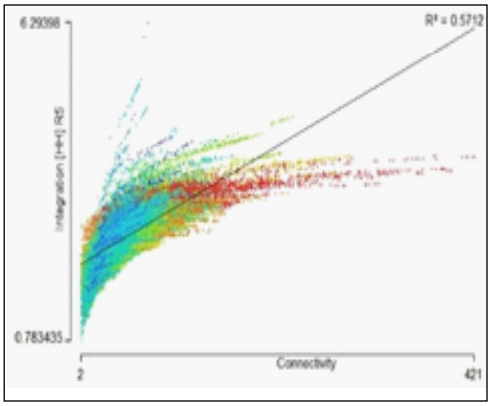
Graph 1. Global intelligibility



Graph 2. Local intelligibility at a radius (R3)



Graph 3. Local intelligibility at a radius (R5)



Graph 4. Local intelligibility at a radius (R7)

Table 1. Results of the main syntactic properties

	Average value	Minimal value	Maximal value
Connectivity	4,554	1	39
Global Integration [HH]	0,497	0,14	0,82
Integration [HH] R3	4,218	1,1	9,211
Integration [HH] R5	2,550	0,738	6,293
Integration [HH] R7	1,909	0,627	4,076
Mean Depht	31,094	17,651	98,591
Mean Depht R3	2,267	1,333	2,915
Mean Depht R5	3,632	1,763	4,722
Mean Depht R7	5,050	2,227	6,627

Image of the City and Properties of the Urban System Revealed by the Questionnaire Survey

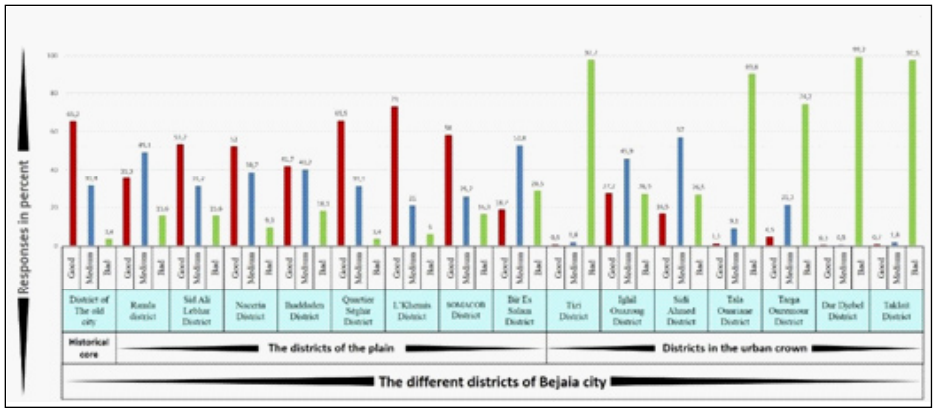
After asking the respondents to reproduce the image of their city based on its five constituent elements, we superimposed all the maps produced by adjusting them to scale, thus constituting a synthesis map (Fig. 9). The latter contains relevant information on the integration of the city's different urban entities, on the global and local intelligibility of the urban system, and the current centrality of the city of Bejaia. We also asked respondents for their opinions on the

integration of the city's different neighborhoods, on the degree of intelligibility of these neighborhoods, and on the city's most frequented axes and neighborhoods in which navigation is easy. We received various opinions with many recommendations from the sample of people interviewed. The majority of respondents agreed that the urban system is unintelligible and discontinuous and that the city is anarchic and disorderly, with no logical urban composition. The main results are summarized in the following points.

Global and Local Integration

Regarding the overall integration of the urban system of the city of Bejaia, 84.8% of respondents consider it very poor, while the remaining 15.2% describe it as average. As for the quality of local integration, the survey revealed that the most integrated urban entities are located on the plain, while the various neighborhoods constituting the urban crown from north to southwest (Fig. 2, 3) are the least integrated of the urban system. These results seem to largely corroborate those obtained from syntactic simulations using the axial map technique.

However, the historical core located on the hill (Fig. 3) is an exception; it turns out to be perceived as the best-integrated urban entity after that of the Khmis (Graph. 5). The survey also reveals that the neighborhoods of Dar Djebel, Tizi, Taklait, and Tala Ourane, in that order, are the most segregated in the city, and according to the majority of the people we interviewed, they require serious attention before they are transformed into a lawless area. Furthermore, some researchers ranked "landmark" as the most important element for the image of the city (Golledge and Spector, 1978; Hart and Moore, 1973; Siegel and White, 1975), while others consider "path" and "district" as the most important in the Lynch method (Appleyard, 1970; Appleyard, 1976). It so happens that in our case study, all the landmarks mentioned (Fig. 9) are located on the integration core of the city, it is the same for "paths" and "districts". This is consistent with Kim's (1999) analysis that spatial integration is correlated with empirical observation.

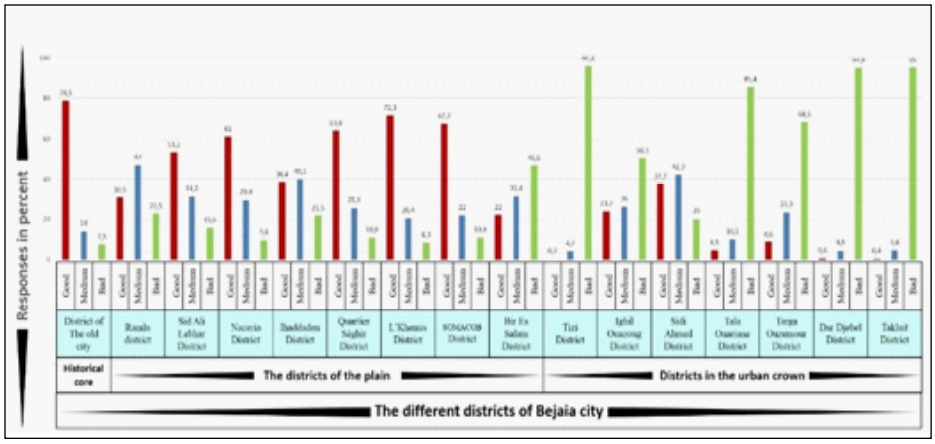


Graph 5. The quality of integration of the different districts of Bejaia city revealed by the questionnaire survey

The Intelligibility of the Urban System

In urban areas, proper intelligibility has been shown to be a crucial predictor of human behavior, promoting people's navigational abilities (Jiang and Claramunt, 2004). One of the key criteria for a city's successful functioning is the high quality of its itineraries (Wheeler, 1998). In our case study, the overall intelligibility of the urban system of the city is considered by the interviewed inhabitants to be poor, especially in the peripheral districts of the upper parts of the city. In some number of urban spaces, navigation requires a perfect knowledge of the places, or strolling for people who are strangers to the district is almost impossible. However, the graph of local intelligibility (Graph. 6) shows the relative quality of intelligibility of the different areas of the city. 78.5% of respondents consider the historic core of the city to be the most intelligible urban entity, due to the legibility and good permeability it enjoys. The quality of intelligibility in the part of the plain varies from one neighborhood to another between good and average, the most intelligible neighborhoods in this area are; the district of Khmis, the city SOMACOB, district Sghir, and the area Naceria.

It should be noted that many neighborhoods were not cited by respondents, and therefore do not appear in the graph, the fact that they are not cited, by omission or voluntarily, means and reflects their unintelligibility concerning the rest of the urban system. As for the peripheral urban ring, it appears like a labyrinth devoid of any landmark and any logic of urban composition. Except for the district of Sidi Ahmed and to a lesser degree that of IghilOuazoug, where opinions are more divided between "Good intelligibility" and "Average intelligibility". The same neighborhoods, whose integration was very poor, are once again the most segregated and the most unintelligible of the urban system.



Graph 6. Intelligibility of the different districts of Bejaia city, resulting from the questionnaire survey

The City's Centrality Area

The concept of urban centrality does not have a widely accepted definition and measure (Pereira et al, 2013). However, by the centrality area, we mean urban spaces that can attract a significant pedestrian and mechanical flow, and where walking is done in a safe and secure environment. These are the most frequented urban spaces that enjoy good physical and visual permeability and are endowed with an important urbanity (Yao Shen, 2017; Porta et al, 2012; Bertaud, 2001). The considerable presence of urban facilities and commerce implies a social and functional mix that enlivens the urban space.

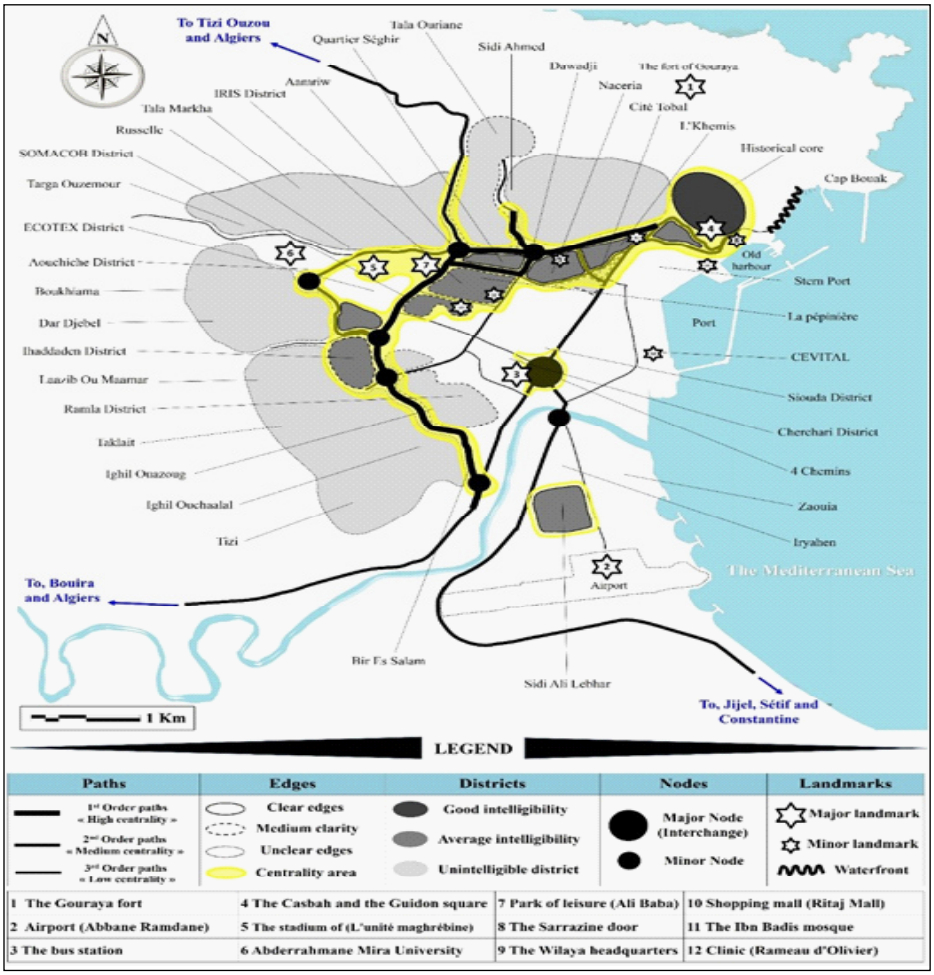


Figure 10. The mental map of Bejaia city resulting from the questionnaire survey

In this investigation, the aim is to identify the configuration and delimitation of this area of centrality, which constitutes the city's entire urban living space. To this end, Figure 10 illustrates perfectly the centrality area inherent to the city of Bejaia as perceived by its inhabitants. First, we note its nebulous horseshoe shape, starting from the old city in the north and ending in the Bir Es Salam district in the south. It extends along the "B, D, T, G, K, O, and L" axes (Fig. 6), which are also expressed by the thickest black lines (Fig. 9). These axes of centrality cross and connect several neighborhoods in the city, including the Khmis and Old Town neighborhoods, which are distinguished as spaces of hyper-centrality in the city according to the sample of interviewees. The survey also allowed us to identify three moments of strong centrality in the city, namely the Dawadji node, the Aamriw node, and the bus station located in the "Quatre Chemin" area, considered to be the most important landmarks in the urban system (Fig. 9). The Sidi Ali Lebhar neighborhood in the southeast of the city is also cited by 52% of respondents as an urban space with a strong centrality despite its isolation from the rest of the city's urban system. It thus constitutes a peripheral centrality (Fig. 9).

It should be noted, however, that the area of centrality revealed by the survey presents considerable urban discontinuities by passing from one district to another, either by anti-urban facilities or by urban wastelands that interrupt the urban dynamic. Moreover, the axes of strong centrality are often furnished and animated on one side only, while the opposite side remains devoid of any urbanity, being content with being a space for pedestrian mobility.

CONCLUSION

The technique of the axial map, which is part of the syntactic approach, proved to be an efficient tool to reveal the morphological properties of the socio-urban space of Bejaia city. Comparing the resulting mental image of the city (Fig. 9) with the different maps revealed by the syntactic simulations, we find a large corroboration between the two results. The people interviewed during the questionnaire survey confirm all the syntactic values obtained, except for the case of the old city where the historical and symbolic dimension of the place confers to this urban entity a better quality of integration and intelligibility contrary to the syntactic results, which are inherent to it.

The investigation carried out until then through the axial modeling of the syntactic approach, and the questionnaire survey with a targeted sample, allowed to put in exergues the main properties inherent to the configuration of the urban system of Bejaia city. The correspondence between the two approaches adopted for this research work revealed a city in the form of a heterogeneous entity, a city established on a natural amphitheater with a stage in the middle surrounded from north to south by superimposed tiers in the form of an arch. The stage is a hybrid urban fabric with some residences, a large industrial area, and a large military right of way in the center, its road system constitutes the core of global integration of the urban system. On the northern bleachers, the historic core of the city has been reduced about the whole system, while retaining its attractive character thanks to the facilities it contains. The urban bleachers that encircle the scene from north to southwest constitute a large informal urban fabric with a residential character, with the appearance of favelas left to its inhabitants. From the contrast between the different urban configurations to the important imbalance between the size of the different islets, the urban stay bathes in confusion and remains to be defined. We can summarize the dysfunctions of the urban system as follows:

- Lack of physical relationship between the city and the sea, due to the railroad that forms a first barrier between the two, and due to the location of the port and the port activities it implies.
- Two-thirds of the lower city is occupied by anti-urban facilities around which several informal dwellings gravitate, reducing the role of the city's structuring axes to their simple function of distributing the mechanical flow.
- Worrying segregation of the entire urban area located in the upper part of the city (Figure 2), which continues to grow in the form of illicit and informal urban sprawl. The excessive number of dead-end roads and the total absence of urban facilities further enclave this area, which lives only through local commerce.
- A flagrant imbalance between the shape and size of the blocks involving serious problems in terms of accessibility and permeability.

To mention only those, this cascade of malfunctions transforms the city into an unintelligible entity in the eyes of its inhabitants, thus denying them the opportunity to live fully in their city. To overcome the various anomalies that hamper the smooth functioning of the urban system of the city of Bejaia, serious measures must be taken in the short, medium, and long term.

In the short term, it is urgent to slow down the current *urbanification* (Term proposed by Gaston Bardet in French language, to designate the spontaneous phenomenon of urban development, as opposed to the organized expression, i.e. urbanism (Bardet, 1941); by a firm control and management of the city, while invigorating the enclosed areas through appropriate urban operations and the injection of a certain number of urban magnets. This will only happen if the various problems related to land are resolved. In the medium term, permeability should be optimized through restructuring to balance the size of the blocks, increase connectivity, and strengthen the integration core of the urban system. In the medium and long term, it is necessary to prepare for the delocalization of the industrial area. We propose for this purpose its delocalization to the town of El-Kseur to about thirty kilometers, given that the latter already has an industrial area with plausible possibilities of extension. It would also be more appropriate to relocate the port and activities inherent to another economic port such as Djendjen, which is located in the city of Jijel to about sixty kilometers and is more suitable to accommodate other port activities by its location and size. The military barracks located in the middle of the city are also to be relocated to another site. The land cleared will be able to house the equivalent of half of what already exists in the city of Bejaia as an urbanized site. Reason for which the urban managers of the city should conduct a thorough reflection on the future of these urban areas able to allow the city to reorganize and get out of its slump.

Furthermore, spatial syntax also allows for the measurement of other spatial variables related to social or economic activities such as; the location of businesses in the city, pedestrian and mechanical mobility, walkability in the city, land values, economic investment opportunities, centrality, crime distribution, and the impact of potential infrastructure projects on the city. These are all topics that can refine the management of the socio-urban framework, especially through coupling with geographic information systems, while involving the whole of civil society in decision-making. The results with which this investigation ended could serve as a support of analysis for future researches inherent to the city Bejaia and its urban system while constituting support of decision support to the service of its urban governors when it is the question of the socio-urban framework and its future.

ANNEXES

Annex. - Cartographic support of Bejaia city established for the questionnaire survey

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