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Comparative study of the correlation between the spatial configuration and its visual quality with the modalities of use. The case of social and collective housing districts.

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ABSTRACT

Large high-rise housing estates share a common history whose geographical context does not seem to be relevant. They are today, in the same way as the populations who inhabit them, often equated with delinquency and lack of safety. The present research attempts to go beyond the preconceptions inherited from sociology and the prejudices amplified by the media and aims to investigate the urban reality of three large housing complexes resulting from successive development policies adopted in Algeria. To do this, the context chosen is that of Bejaia's suburbs, an average southern Mediterranean city, and a representative sample of cities of its size. The approach refers to Hillier, who considers mobility as the modality use that most likely to inform us about the potential uses of spaces (Hillier et.al 1984). This modality is itself guided by vision, which leads us to scrutinize any variation in visible space that may influence it, particularly the angles of deviation of routes, the degrees of openness of spaces and their overall three-dimensional properties. It is based on the study of the urban landscape's qualities and the modalities of use, by using the combined methods of syntactic analysis and analysis of visible environments by PixScape©. The results of these two analyses will be confronted with reality through a survey of the uses of the people who use these places.

The findings show a strong concordance between the quality of the visual landscape, its topological and morphological variations in three dimensions, and the actual usage patterns.

KEYWORDS

Space syntax, large housing estates, urban planning, landscape, visibility analysis.

1 INTRODUCTION

Large high-rise housing estates emerged as a miracle solution to the post-war housing crisis in Europe. Bright, hygienic and modern, they turned into hotbeds of delinquency where authority no longer had any rights (50 ans qui ont changé notre quotidien - Mon logement 2009). Made up of towers and bars, they are often equated with danger and delinquency, just like the people who live there.

The first criticisms, such as those made by (Jacobs 1961, Newman 1970, and Hillier and Leaman 1973) present them as favourable contexts to the emergence of social unrest, essentially due to their configuration, which lacks a clear hierarchy of spaces.

The Algerian context does not escape that observation: since the 1970s housing crisis, Algeria has adopted new planning tools to accompany social housing projects such as the New Urban Housing Zone (ZHUN) and New Towns (Villes Nouvelles). These large-scale projects aimed at resolving the successive housing crises by resorting to an urbanism of towers and bars.
Today, it is clear that these programmes do not produce the expected results of liveable and sustainable cities. They often give rise to neighbourhoods that quickly become hotbeds of delinquency and incivility, where outdoor spaces are conducive to squatting and the emergence of social unrest.

Furthermore, studies on the relationship between spatial morphologies and usage patterns from morphological studies provide convincing results (Cullen 1961, Alexander 1964, Benedikt 1979, Al_sayed et.al 2014, Dettlaff 2014). They attest to strong links between these two parameters and the potential of a space to favour the appearance of certain uses; an observation supported by studies based on space syntax as initiated by Hillier and Hanson (1984).
In the same line of thought, this research attempts to go beyond the prerequisites inherited from sociology and the prejudices amplified by the media in order to apprehend the relationship between the morphology of urban spaces in social and collective housing neighbourhoods and the modalities of use that take place there. Indeed, the present essay is part of a doctoral thesis in progress, and stems from a more global problematic that aims to re-examine the capacity of urban planning policies to create urban continuity.

In order to understand it, such a subject raises a range of questions that we consider important to address:

- On a global scale, why does the succession of urban social housing policies' reforms in Algeria generate perpetual dysfunctions? ;

- What is the role of the urban grid in generating a coherent articulation between the different neighbourhoods that constitute it? ;
- How could urban morphology and its visual quality be two eloquent factors of the social practices of a space? ;
- What is the contribution of each generation of social housing to the creation of the city?

To answer the above questions, the city of Bejaia, a medium-sized southern Mediterranean city in eastern Algeria, was chosen as a context for the research. This choice is supported by the fact that the urban development of this city was generated in the same logic as the majority of Mediterranean cities of its size. Characterized by the coexistence of several urban typologies resulting from the succession of civilizations and urban policies, specific to each period of their history. The historical cores, which witnessed the advent of several civilizations, were followed by a large expansion in the post-independence period and dominated by the perpetuation of the zoning model. The aim is to compare the results of the analyses of three districts from different successive programming generations. This approach consists of understanding the urban fact in these three districts in order to visualize the convergences and divergences of three planning policies.

To attain this objective, we will relate the neighbourhoods' morphological and visual qualities to the modalities of use that take place in them. We refer to Hillier, who considers mobility to be the modality of use most likely to inform us about the potential uses of spaces (Hillier and Hanson 1984). This modality is itself guided by visual perception (Hillier and Leaman 1973), which leads us to examine any morphological variation in the visible space that may influence it. Among these variations, we will be interested in the routes' angles of, the degrees of openness of the spaces and their three-dimensional features. We will use the combined methods of axial and angular syntactic analysis and analysis of visible landscapes by Pixscape©. The results of these two analyses will be confronted with the reality through a social survey taking note of the users' uses.

2 THEORY

Space syntax is the main method used in this research. It offers a wide range of tools to analyse the morphological variations in architectural and urban spaces. Initiated in the 1970s by Hillier and Hanson (Hillier and Hanson 1984), space syntax draws its theoretical foundations from a long tradition of morphological studies, (Conzen 1960, Lynch 1960, Alexander 1964, March and Steadman 1971, March 1976, Krier 1979, Steadman 1983).

Among the concepts inherited from this stream of research, Alexander introduced the new notion of "*Pattern*", which relates the design patterns of urban and architectural forms to their spatiotemporal, social and cultural contexts. The space produced is no longer a backdrop to the spatial web, but shaped by and for man. In addition, Lynch developed the concept of 'imagibility',

emphasizing the crucial role of visual permeability in the choice of travel routes. The visibility of a space is an indicator of its structured power. The more structured it is, the easier it is to see, which naturally encourages people to use places thanks to a simplified reading of the landscape through easily identifiable and understandable codes.

These two concepts combination provides a thoughtful basis to space syntax research. A new theory of urban and architectural planning that analyses the sensible variations of spaces beyond the "*anti-physicalist assumptions*" (Hillier 1987) inherited from sociology that consider physical space as the background of social action. It defines space as a complex system containing and, to a certain degree, influencing the social facts that take place in it. It allows emerging with the "*social logic of space*" (Hillier and Hanson 1984) according to three dualities: the first is that each space is made up of solids and voids materialized by the buildings and the spaces that connect them. The second one is relative to the global and local dimensions of spaces, respectively explained by the '*topo'* and the '*urban grid*' (Hillier and Leaman 1973). The last duality is related to the concept of 'pattern' in the sense that space is both the result of social action and its physical container which continuously shapes it (Hillier 1987). Thus, space syntax makes it possible to objectify the object in order to calculate, interpret and quantify the social facts of spaces. This, thanks to a series of mathematical calculations based on graph theory and computer simulation of urban phenomena (Laouar et.al 2019).

In order to understand the process of space syntax analyses, Hillier takes up Lynch's concept of imagibility because the epicentre of these analyses is mobility, which is the main modality of use that informs us about the social logic of space (Hillier 1987). It is measured through the pedestrian flow generated by the urban configuration under study and essentially conditioned by the visibility of space (Hillier 1996).

Studies based on space syntax have been able to demonstrate the existence of mutual relations between morphological variations of spaces and social life through the studies of urban economic centrality processes (Hillier and Leaman 1973, Hillier et.al 1976, Benedikt 1979, Hillier and Hanson 1984, Di Bella et.al 2011, Mazouz 2013, Laouar et.al 2019).

The methods and variables introduced by space syntax give several possibilities of calculation combinations, depending on the chosen subject. Nevertheless, like any theoretical basis, space syntax faces scientific criticism. One of the most detailed is that made by (Ratti, 2004). He questions the validity of computer simulations that reduce urban systems to arbitrarily constructed axial maps. A criticism to which space syntax researchers answered with a statistical study of 36 cities showing that the axial maps' variations were statistically negligible (Carvalho and Penn 2004). For Ratti, space syntax, because of its reduction of spatial data to topological data and its uses in mobility, ranks with theories of space. He also regrets the fact that it does not

consider topography and three-dimensional features of spaces. He has thus raised a series of questions that researchers in space syntax are trying to answer.

One of the innovative methods of space syntax is angular analysis. Based on the segment map tool, its originality resides in the consideration of the degrees of directional variation when generating movement. Its main assets consist in the possibility to integrate the metric data of the routes as analysis variables such as the flow, the distances and the lengths of the paths (Turner 2000). It is based on two concepts:

- The user no longer follows the shortest linear path to make a route but chooses the one with the fewest changes of direction;
- The probability of taking a route is equal to the number of all possible routes available in the spatial system.
- In the angular analysis, the estimation of the path length is expressed as an angular distance equal to the minimum number of changes in direction.

Van Nes points out a major interest in the use of angular analysis, because even if the classical axial analysis by applying topological radii gives convincing results, they cannot correspond to certain urban typologies (Van Nes 2011). This is demonstrated in his investigation of the city of Delft, comparing the axial analysis of the global and local integration at radius 3 of the city with the analysis of the angular integration. The atypical morphology of the city dominated by sinuous streets gives a mean depth value of 28. This result, far from the usual values for resorting to axial analyses at topological radii of 3 or 5, naturally imposes the use of an angular analysis.
This innovative method provides more detailed and reliable results than conventional axial analyses by reducing the number of variables relevant to the overall understanding of the system. Its results can be generalized to urban fabrics where the application of other methods is compromised by a complex urban morphology that simple axial analyses are not sufficient to study. This bibliographical synthesis constitutes the theoretical basis which inspired our research. It develops a set of tools which will help us to respond to the problematic posed.

3 DATASETS AND METHODS

The aim of this research is to question the policies of social housing creation in Algeria through a comparative study of three districts produced by three successive planning generations. This approach attempts to confront these policies with each other in order to come up with comparative and/or similar points of view that allow us to identify their respective capacities to shape the city. To do this, we study the relationship between urban morphology and practices whilst assimilating the role of visibility in the choice of pedestrian routes. For this purpose, we used space syntax analyses using axial and angular maps, complemented by visible environment analyses. The results obtained from the two computer simulation tools will be compared with reality through a social survey carried out on-site.

Analyses based on space syntax highlight the importance of movement as the major usage modality of spatial systems. Thus, understanding movement allows us to understand the spatial system as a whole through two components that emerge in the common jargon of space syntax theories: "**to-movement**" and "**through-movement**":

- the to-movement refers to the destination or a route from a starting point to a destination point. It is generally assimilated to global accessibility analyses and quantifiable by global (axial and/or angular) integration (Yamu et.al 2021);
- The through-movement allows describing the potential of passage through an urban segment and is used to describe processes of use of urban spaces at more local scales and is calculated by the choice measure.

Critical analyses of urban systems use the almost systematic combination of these two types of movement. This is because the city is produced and transformed according to a harmonious logic of combination between both types of movement. The to-movement makes it possible to describe the urban grid in its whole and to detect the processes of accessibility by explaining its social logic through its configuration made up of centralities and peripheries, while the through-movement refers to the potential of choosing an itinerary. It allows us to enrich the reading of the urban grid on a more local scale and to inform us about the socio-economic practices of local inhabitants.

In order to understand the composition of the city's urban system and to help us identify the relationship of the three case study districts with the rest of the fabric, we first carried out axial map analyses. Referring to (Hillier 1987), we selected three syntactic variables: global integration HH; connectivity and intelligibility, whose combined interpretation makes it possible to explain the economic process of the city's natural movement (Hillier et.al 1993).
The second chosen tool is the angular analysis. At the city scale, the aim is to understand the system as a whole and to come up with initial observations concerning accessibility to and through the selected districts. Then, at the neighbourhood level, two metric radii (R) will be used, aiming to study mechanical (R=1200m) and pedestrian (R=400) mobility. This step will provide information on the local social life of the districts.

In addition to syntactic analyses, we opted for a landscape visibility modelling based on digital spatial data. This innovative technique includes the site's volumetric and topographical features, which, according to (Lynch 1960), remain relevant parameters in itinerary decision-making. To do so, this tool offers a set of complementary variables to the space syntax methods generated by the PixScape© software on three-layer cartographic databases (Sahraoui et.al 2016) which are based on two analytical methods:

- **Planimetric analysis**: studies the intervisibility between an observation point (the user's eye) and its visible environment. From this analysis, viewsheds are created (Sahraoui et.al 2016), similar to the visibility graphs (VGA) used in space syntax

(Benedikt 1979). Each viewshed is formed by the set of visible pixels and its contours stop at any existing visual obstacles. This method incorporates any visual obstacles shaped by the elevations of spatial objects and the topography of the site, which are added to the boundaries of the buildings;

- **Tangential analysis**: emphasizes the importance of intervisibility in the description of a visible landscape. It allows the transition from a two-dimensional map background to a two-and-a-half-dimensional synthetic view. A graphical representation of trigonometric calculations taking into account both the sizes of visible objects and their distances from the virtual observer (Sahraoui et.al 2016).

The use of visible landscape analyses provides a significant complement to the space syntax analyses by highlighting the importance of the landscape qualities of a spatial system in shaping uses. Thus, two cartographic databases have been produced. The first one is the axial map of the city of Bejaia recreated manually with a computer-assisted drawing software on a GoogleMaps© base map, then processed with DepthMapX.net© and QGis©. The second database contains three maps in Raster format developed in collaboration with the ThéMa laboratory:

- **The numerical terrain model (MNT)**: a topographic map generated from the EarthExplorer site (science agency for the Department of the Interior s.d.) following the steps explained by the group (Les Hydrologues du Maroc 2019);
- **The land-use model (MOS)**: imported from the OpenSteetMap© database (Anon 2018);
- **The numeric elevation model (MNE)**: made on the basis of the MOS to which we added the elevations of the buildings. Once obtained, this map was modified to include vegetation heights (initially not included in the MOS) through a complex colour detection processing on the original satellite image. We then combined the two layers in Raster format (original MNE + vegetation map obtained).

After their extraction, these three maps were edited with QGis© software so that they have an identical geometry with a resolution adjusted to 5 metres per pixel to optimize the accuracy of the analyses.

Finally, the results of the simulations were confronted with reality through a social survey. We questioned 450 randomly selected users in our three districts about their spatial practices and the parameters that influenced them. In this article, we only include the variables that link route choices to morphological and visual variations in the frequented spaces. To do this, this part of the statistical results will be processed by a multiple component analysis (MCA) which allows us to correlate several sets of nominal and/or ordinal variables with each other and to establish typologies for the use of the different spaces.

The last section is devoted to crosschecking the infographic results with the surveys in order to highlight the spatial parameters which, by conditioning visibility, have a significant influence on mobility in the neighbourhoods under study. In this way, the combined results of each stage will make it possible to identify the contribution of each urban policy in creating the city.

4 RESULTS:

This section is structured as follows:

9.1. AXIAL ANALYSIS:

The axial map of the city of Bejaia is composed of 2938 axial lines and covers an area of more than 60 km².

9.1.1. THE GLOBAL INTEGRATION HH:

The integration quantifies the visual accessibility of a given spatial system and identifies the urban centralities likely to be the support of socio-economic life.

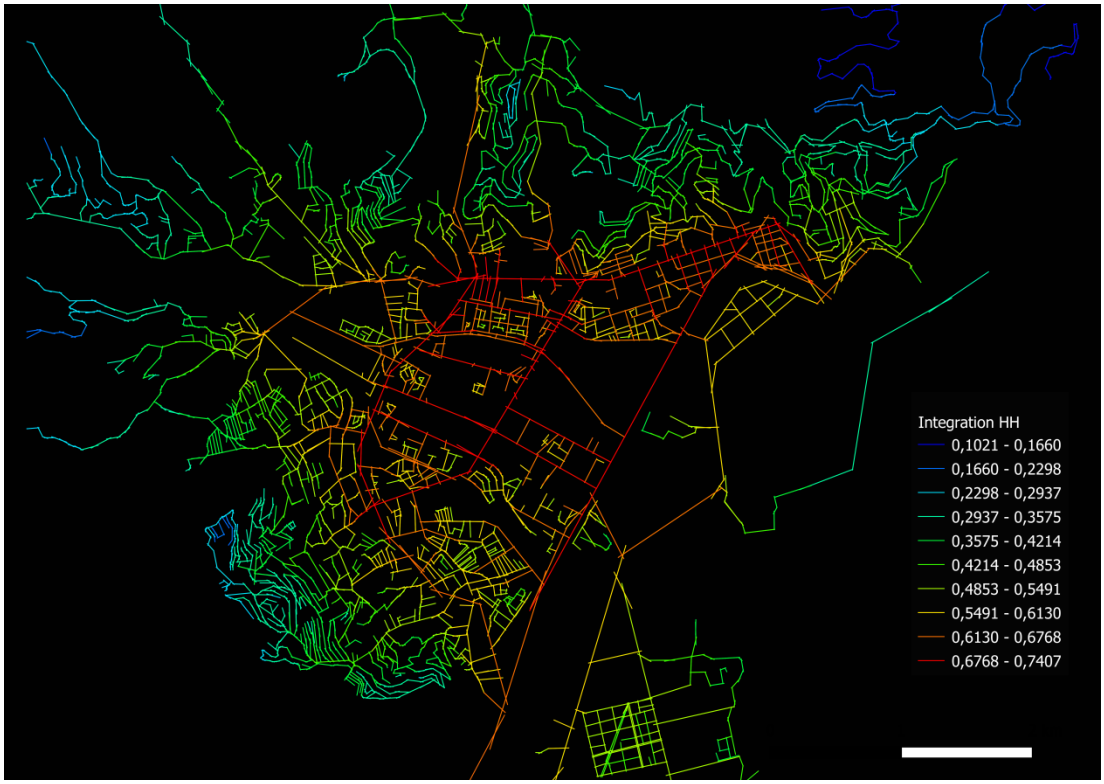


Figure 1: Integration HH. (Authors, 2022)

The integration HH of the city varies between 0.102 and 0.740 for an average of 0.449.
We can note the existence of an integration core located in the centre of the city, grouping together the “La Pleine District”, which is the first extramural extension dating from the beginning of the 20th century, in the east, and the whole of the industrial zone with its grid layout, resulting from the Master Urban Plan (PUD) of the 1970s, in the centre. This centrality

core forms a deformed wheel pattern (Hillier 2001), whose axes extend beyond the contours of the wheel. They have the values of 0.737 for the “Aures” road (north-south axis in the centre), of 0.730 for the "Rue de la Liberté" linking the old city to the post-independence extension, and of 0.697 for the Moulay-Enacer avenue which is extended by the "boulevard de la Soummam" then towards the national road N°12 linking Bejaia to Algiers by Tizi Ouzou. To the north of the industrial zone is a district of collective housing dating from the 90s, with a squared plan, which skirts the "boulevard of the ALN" with a global integration HH of 0.740.

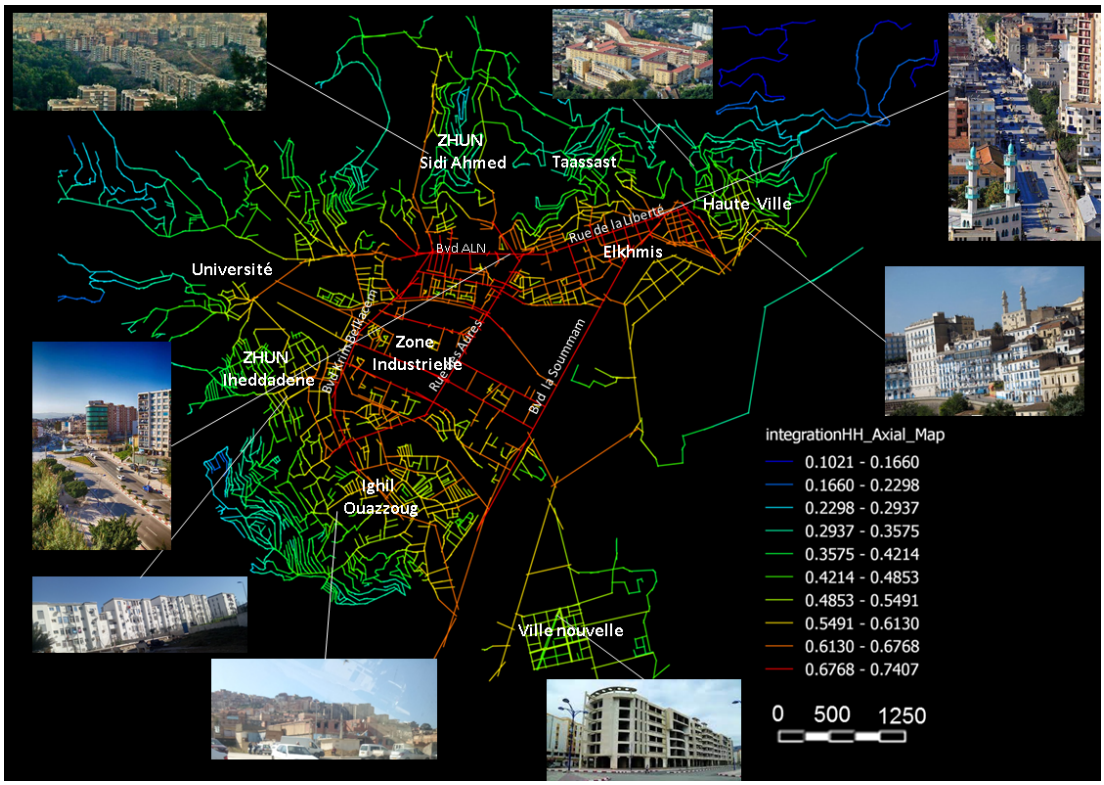


Figure 2: Illustration of the different urban parts of Bejaia. (Authors, 2021)

The integration core groups together the main arteries of the city which link the historical core in the north-east to the new post-colonial extensions in the south-west and gather most of the socio-economic activity of the current city.

On the other hand, the peripheral districts, which are less integrated, are essentially made up of large housing complexes and/or individual and spontaneous housing, particularly in the south-west.

9.1.2. CONNECTIVITY:

Connectivity defines the number of connections of the axial lines. It is a local measure that allows the analysis of the relationship of a given space to its direct neighbours to which it is connected (Hillier et.al 1984).

The average connectivity is 2.74 and ranges from a value of 1 to 24 connections. Its distribution follows the same trend as the integration HH with high values in the centre and low values in the periphery.

9.1.3. INTELLIGIBILITY:

This is a second order measure that correlates integration and connectivity. It is equal to the coefficient of Pearson's Determination (R^2) of the two values and its interpretation informs us about the visual accessibility of a space at both local and global scales.
The global intelligibility of the city is equal to 0.114 which is a rather low ratio revealing a low legibility of the urban fabric.

9.1.4. THE CASE STUDY DISTRICTS:

In order to deal with our problem, we have selected three social and collective housing areas which are the result of a profound reflection based on a set of social, morphological and temporal principles:

- The «**Amimoune District**»: part of the Constantine project in 19581, it is one of the first generations of social housing in Algeria. It is located on a hilly area overlooking the panoramic view of the city and follows the principles of the architecture and urban planning of the CIAM and the French HLM2. It groups together several R+8 bars, organized either linearly or around a courtyard, creating a new typology of public spaces.
- **The new urban housing zone (ZHUN) of Iheddadene**: located in the first post-independence extension on a relatively flat ground in the extension of the plain. Resulting from the Master Urban Plan (PUD) of 1976, it applies the principles of functionalist planning inherited from the modern era. It includes a programme of more than 1900 dwellings divided into 4 entities, including 3 collective housing estates and one individual housing one, provided with proximity equipments and services. Its development obeys the law of the crane, resulting in poorly structured public spaces, scattered with towers and bars in a low-density area.
- **The New Town of Sidi-Ali-Lebhar**: dates from the quinquennial programme of 2005-2009. It includes several access and housing production formulas totalizing 1322 dwellings. Its development obeys the new legislation with the injection of social and functional diversity. It is established on a flat site following a squared layout that

[1] "Le Plan de Constantine" is a socio-economic programme which aims to raise the general living conditions of the underprivileged social strata in Algeria. Drawn up by the French government in 1958, it targets the development of all of Algeria's resources and the resorption of the revolution. Inspired by the principles of development strategies adopted in France following the second world war, the Constantine project includes a major development programme with several components like the creation of Large high-rise housing estates; the redistribution of agricultural wealth; the creation of jobs and schools for the natives,... (Lefeuvre 2005).
[2] HLM "Habitat à Loyer Modéré" refers to a social housing system adopted in France in 1945, the majority of whose conception and acquisition is subsidized by the government (Rungis 1960).

is based on French military engineering principles and aims to bring back the notions of parcels and islands lost in previous generations.

9.1.5. AXIAL ANALYSIS OF THE SELECTED NEIGHBOURHOODS:

The results of the axial analysis of the selected districts are summarised in the Table 1 below as follow: The most integrated district is ZHUN with a value of 0.563, followed by the new town with a value of 0.511. The Amimoune district is the least integrated with an average value of 0.397. Connectivity seems to follow a different tendency than integration HH. It is highest in the new town (4.772), followed by the ZHUN (3.183) and the Amimoune District (2.785).
The ZHUN is the most intelligible part with a value of 0.3190. While the New Town and the Amimoune District are less intelligible with respective values of 0.026 and 0.092.

Table 1: Table of global integration HH, connectivity and intelligibility values (based on space syntax analyses by axial map (Authors, 2022)).

	global Integration HH		**Connectivity**		**Intelligibility**
Amimoune district	Average	0.397	Average	2.785	R^2= 0.092
	Maximum	0.483	Maximum	5	
	Minimum	0.332	Minimum	1	
ZHUN Iheddadene	Average	0.563	Average	3.183	R^2= 0.319
	Maximum	0.708	Maximum	10	
	Minimum	0.449	Minimum	1	
New town Sidi-Ali-Lebhar	Average	0.511	Average	4.772	R^2= 0.026
	Maximum	0.612	Maximum	15	
	Minimum	0.458	Minimum	1	

9.1.6. THE MEAN DEPTH

The mean depth value of the system makes it possible to determine a topological radius which is useful for local analyses. The city of Bejaia is essentially developed as an amphitheatre and is characterized by a predominantly organic urban fabric imposed by the relief. The axial analysis gives a mean depth of 23.22, which makes the application of a topological radius of 3 or 5 meaningless. Therefore, the use of an angular analysis becomes self-evident.

9.2. ANGULAR ANALYSIS

Based on the research of (Van Nes 2011) and the mean depth value of the city of Bejaia, we will proceed to space syntax angular analyses.

9.2.1. ANGULAR CHOICE (BETWEENNESS):

It defines the potential of each segment to be borrowed by pedestrian users at the local scale or by vehicles at more global scales (Al_sayed et.al 2014, p. 77).

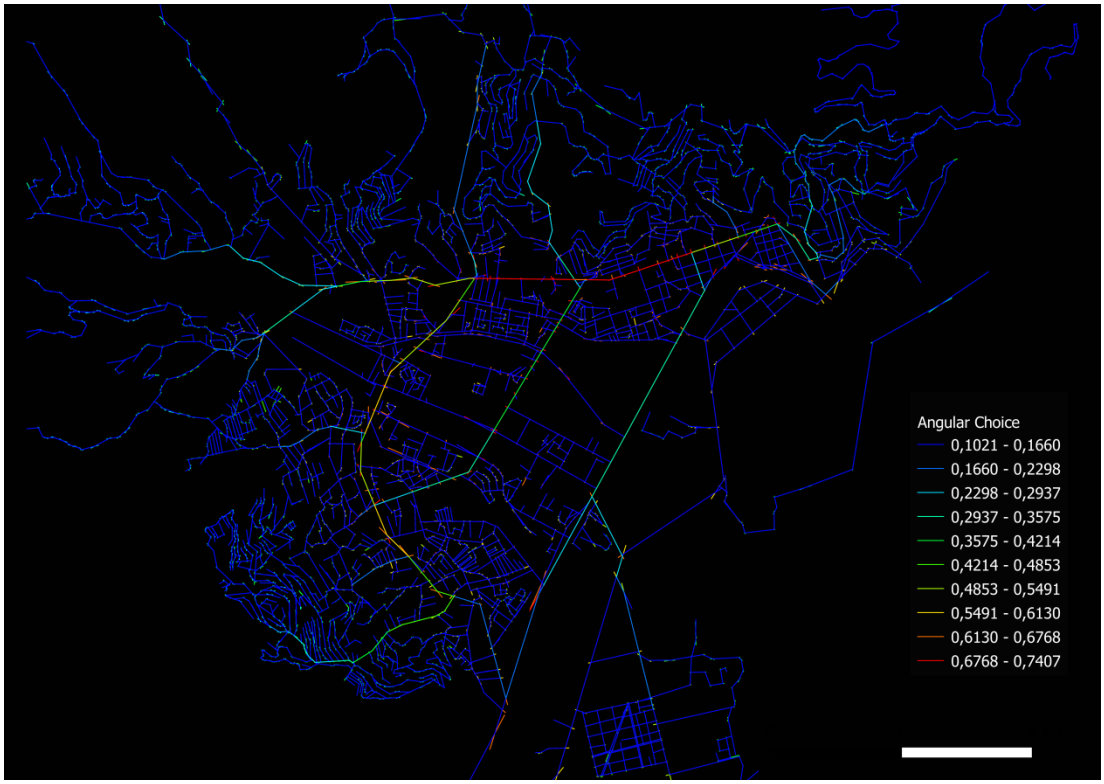


Figure 3: Angular Choice. (Authors, 2022)

The angular choice analysis of Bejaia City presents an average of 300405. It shows high angular choice values in the two segments formed by the "boulevard de l'ALN" and the "Rue de la Liberté" reaching 9553429. This corresponds to the number of probabilities for a user to pass through the segment. These segments are closely followed by those directly connected to them. On the other hand, the streets located on the periphery of the city have low values, especially in the heart of the blocks. This is the general case for the three study cases, with variations depending on their size and location vis-à-vis the rest of the urban system. This last observation leads us to go beyond the metric properties of the selected districts. This is why, referring to Hillier, cited in (Al_sayed et.al 2014, p. 77), we have retained a main angular analysis variable which is the normalized angular choice (NACH).

9.2.2. GLOBAL NACH

The overall NACH values vary between 0 and 1.546 with an average of 0.802.

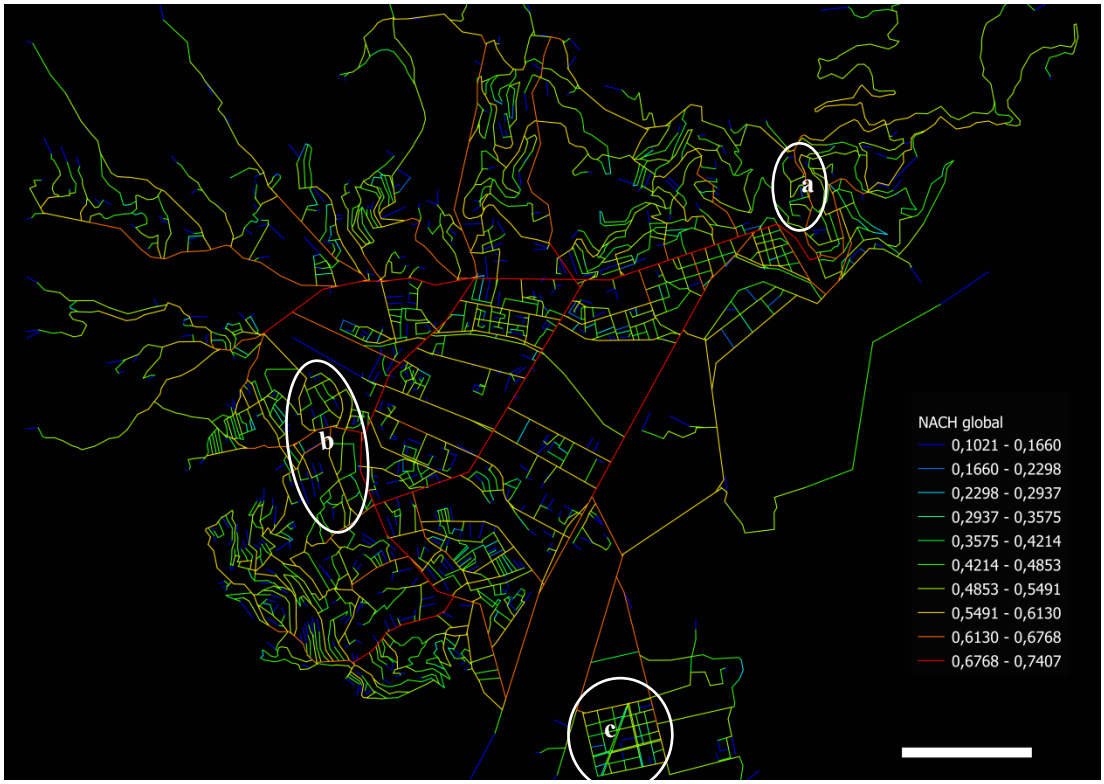


Figure 4: NACH; a)Amimoune District; b)ZHUN; c)New Town. (Authors, 2022)

Its interpretation allows us to highlight 3 main categories of classification of the urban axes that structure the city:

- **Main roads:** grouping the main roads of the city with NACH values from 1.391 to 1.546. These are the same ones that form the deformed wheel integration core (Figure 1) and that extend over the whole industrial area.
- **Secondary roads**: represent the segments directly connected to those of the first category. They serve the peripheral districts they border and have values from 1.082 to 1.391.
- **The tertiary axes:** they bring together the rest of the segments forming this map. They represent all the traffic routes within the districts and are extended at times by segments with zero values leading to dead ends and/or the heart of the blocks.

9.2.3. THE CASE STUDY DISTRICTS' GLOBAL NACH:

The map in Figure 4 shows a different distribution of the NACH values into the three districts, as follow:

- **Amimoune district (1):** the segment most likely to be borrowed by users is that of "Hassen Tahir Street" which borders the district towards the east. While the segments located inside the district present low rates.
- **The ZHUN (2):** the segments with high NACH rates are those formed by the Boulevard Krim Belkacem bordering the south-eastern part and the East/West street separating the 1000 housing neighbourhood in the north from the rest of the ZHUN.

These segments are closely followed by those of the peripheral streets. Whereas the streets in the interior of the districts have low values.

- **The new town of Sidi-Ali-Lebhar (3):** the highest NACH values are found in the segment formed by a part of the "LTN Ferdjellah-Mouhand-Oulhadj Boulevard" which allows access to the new town from the north-eastern side. In the second rank we find the streets that border the rest of this urban area, while the streets serving the blocks have very low values.

At the global scale, the NACH values inform us about the potential of each road to be crossed regardless of the type of mobility chosen (pedestrian/mechanical). For such a degree of analysis, it is necessary to apply a metric radius of calculation. According to (Yamu et.al 2021) radii of 400 m, 800 m or 1200 m correspond respectively to a 5, 10 or 20 minutes walked time. Thus, the application of low radii constitutes the most appropriate indicator of pedestrian mobility, while high radii aim to analyse mechanical mobility.

9.2.4. MECHANICAL MOBILITY (NACH1200) :

At the city scale, we notice that the hierarchy of routes significantly changes, especially for segments that had high values at the global scale, such as the "boulevard de la Soummam". On the other hand, the access roads to the different districts and their respective peripheral roads stand out with high rates.

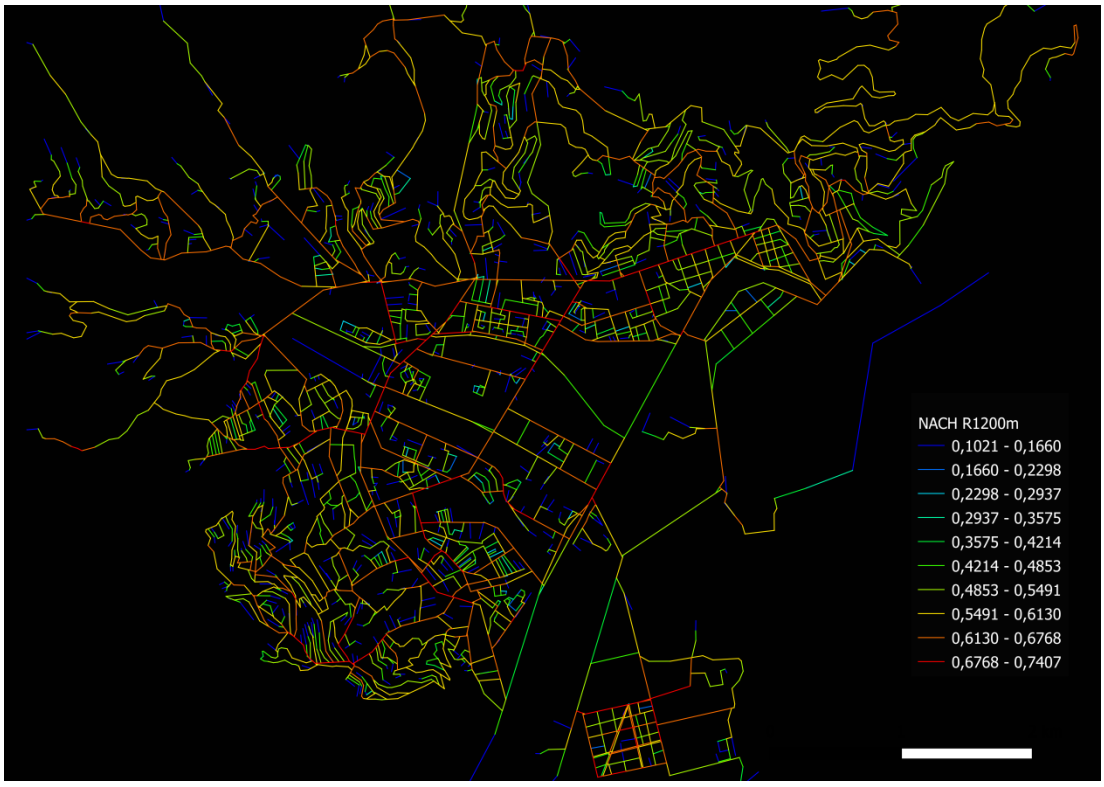


Figure 5: NACH 1200m. (Authors, 2022)

In the three districts, the distribution trend of the NACH 1200 follows the same pattern as the global NACH values. The only notable variation is in the new town with the emergence of new segments grouping all the peripheral streets of the area, the central north-south, east-west axes crossing it and the inclined artery connecting them.

9.2.5. PEDESTRIAN MOBILITY (NACH 400):

A metric radius of 400 metres was applied to analyse the pedestrian route choice potential.

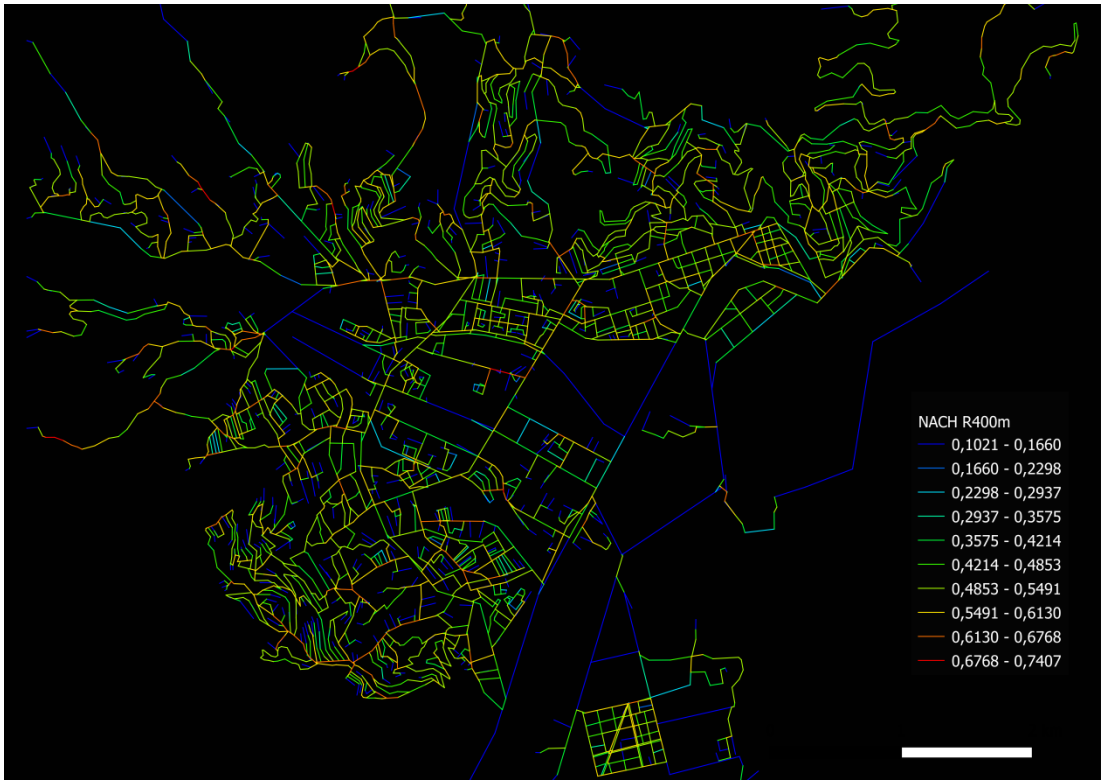


Figure 6: NACH 400m. (Authors, 2022)

On a city-wide scale, the segments most likely to be used by pedestrians are those connecting neighbourhoods to each other. Longer segments, such as the main boulevards, are in the background. This is also the general case in our case studies, where the intra-neighbourhood feeder roads have low values.

9.3. LANDSCAPE VISIBILITY ANALYSIS:

The use of landscape visibility analysis provides additional information not supported by space syntax. This is the overall topography and three-dimensional properties that makes up the landscape.

9.3.1. THE ANALYSIS OF MULTIPLE VISIBILITY BASINS:

This analysis was developed by integrating a cartographic database made of observation points placed along the mechanical streets. In order to facilitate the calculation process, referring to the study conducted by (Piombini and Foltete 2007), we have retained only the observation points located at the bifurcations of the lanes and at the changes of direction.

The principle of calculating multiple basins is similar to that of viewsheds. The difference lies in the possibility of calculating several viewsheds at the same time (Vuidel et.al 2019, p. 13).
The result of this analysis is a raster map formed by the visibility polygons of each of the observation points. These polygons are then formed by the 5m resolution pixels visible from the corresponding observation point. The interpretation of the results is based on a chromatic logic referring to how many times the pixel is contained in a visibility basin (Vuidel et.al 2019, p. 14).

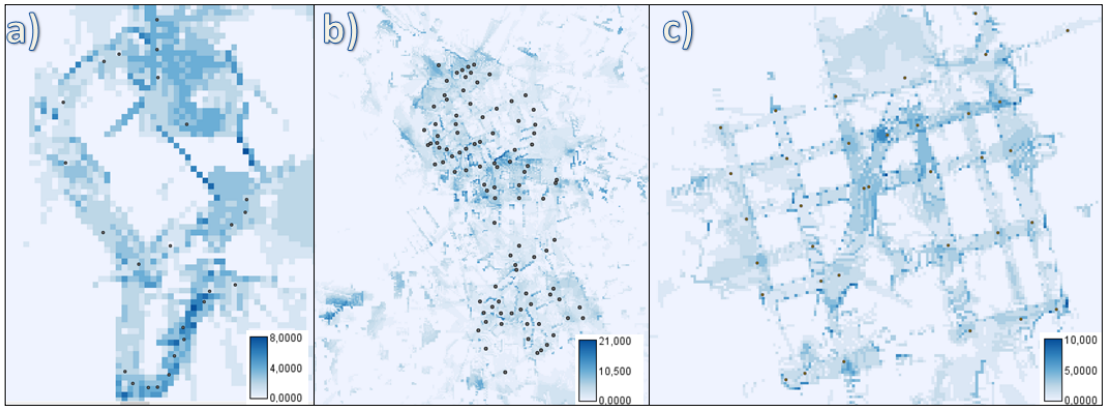


Figure 7: Multi-viewshed analysis. a) Amimoune district; b) ZHUN; c) New Town. (Authors, 2022).

- **Visibility in the Amimoune District:** The map in Figure 7 shows high values for the visibility of the pixels covering the mechanical axes bordering the neighbourhood and the spaces between the building blocks facing the main street to the north-east. In contrast, we observe very low values in the heart of the blocks and in the pedestrian spaces serving the building entrances.
- **Visibility in the ZHUN:** The analysis by visibility basin of the ZHUN shows higher values than those observed in the «Amimoune District», which are more important along the peripheral axes of the districts and in those connecting them. In opposition, we note a more diffuse visibility at the heart of the blocks and on the internal access roads.
- **Visibility within the new town of Sidi-Ali-Lebhar:** The visibility values have averages between those of the two previous years. We note high values evenly distributed along the mechanical axes, while the cores of the islands are displayed in white.

The multi-basin visibility analyses, in addition to providing images of the distribution of visibility basins, allow for the calculation of a set of metric variables summarized in the following table:

Table 2: Descriptive statistics of visibility variables. (Auteurs, 2022)

Types of metrics	Metrics	Amimoune Average	ZHUN Average	New town Average
Common metrics	Surface (A_0,0-Infinity)	1382854,9587	669343,2489	91508,1831
	Shannon Index (S_0,0-Infinity)	,3883	,2478	,5180
	Maximum distance (DISTsum)	218949160,9957	97027588,0834	14799782,8758
	Average distance (DISTavg)	2876,3609	3115,7812	1864,6861
Planimetric metrics	Compactness (C)	19,5940	24,3355	11,5564
	Fractal Dimension (FD)	1,2369	1,2806	1,0686
Tangential metrics	Shannon distance max. (SD)	,6375	,6822	,5946
	Depth of view (DL)	4,8643	8,1546	6,4308

The common metrics of both visible landscape calculation methods allow to describe the composition of the landscape as a whole. In addition, the Shannon diversity index (S) measures the diversity of the visible landscape in terms of land use. A value close to 0 corresponds to a monotony of a land cover category, while a value close to 1 is synonymous with high diversity (Sahraoui et.al 2016). Thus, we observe a low diversity of land use in the «Amimoune District» and the ZHUN (S<0.5) compared to the new town (S>0.5).

The distribution of average and maximum distances gives us information on the overall texture of the site (Foltete et.al 2015). They measure the lengths of view and allow us to quantify the degrees of openness/closure of the landscape (Sahraoui et.al 2016). Thus, we note that the average sight distances are highest in the «Amimoune District», followed by the ZHUN and then the new town. The maximum viewing distances also follow the same trend.

9.3.2. PLANIMETRIC VARIABLES:

Relating to the shape of the visibility basins, we retain the compactness (C) and the fractal dimension (FD):

- The first(C), defines the ratio between the perimeter of a visibility basin to a circle of the same area and informs us about its degree of openness (Foltete et.al 2015). The higher the compactness, the longer the area covered by the viewshed (Sahraoui et.al 2016) ;
- The second (FD), describes the homogeneity of the distribution of the visible surfaces. Located between 0 and 2, values that tend towards 0 are synonymous with a high concentration of a visibility basin. Whereas, those tending towards 2 mean a more spread out distribution of the observed surfaces (Sahraoui et.al 2016).

9.3.3. TANGENTIAL VARIABLES:

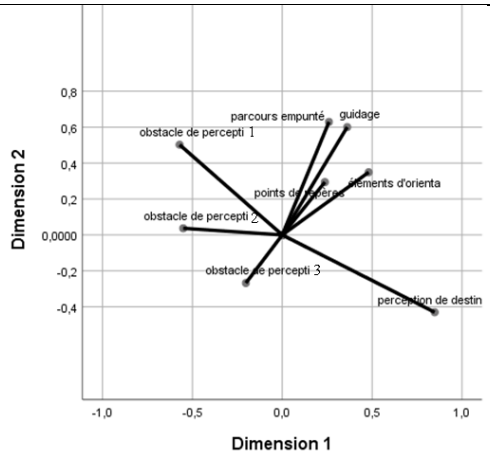
Tangential analyses provide information on the composition of the landscape in 2.5 dimensions. They are based on variables that quantify the significant variations of the horizon lines across the depths of tangential views. In this study, two variables were selected:

- Shannon Depth (SD), taking up the calculation principles of the Shannon diversity index(S) applied to tangential divergent rays (in 2D and½), measures the invariance of the depth of view (Foltete et.al 2015). We observe that the elevation of the visibility fields changes the distribution of land use within our selected neighbourhoods;
- The Depth of View (DL) is the compactness index applied to tangential (Sahraoui et.al 2016). The distribution of this coefficient shows very high rates within the ZHUN against low rates calculated in the «Amimoune District».

9.4. SOCIAL PRACTICES (FIELD SURVEY):

The syntax and visibility analysis results were confronted with the urban reality thanks to a social survey conducted in our neighbourhoods. This investigation includes a random sample of 450 users, mainly pedestrians, who were questioned about how they use the space. We selected a set of variables relating to the spatial configuration of the spaces, likely to influence the behaviour of the users, analysed by a multi-component analysis (MCA). The MCA reveals two main factorial axes explaining 90.40% of the information: The first one shows a negative correlation between the perception of the destination and the existence of visibility obstacles. The second one shows the influence of visibility[3] on the choice of routes.

Table 3: Multiple Component Analysis (MCA). (Authors, 2022)

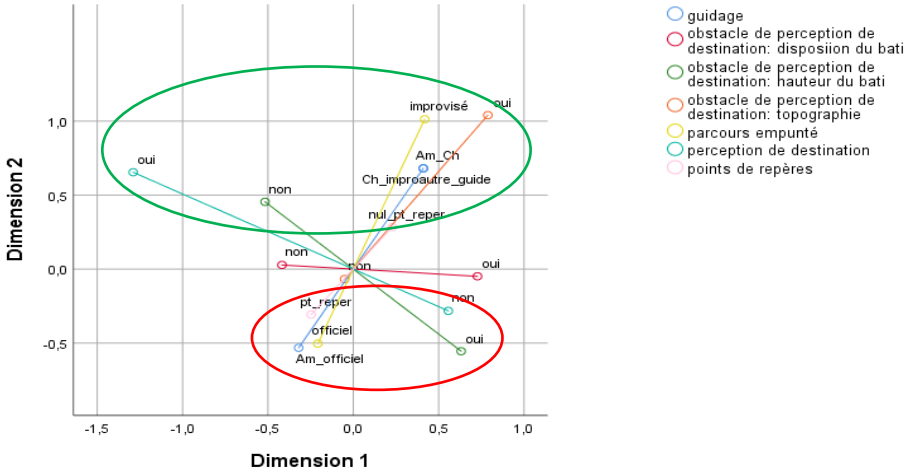


Variables	Dimension	
	1	2
perception of destination (perception de destin)	,848	-,430

[3] **Visibility** includes the qualitative variables describing the existence/absence of visual barriers related to the layout of the building and its heights.

perceptual barrier of destination: height of the buildings (obstacle de percepti 1)	-,571	,502
perceptual barrier of destination: the layout of the buildings (obstacle de percepti 2)	-,551	,037
Orientation elements (élements d'orienta)	,480	,349
Route taken[4] (parcours emprunté)	,260	,629
Guidance[5] (guidage)	,361	,600
Landmarks (points de repères)	,237	,294
perceptual barrier to destination: topography (obstacle de percepti 3)	-,203	-,268

Other parameters of spatial configuration correlate negatively with the path choices made, but their weight seems to be less important as summarized in the following graph:



Graph 1: Joint plotting of the points of the category (according to the CMA analysis). (Authors, 2022).

Itineraries along the roads (red cluster) are generally guided by restricted fields of visibility due to the existence of visual masks limiting the perception of users. To find their way around, users refer to the existing road layout and to the landmarks that develop in elevation.
In contrast, users opting for improvised routes (green cluster) are encouraged by the perception of the final destination and the topography of the site.

5 CROSSING THE METHODS (DISCUSSIONS)

The results of the integration analysis of the city of Bejaia illustrate the presence of an integration core which is developing like a deformed wheel whose spokes extend beyond its contours. Covering more than a third of the total surface of the urban area, it mainly encompasses the flat part of the city with a squared layout. In contrast, the peripheral tissues are less integrated, characterized by a more organic morphology, such as the old city, the large housing complexes of the ZHUNs and the spontaneous housing districts.

[4] **The route taken** refers to the type of itinerary chosen by the user, with two types of responses: itineraries that follow the official road layout (official layout) and those that do not follow the public roads (unofficial paths).
[5] **Guidance** represents the elements that guided the user in his choice of itinerary with two response modalities: the first is the streets patterns and the second refers to the traces of improvised routes.

The calculation of intelligibility demonstrates the fragmented character of the city, which is synonymous with a low legibility of the spatial system typical of organic cities. This finding is in accordance with the results of a comparative study carried out by Hillier (2001), which shows that the intelligibility averages are higher in square cities with an average of 0.559. In contrast, more sinuous urban fabrics show low rates with an average of 0.250 for European radiating cities and 0.160 in Arabo-Muslim cities (Hillier 2001).

Within the three districts, the average values for integration HH and intelligibility tell us something about their accessibility from the rest of the urban system. Referring to Table 1, at the city level, the readability of a space depends on its size, its morphology and its proximity to the integration core. In comparison, the ZHUN is more readable (R^2=0.390) due to its position, while the new town remains disconnected from the whole (R^2=0.026).

The results of the NACH calculations agree with and support those of accessibility. On the global scale, the routes most likely to be used are the most integrated ones. In contrast, the peripheral parts of the city and the heart of the neighbourhoods are less favourable to movement. This reading, applied to our three neighbourhoods, shows results that can be generalized to the whole fabric. They allow us to establish a hierarchical classification of roads into three categories that facilitate the reading of the urban system through mobility.

The crossing of the axial and angular analyses provides information on the overall composition of the urban fabric and gives some concrete indicators for understanding the development of social life and economic exchanges that emerge in and shape the city.

The analysis of mechanical mobility through the calculation of the NACH at the metric radius of 1200 m brings out a significantly different reading of urban mobility with a strong contrast within the new city with its quadrangular morphology. It demonstrates the importance of the access roads to the various districts of the city in the mechanical movements.

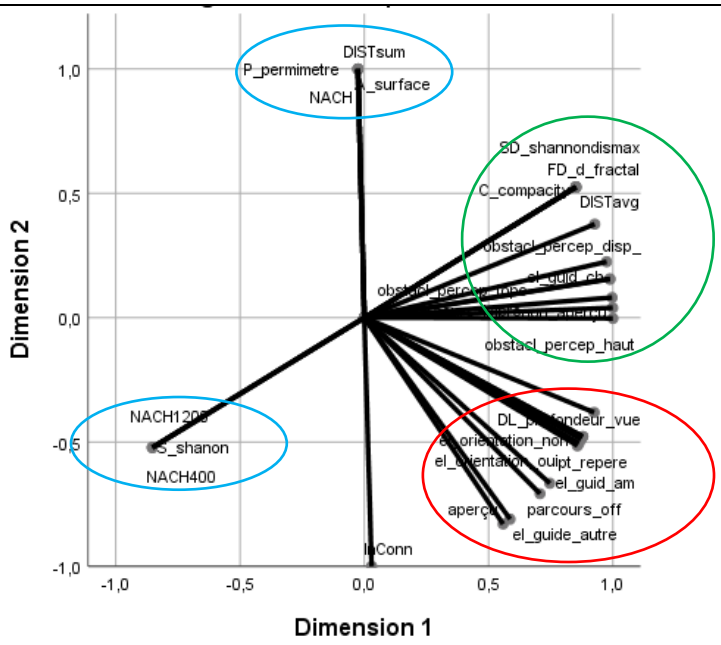
When interpreting the pedestrian mobility analysis (NACH400), the importance of the road segments connecting the city's districts to each other becomes apparent. On this scale, what seem to guide pedestrians are the short transitional segments connecting the districts to one another. While the main mechanical routes take a back seat, almost on the same level as the routes in the heart of the blocks. This section demonstrates the importance of the size of the road segments in choosing itinerary.

In addition to the above findings, the analysis of visible landscapes demonstrates, firstly, the importance of the degree of openness and closure of spaces in the choice of routes. The spread of visibility areas, strongly conditioned by the layout of physical obstacles, explains to a large extent the results of the analyses of pedestrian mobility within the three studied areas.

On a planimetric scale (in 2D), we note a very high compactness in the ZHUN, followed by the «Amimoune District» and low in the new town. This can be explained by the lower density of the ZHUN tissue, which gives more extended fields of visibility. This is confirmed by the values of fractal dimensions (FD).

The calculations of tangential variables make it possible to highlight the influence of the global three-dimensional elevation of the sites on the conditioning of visibility and enrich the reading by calculating indicators relating to the three-dimensional properties of the observed spaces. The SD values recorded are all higher than 0.5, synonymous with a great diversity of landscapes, with a maximum value recorded within the ZHUN SD=0.6822, closely followed by the «Amimoune District» SD=0.6375 then the new town SD=0.5946. The depth of view Dl follows logic of distribution giving metric indicators which emphasize the potential role of the topography of the sites and the degrees of visibility opening up guided by building density.

Table 4: Categorical principal component analysis (Authors, 2022).

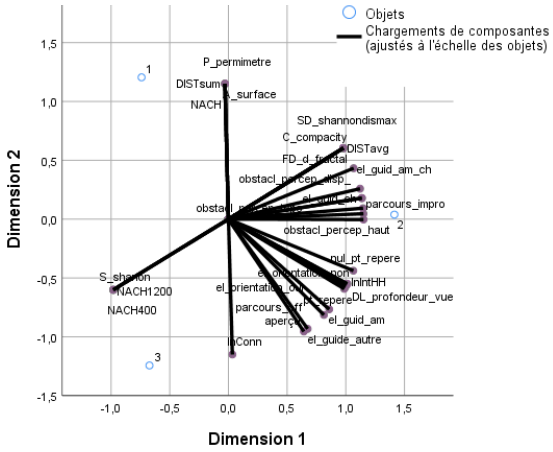


Dimension	Cronbach's Alpha	Represented Variance%
1	,980	63,031
2	,941	36,969
Total	1,000a	100,000

This finding substantially agrees with the results of the infographic analyses by establishing a strong link between the topological and angular distances of the routes, influenced by the openings/closures of visibility fields. Overall, cognition within spaces is both a function of fields of view and the minimum topological and angular distances to be taken.

The comparison of the computer graphics data with the survey results makes it possible to summarize the existing interdependencies between urban morphology and uses and draws up two strong sets:
The first (red cluster) shows a strong correlation between spatial accessibility and the choice of official routes. Indeed, users seem to take the pedestrian and/or mechanical itineraries dictated by the roadway in urban spaces with a high global integration. In this first category of spaces, users choose their route according to the destination point they can see, which is in line with the depth of view measured by Pixscape.

The second (green cluster) set shows that users opt for improvised paths in spaces with low readability. The latter seems to be partly caused by the arrangement of visual obstacles such as the layout of buildings and topography, and by the opening/closing of fields of vision and the diversity of occupation that develops on high ground.



Graph 2: Categorical principal component analysis double plot (auteurs, 2022).

The double layout including the three districts allows the comparison between each type of space. Their opposite positioning on the graph is an eloquent demonstration of their divergence and makes it possible to identify their specific characteristics. In fact, the new town (3) is less accessible than the rest of the urban fabric, but seems more favourable to more localized uses. It also has a good diversity of land use (S) and is characterized by the absence of landmarks. This can be explained by the mixed-use intentions injected into the new town planning project, the flat topography of the site and its off-centre position to the parent town.

The ZHUN(2) has a more varied character which, on the whole, reflects the scattered nature of the fabric and the monotony of the land use. Users opt for informal routes dictated by a dispersed space which favours large fields of visibility obstructed by the layout of the buildings and the topography.

The «Amimoune District» is less accessible and less legible from the rest of the city. This can be explained by its morphology shaped by the topography of its site and its eccentric position favouring the emergence of large fields of vision (A; P).

6 CONCLUSIONS

Space syntax analyses offer powerful techniques for dissecting urban systems and allow to critically read the space and the resulting uses that shape it at the same time.

At the city scale, axial analyses based on the combination of the values of HH integration and intelligibility reveal the existence of urban discontinuities generated by the succession of several planning policies with divergent aims, the appearance of which dates back to the beginnings of the modern era and the French military engineering: Clear cuts favouring urban and social fragmentation. Indeed, the first urban reorganizations of the French era tended to separate the European classes from the natives. Later, post-colonial policies reinforced these divisions by establishing a zoning of the city and a mono-functional division of the new extensions. The latter, in particular those where the ZHUNs are created, follow random urban layouts dictated by the simple law of the crane. In parallel to these developments guided by planning policies, spontaneous housing districts are developing in the near suburbs and in any available urban wasteland.

Secondly, the use of angular analyses of theoretical route choices provides us with information on the varied potential of the itineraries according to the direction changes and the type of mobility chosen.

On the scale of the three selected districts, the study of the morphological compositions of the spaces, supported by visibility calculations, informs us about the intimate relations between the choice of routes and the composition of the landscape. The comparison of the results makes it possible to highlight the typologies specific to each planning mode. Then, the recourse to statistical treatments of the survey data relating to the morphological determinants of the choice of itineraries allowed us to confront the theoretical uses such as they emerge from the infographic analyses and the real modalities of use which take place there.

This research highlights the influence of sensitive variations in space and the emergence of certain types of usage modalities such as mobility. The results make it possible to assess the contribution of each urban policy to the creation of the city: the French “Grands Ensembles” (large Housing Estates) policy has generated segregated spaces where accessibility remains entangled by the eccentric disposition of the studied neighbourhood. On the other hand, the project site gives a good visual quality on the rest of the city.

The second generation of ZHUNs shapes the space differently. The latter is characterized by functional monotony and low density, which makes the choice of routes ambiguous. The new

town design creates new relationships between space and uses. Indeed, its planning respecting the injection of functional diversity is reflected by a good functional diversity, where the routes of local users are facilitated, notably thanks to the return to a squared layout. However, its peripheral position makes it less accessible in relation to the parent city, and the non-use of the buildings located in the geometric centre of the new town, observed during the survey, makes the space favourable to squatting and encourages incivilities.

In conclusion, the adopted analysis protocol allows a detailed understanding of the urban fact and creates a strong means of analysis of social facts and spatial systems. However, the ease of access and the readability of spaces should not be over-interpreted in spite of the urban reality. In fact, the latter opens up new fields of investigations integrating the socio-demographic context of the areas under study. This makes it possible to establish new complementary questions, which are likely to lead to new future axes of research.

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