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Determining the Morphological Characteristics of the Urban Fabric by the use of the Fractal Analysis case Study the City of Guelma in Algeria

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In this paper, we illustrate the importance of architectural model analysis in describing and analyzing the urban morphology of the city. It represents an important approach by which we can identify the general characteristics of growth and urban expansion in it., in order to achieve a field organization that ensures the optimal use of urban land in the framework of its conservation and sustainability.

The results of the analysis showed that the city of Guelma, due to the different stages of urbanization and development, witnessed a clear shift from the compact urban structure to a fragmented town. We produced it in accordance with this development. The new parts and expansions are characterized by the loss of morphological homogeneity, especially because the urban tissue was characterized by density at the beginning of the growth and then expanded in many directions. This confirms that the city expends towards the periphery in a fragmented and encircled manner, as the city is known for its location encircled by natural obstacles, on one hand, and agricultural lands, on the other hand. The results of the study thus confirmed the existence of a clear fraction in the urban tissue, resulting from the lack of correlation between the city's various expansions.

Key words: Frequent architectural model analysis, urban morphology, Guelma City, Urban Tissue, Homogenization.

INTRODUCTION

The city is considered the constant and the variable at the same time, because its urban trajectory has been affected and continues to be influenced by many variables and shifts due to multiple internal and external factors, making it a complex system and a phenomenon that is difficult to determine. It changes its shape and content every time, depending on the place and historical circumstances. (SAIDOUNI,M,2000), The city is also the place where many practices intersect with the primary objective of meeting the growing needs of the population. Thus, the dual (sphere-inhabitants) is in a constant relationship and development, which is translated through the urban form. The structure of the city, according to which it witnesses diverse shifts during several historical stages, especially after the industrial revolution, has witnessed a series of shifts, both through the rapid increase in the population as well as the increase in the number of urban areas (BENYOUCEF,B,2015).

So, the and is a system that witnesses sustainability of formation, that results in multiple urban models; from the historic city, to the model of expanded contemporary city (DECHICHA, A,2000). The emergence and birth of these new urban models is thus an expression of spatial growth (MADANI,S,2012). So, field expansion and the multiplicity of urban structures are only a response to the changing needs of the population, as this expansion is accompanied by the loss of morphological and spatial cohesion, resulting in a fragmented and less homogeneous urban appearance (CHOUADRA, S,2009), This requires an intervention to achieve a balanced city.Reforming the fragmented city constitutes a real challenge that must be put amongst the most important priorities in the city's policy.

Moreover, we can equate and balance the relationship between the individual and his urban environment, and thus, put an end to the various clashes between both of them. (CHOUADRA, S,2009), especially because the collision of the relationship between the individual and his environment led to an unbalanced consumption of the field, resulting in a branched city with non-interconnected peripheries. Based on all that, the aim is to achieve a balance between the

relationship between the individual and his environment., and try to produce a compact and homogeneous city, with interconnected urban elements in accordance with the principles of sustainable development (MADANI,S,2012).

Problem Description

In fact, there are different readings of the city through its forms and stages of its development (ABED, B, HAFIANE, A, 1998), where all urban areas, generally, and the Algerian city, in particular, have been and continue to be known as major urban growth resulting from the demographic explosion, due to the natural increase and rural exodus, as well as socio-economic and cultural factors, which have made it challenging, As a result of this rapid urbanization, which has affected all cities in Algeria, As a result of this rapid urbanization, which has affected all cities in Algeria. (MEBIROUK,H,2012). Thus, the formation and multiplicity of urban forms, with their increased size in many cities It has created a heterogeneous urban tissue, especially when it comes to the obvious difference between the old and the new urban tissue and between the center and the periphery., Because the city is a system that is known by the continuity of the formation, as it is formed and restructured in its peripheries under the influence of environmental and socio-economic factors. (MEBIROUK,H,2012). This is differently explained in the mechanisms of production, which inevitably leads to a difference in the urban structure and changes in its various components. The growth of the city, therefore, usually results in the emergence of unregulated and fragmented urban tissue and thus the emergence of an irregular morphology that runs counter to the city planners' vision, because their most important goal is to reach a compact and regular city (FRANCHAUSER, P,2005).

Guelma City is one of the cities in Algeria whose area is characterized by the same urban reality. Although there is a difference in the specificities of the location, historical and economic data, demographic growth and rapid urbanization are strong and common drives. Following that, all cities witnessed an urban expansion, which led to a marked change in the city's shape and space after the expansion witnessed in different stages. At the same time, the peri-urban tissues surrounding the city witnessed a significant development, which led to a remarkable change in their overall landscape. Guelma City maintained a kind of interconnectedness in its urban composition, after which it appeared as a fragmented city through its surrounding urban peripheries, especially in the 1970s, when the city's formation started as parts, with a specific formation logic for each one of them.

The plurality of actors as the population and governing may lead to a difference in the logic of the city's production that has been planned or spontaneously, resulting in irregular growth, which constitutes the primary driver of the emergence of a fragmented urban system (BOUICHE, FZZ, ALKAMA, D, BOUAMRANE, A, 2020). We will then try, through this research paper, to search for spatial regulation of urban tissues. (Based on classic fractal analysis aimed at studying the surface distribution of the built framework of urban tissue (BATTY, M, 1986), This type of analysis is usually used by geography researchers and for field preparation, because the urban tissue of cities and urban agglomerations develops and grows according to planned or random form due to urban expansion and is difficult to control as the expansion is often fractional, which requires the use of some mathematical formulas, especially the fractional geometry, which is considered an alternative geometry and is adopted by many researchers

Through this analysis, we can distinguish the expansion of the built area and identify the main trends and axes of urbanization, especially since the exploitation of the field is an ongoing phenomenon, during successive historical stages that we can track to identify the way of formation and reformation of the city. This is in addition to the identification of the logic of the city's formation, how it was produced and who controls its growth. Through the fractal analysis of the urban tissue of Guelma City, based on some mathematical formulas, we can also make sure whether the urban tissue of Guelma City is morphologically homogeneous or not. In other words. Was the development of the city in accordance with balance and coherence between the center and peripheries, or was there a distinction and difference between them?

METHOD AND MATERIALS

Analysis Tools

Fractal dimension or fractal analysis is the method that we adopt to analyze the urban tissue in Guelma. The term fractal geometry has emerged through the researches of the famous mathematician Benoit Mandelbrot in 1975, where it was used to describe many natural phenomena. The word fractal, which derived from the Latin verb *franger*; a verb

associated with describing the natural characteristics of seemingly uneven objects. (MANDELBROT, B, 1983). Fractal geometry can be described as the irregular geometric forms consisting of incomplete and overlapping parts of various dimensions.

Fractal geometry is associated with the geometry of repetitions, where the geometric shape is repeated according to a specific mathematical rule, so that the duplicate shape is a picture of the initial shape, according to the characteristics of the applicable rule.

Many researchers in geography and the preparation of fields and urbanization see that the urban tissues and urban agglomerations of cities develop and grow randomly because of their exposure to the phenomenon of urban expansion, which is therefore very difficult to control, especially since this urban expansion is often fractional, which means that it is fragmented. That is why many studies were conducted using fractal geometry, in order to measure these urban tissues.

This method has seen significant advancement, particularly thanks to the work of researcher Pierre Frankhauser (2002), who is regarded as the pioneer of this approach, which is based on a mathematical method for analyzing urban tissue. He explained this approach and interpreted it in a way that allowed its application. The fractional dimension is a reflection and expression of urban homogeneity and the intensity of field occupancy in the city center and its periphery spaces. By homogenization, we mean the presence of regularity and repetition in the urban tissue, with a clear hierarchy between the center and the periphery. As for the heterogeneity of the tissue, it means that the latter is arbitrary and irregular. The fractal dimension also allows the definition, analysis, and classification of urban tissue, and then, the verification of its regularity and fraction, using several indicators that enable us to measure the fraction aspect of the urban tissue. (Surface homogeneity and complexity that characterize urban tissues and measure their morphological properties). So, through this simple analysis, we will identify the basic principles of this method and apply them to Guelma city to analyze its morphological structure, as we based on the data set, extracted from topographic maps scaled at 1/50000 for the years 1966, 1977, and 2014. We digitized these maps, processed them, and dotted them in uncompressed format (tiff). This is based on the image of the urban spot (see figure 1) that has been processed and then modified in a monochrome mode., After which, we study the different fractional measurements using a software package (fractalyse), Version (1.2.3), which allows us to study the overall shape of the city with a detailed study of the built tissue in Guelma City. This study started from a central nucleus and then shows clear branches towards, where this form is driven by the characteristics of the location of the city (natural obstacles), as well as the main road axes.

Figure 1. picture of the form of the urban spot (tiff format) 1/50000. Source: topographic maps – Guelma

Measurement of Urban Tissue Fracture

Indicators of Morphological form Description

Among the analytical methods provided by fractal geometry is the reliance on computational indicators, through which we can identify the most important features of the urban tissue:

- **Degree of surface homogeneity:** is an indicator that gives information about the homogeneity or heterogeneity of the built frame and determines the similarity between its constituent units. It also enables us to measure the homogeneity of its distribution, and thus, it initiates a method to distinguish between the studied tissues whereby: the closer the attachment is to the value (2), the more the urban tissue is homogeneous; and the closer we are to the value (0), the more the urban tissue is heterogeneous.

- **Degree of complexity:** is an important indicator that gives us information on the degree of complexity in the urban tissue, as it shows the extent of the density of the tissue and whether it is compact or not. We rely in this analysis on the shape coefficient (a), where the greater the value of (a), the greater the degree of complexity and the fabric density are.
- **Radial Analysis:**is a local analysis that provides us with data, different from other analyses where it allows us to divide the zones according to the fractional behavior that we read in the irregular graph curve, and then, through this analysis, we try to track the local changes of this refraction, using the graph curve of the sizing behavior and the data that follows. For this analysis, we must, as a first step, choose the counting center, which constitutes a point that we identify in the center we choose.
- **Tissue compression degree:**is one of the most important indicators used in the description of the morphological shape. It gives information on the density of the tissue by the number of repetitions resulting from the expansion analysis, which means, what is the number of the required repetitions so that the city reaches its full and saturated degree and appears as a single mass, i.e., achieves a harmonious and interconnected city.
- **Degree of dispersion and fragmentation of the urban boundaries:**

To understand the logic of the constitution of the studied boundaries, we have studied and calculated two coefficients, used by PIERRE FRANKHAUSER: the fragmentation index and the bifurcation index, which allow us to know the nature of the tissue and provide information about it based on the previously calculated dimensions, where it is vital to:

- ✓ Identification of the fractional dimensions of the built area (Dsurf)
- ✓ Determining the frontier dimensions of the general border (Dbord/tot) for all the parts constituting the urban spot that forms the urban community, taking into account the inbuilt area within the urban areas.
- ✓ Defining the fractional dimensions of the larger main frontiers, which include the historical center (Dbord/agr),

- **Fragmentation index φ:** It is calculated by applying the following law:

$$Dbord/agrDbord/tot= \varphi$$

According to Frankhauser (FRANKHAUSER, P, 2003), the value of this indicator is limited between zero and one, where:

- ✓ The near-zero value indicates that the urban spot is made up of a single mass (agregat).
- ✓ The value close to one indicates a fragmented tissue, consisting of numerous islands, covering the area in a semi-homogeneous manner.

As for the index of dendricity:δ is calculated by applying the law:

$$Dbord/\ agrDsurf=\delta$$

Concerning the bifurcation index, its value is between zero and one, where the closer it approaches zero, the more it indicates that the structure is dense and with smooth borders. But if it approaches or equals the value of one, we will converge it with the theoretical shape of (the Sierpinsky carpet), where the surface and boundary dimensions are integrated.

- **Synthetic complexity index (Is):**it is defined by the following relationship:

$$Dbord + Dsurf - 1=(Dbord -1)- (Dsurf- 2)=Is$$

Through this indicator, we can provide a simple and formal synthetic value for different surface and boundary dimensions.

Presentation of the Case Study

Guelma City is a medium-sized city in the Algerian East. It is an important point of contact and transit, and a strategic location between the largest metropolises of the East (Annaba and Constantine). It is the province's chief place, with agricultural capacity and potential, characterized by a physical center and with significant natural obstacles that have limited its real estate base.

The city of Guelma has undergone morphological changes over the course of its history. These shifts will certainly continue to coincide with the development that the city knows in different areas, and the pace of urbanization has been affected by the same factors affecting the Algerian field, as it witnessed the succession of diverse civilizations (the Roman and Carthaginian), whose fingerprints appeared in the old city.

It was also affected by French colonialism, through the colonial nucleus; to witness after independence the influence of other factors (the physical policies and laws set by the Algerian legislators; economic crises and the urban Neglection they left in all cities without exception; and other factors that gave novel forms and patterns of the city's urban structure, in the form of planned or unplanned expansions, characterized by indiscriminate urbanization and irrational consumption of the territory.

In order to verify the previous forms, we will then know the morphological characteristics of the built field, so that we can identify the changes that it witnessed, resulting in a changing urban composition according to each period, while looking for the possibility of the existence of deficiencies within the city to exploit and install in them a part of the city, especially if the analysis proves that the city knows an urban creep or an expansion towards the peripheries, despite the existence of vacant spaces that can be exploited, and thus, develop the rational use of these spaces within the urban tissue without fragmenting its unity (CIRMU, L, 2014).

That is because the indiscriminate and fragmented expansion is certainly inconsistent with the capacity of its area to absorb and is contrary to the principle of optimal exploitation of the area, which is an urban challenge to achieve for urban sustainability.

Results and Discussion

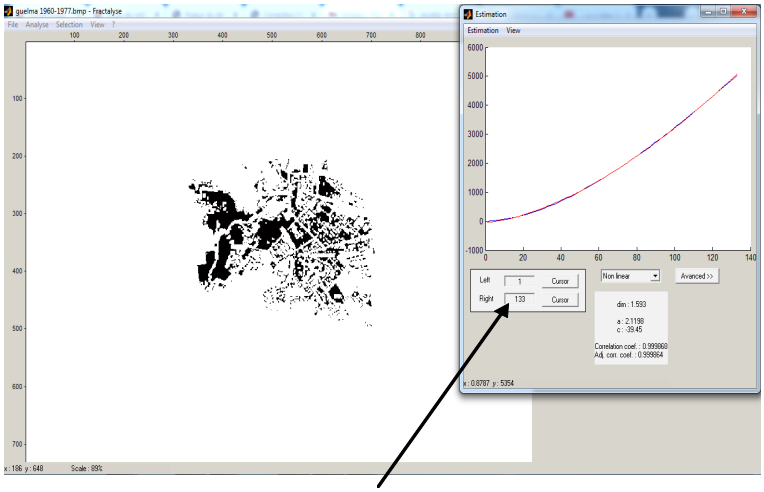
To achieve the General Fractal Dimensions, we try to figure out and determine the morphological shape of Guelma City as follows:

Analysis by Correlation

By analyzing the correlation, we get after measuring the fractional dimensions of the urban agglomeration, we can determine the characteristics of the city's planning within three periods (1966, 1977, 2014), and conclude the degree of their homogeneity from the hierarchy and stacking, as we calculate the homogeneity index and the hierarchy of the distribution of the built area.

a- *Degree of Tissue Homogeneity*

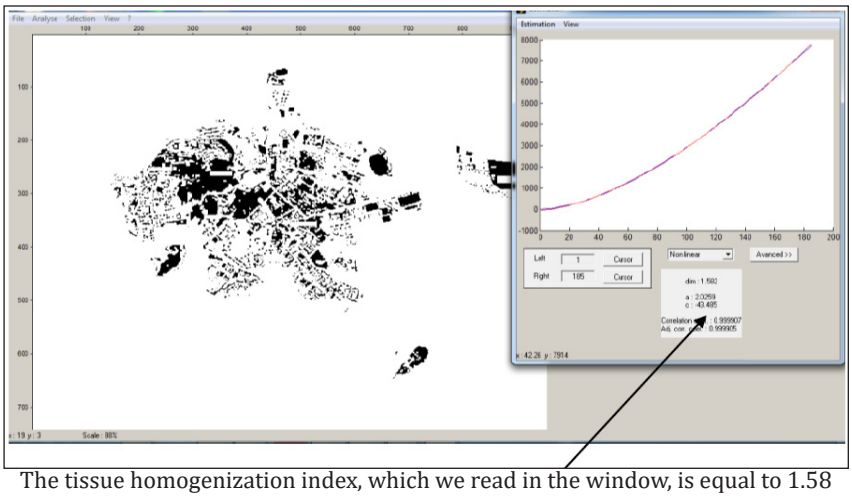
Concerning Guelma city, and after applying and calculating the degree of the tissue homogeneity during the studied periods, we found the different values of the dimensions of differentiated interconnectedness (as shown in figure No. 2) between 1.59 in 1966 and 1.58 in 1977, and the value of 1.65 in 2014. Through these values, we find that the period during which the Guelma city appeared had a less homogeneous urban tissue and had a low fractal dimension of 1.58. during the years (1966–1977) are very close to each other: 1.59 and 1.58, respectively, because it is the stage during which the Guelma city experienced significant expansions, motivated by the response to population needs as well as the reception of waves of rural exodus, which coincided with the administrative division of 1974, and the settling of industrial units thereby, which affected the demographic increase that led to an increase in urbanization, the diversity in its forms, and the emergence of peripheral areas that differ in many characteristics from the colonial nucleus.



The tissue homogenization index, which we read in the window, is equal to 1.59.

Figure 2. Measurement behavior curve for 1966

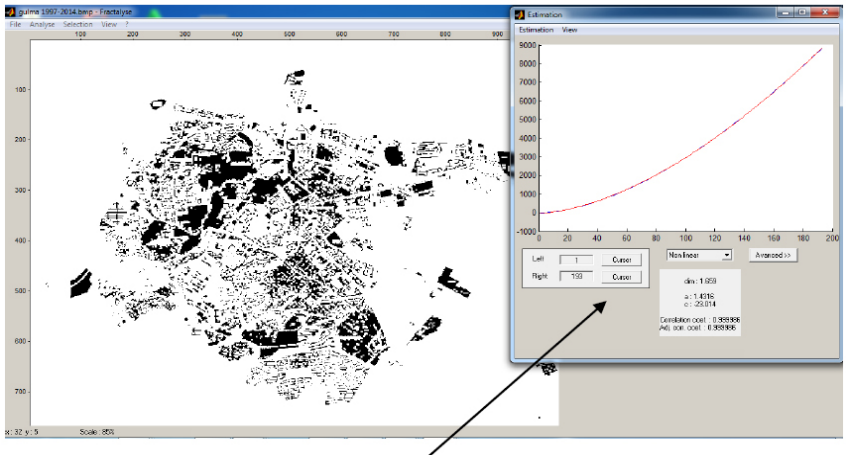
Moreover, the curve of gradual behavior shows that the tissue of the city in 1977 shows a less homogeneous hierarchical form. This period is characterized by the intensification of the city, with the aim of meeting the population's needs for housing and equipment without taking into account the elements of the urban composition. The previous period also seemed less homogeneous because the production of the city during the same period was subject to popular logic, and thus, the appearance of a random form and a heterogenic urban structure (See figure No. 3).



The tissue homogenization index, which we read in the window, is equal to 1.58

Figure 3. Measurement behavior curve for 1977

As for 2014, it is the most divergent period. It has a large fractal dimension compared to the previous periods, and its value is close to 2, where it was estimated at 1.65 and thus presents a rather high degree of homogeneity, because the city is the result of a historical accumulation and multiple interventions that each time lead to a multiplicity of forms and a change in The final image of the city, especially after the emergence of random housing, but the emergence of the tools of preparation and reconstruction, which are planning tools, faced such manifestations and several other challenges, the most important of which are limiting expansion and trying to intensify and avoid the consumption of agricultural land on the other hand, showing the fractal surface dimensions of the different tissues that were studied There is a positive correlation where the value of r is 0.99 where urbanity exist.



The value of correlation we read in the window is 1.65

Figure 4. Measurementbehavior curve for the period 2014

b- ***The Degree of Tissue Complexity***

Through our analysis of Guelma City, we found that the coefficient of the Shape "A" of the city is as follows:

In 1966, the coefficient of the shape "a" was equal to 2.11 and its value was achieved (2.02) in 1977, whereas in the year 2014, it was estimated at 1.43. This confirms that the year 1966 has taken a compact form, where the urban tissue was characterized by a compact hierarchical homogeneity and urban islands. This confirms the absence of empty pockets within the city, while the value of "a" n 1977 is very close to the one of 1966. Through tackling the history of the city,

We find that it appeared with a dual urban structure, composed of two units, separated by — Oued As-khoun—, where the colonial tissue is situated in the eastern part, with a compact chess form, whereas the western part contains the random tissue, which, despite the logic according to which it was created, is characterized by homogeneity and compaction, because the goal and the aim behind creating it are common between all its components.• So, the shape coefficient between 1966 and 1977 is converging, showing a slight decrease during the last year. This indicates that the city began to spread and expand during this time period, resulting in a shift in the character of the urban tissue from compacting and homogenization to heterogeneity and complexity.

As for the year 2014, the shape coefficient was estimated at 1.43, which constitutes a significant decrease compared to the previous periods. This confirmed heterogeneity in the urban tissue and non-hierarchical urban development. This is due to many factors, among which the poor planning and natural obstacles that characterize the region.

If we compare the previous results with the urban development that the city knew in the Directive Plan for Preparation and Urbanization, we find that the city was, in the early stages, a central nucleus, which was compact and regular, adopting a balanced urban tissue until the stage that preceded independence, because the city witnessed new updates, especially in the 1970s, when it relied on industry as a new logic in the economy, the construction of the railway and its proximity to National Road No. 80, the administrative promotion to a province. All these factors led to an increase in the population due to rural exodus and the improvement of the standard of living, which are certainly factors and drivers of the urban growth of the city at the urban level.

The stage of 1977 specifically witnessed the emergence of a city with two fronts; one representing the planned and organized facet of the city, with a compact tissue; and the second, a random and anarchic neighborhood. They were both separated by Oued As-khoun, which constituted for many years a natural barrier after a long drying up. It is considered among the regions that experienced random urbanization, which coincided, as we mentioned earlier, with the settlement of the industrial units in the city, and thus, it became, because of this density, a very dynamic region, especially from the commercial side, and is known at present time as Volunteering Boulevard (*Chari'âAttataou'â).*

It is worth mentioning that Oued As-khoun is a clear boundary that divides the city into two different parts. The first is the planned part of the city, and the second is the random part of it.• The next period of urban development, namely the 1990s, is the period shared by all cities in Algeria because it coincides with the adoption of tools for preparation and urbanization in the management of city affairs. Based on this, the city benefited from multifaceted housing programs in the form of collective and individual residencies. The South West was the real estate spot that hosted all these housing programs, which were accompanied by a series of educational and service facilities.

From the foregoing, we can say that due to the various stages of urbanization and development, the city has witnessed a clear shift from a compact urban structure to a fragmented city, especially with the emergence of the random tissue, without planning, which contributed strongly in that image.

Radial Analysis

Through this analysis, we try to track the local changes of this fraction by using the graphic curve of the sizing behavior and the data it follows. For this analysis, as a first step, we must choose the counting center, which is a point that we determine in the historical center of the city, and this point is surrounded by a square or circle, where we gradually expand the size of the latter, and at each stage we calculate the radial fractional dimension. (drad), and follow its changes according to consecutive stages; representing these variables constitutes the so-called curve of sizing behavior. The following graphs illustratethis(See figure 5,6,7).

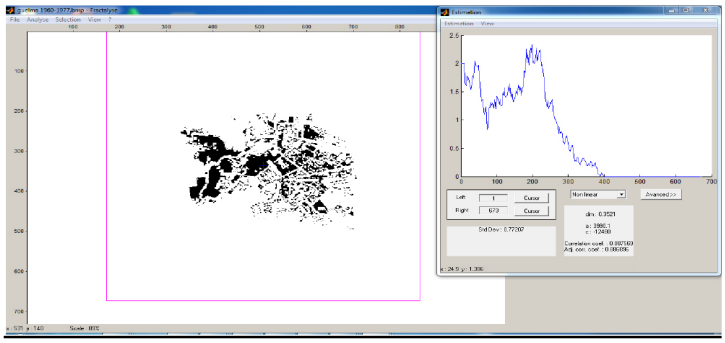


Figure 5. Sizing Behavior Graphic Curve for Guelma City in 1966

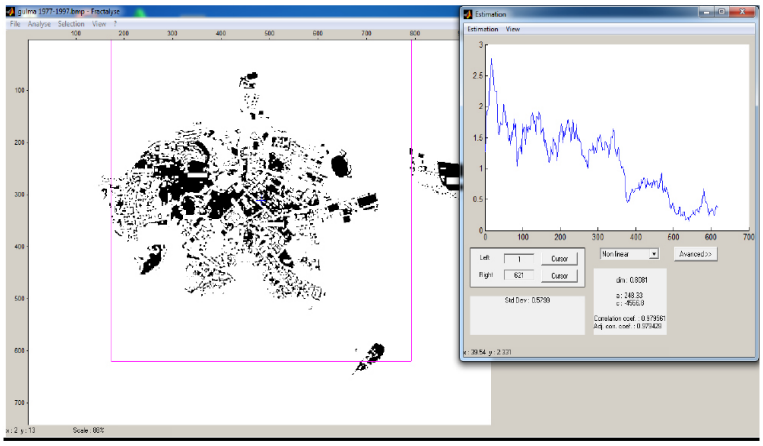


Figure 6. Sizing Behavior Graphic Curve for Guelma City in 1977:

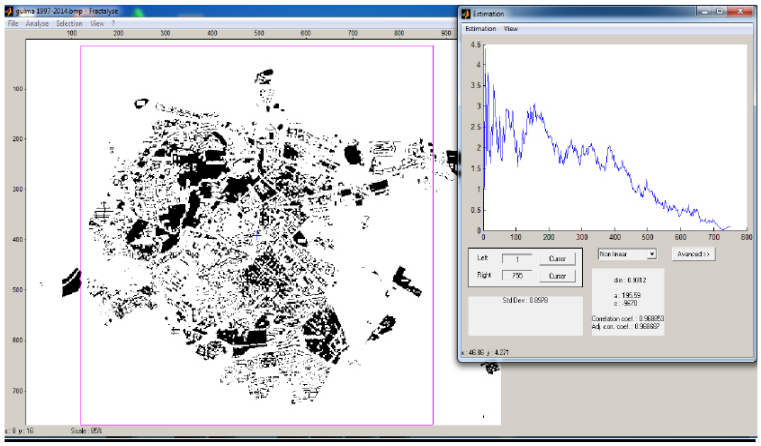


Figure 7. Sizing Behavior Graphic Curve for Guelma City in 2014:

Through the preliminary observation of radial fractal analysis that clearly highlights the structural interruptions of the main groupings shown at the top, the above curve shows large breaks and oscillations that reflect a decrease infraction from the center to the peripheral spaces. There are also clear deviations and fluctuations spread across this entire curve, which are explained by the fact that there are consecutive natural interruptions and obstacles (mountains, lowlands, fractions, canyons, and watercourses). Furthermore, the decrease recorded in the curve of measurement behavior indicates the loss of morphological homogeneity at the level of the urban tissue, as we set off from the center towards the peripheral spaces.

We will clarify this oscillation through the followingcurves:

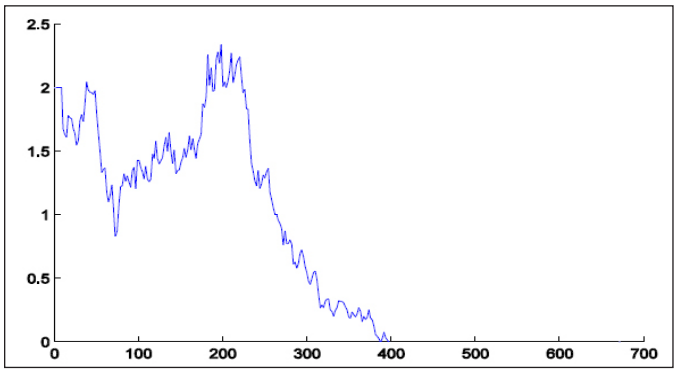


Figure 8. Illustrates the oscillations in the graphic curve of the sizing behavior of Guelma city in 1966

The curve shown in figure No. 7, which represents the fractal analysis of the tissue of the city in 1966, in which we record clear declines up to 100m away from the specific position, indicates that there are empty spaces and ruptures at the

level of the tissue of the city, and through the curve, it is shown an increase in the decline within 200 and 400 m of the center, which explains that there are breaks in the fabric of the city, The major interruptions that are actually translated into a difficult topography and natural obstacles, which make the urban tissue appear in a disrupted way. That assures the loss of morphological homogeneity on the level of the urban tissues. As the fractal distance is estimated here with the value of 0.35, we notice the increase to the value of 0.80 in the recorded curve for the year 1977, after 200 and 400 m from the center, which reflects an increase in the gaps and empty spaces within the tissues.

And a fraction of the urban tissue, in comparison with the curve of the year 1966. And thus, we can say that the urban tissue during the previous period is more compact than the one starting in 1977, in which we can observe more separation, in the curve that shows big oscillations and a clear decrease, in which we record the highest value at a distance of 350-400m from the center, and also at 500m from the center. This is due to the great diversity witnessed by the city during this period, especially with the multiplicity of its expansion and urbanization reasons, with the emergence of the industrial tissue, as shown in figure 09:

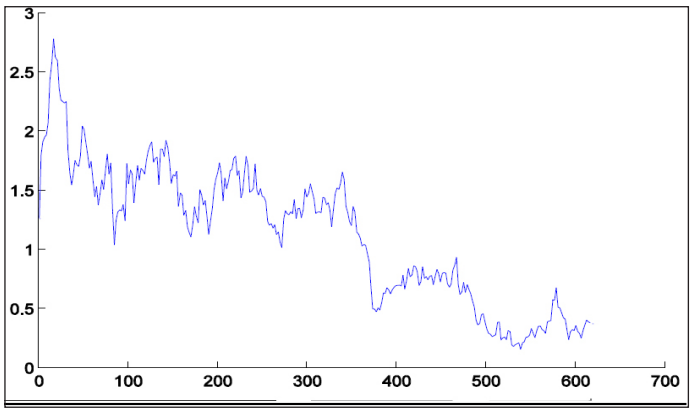


Figure 9. Curve Showing Fluctuations in the Sizing Behavior Graphic Curve of Qalaa City of 1977:

As for the year 2014, the curve shows several oscillations, where we find a rise and a decrease in the curve. The curve shows a significant rise, indicating the morphological homogeneity that characterizes the urban tissue. It also indicates its density and confirms the flat topography, which is free from obstacles and fractions. This has led to the emergence of the tissue in a compact form. On the other hand, we find a heterogeneous and disrupted urban tissue, proved by the great decrease in the measurement behavior graphic curve, at 600-700m from the specified center. This oscillation is proved by the value of the fractal distance, recorded in the same period, which is estimated at 0.93, and thus, the expansion of the city and the increase in its area are accompanied by an unbalanced distribution of the population between the urban zones, which results in the diversity of the forms of urbanization from one zone to another, especially between the center and the peripheral spaces. The following graph illustrates that:

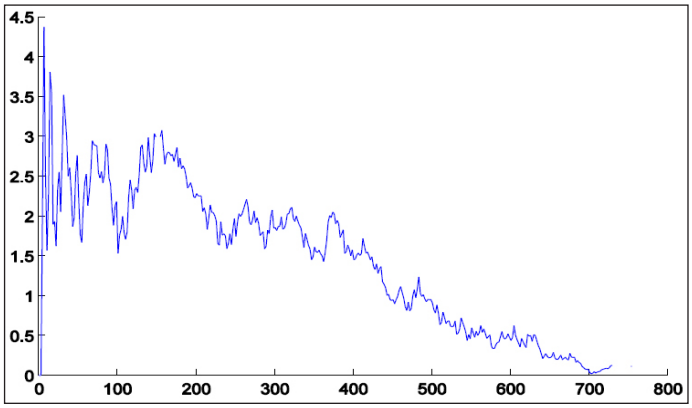


Figure 10. Curve showing oscillations in the graphic curve of sizing behavior of Guelma city for 2014:

To confirm the previous analysis, we are trying to match curve No10 with the urban spot image of 2014 to illustrate the interruptions in urban tissue that correspond to each stage of the growth of the city, as illustrated in figure No.11. The urban area appears to be compact and dense in some parts of the area and fragmented in others. This is certainly explained by many factors that the city has witnessed in conjunction with its growth throughout different stages.

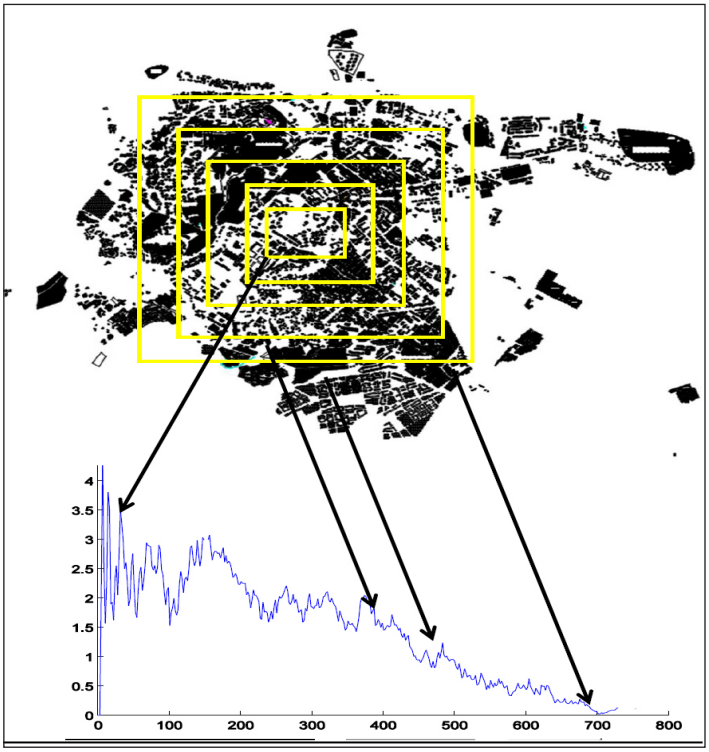


Figure 11. Conformity of the graphic curve of sizing behavior of 2014, with the urban spot image:

Expansion Analysis

a- *Tissues compression degree*

By applying this indicator to the field of study, we found that obtaining a single mass of urban tissue in Guelma City requires between 10 and 40 repetitions. The most interconnected and compressed tissue is the historical center of the city, where urban tissue is formed in a single block after 10 repetitions. This was in 1966) See figure13(. Whereas for 1977 and 2014, the urban tissue cluster is after 15 repetitions and 40 repetitions) See figure 14,15,(respectively. This reflects that the city contains gaps and fractions in its tissue, which is of less value in 1977 than it was in 2014, because the number of the required repetitions to be filled during the latter reached 40 repetitions it is considered an important value in comparison with 15 repetitions in 1977. This may be explained by the diversity and the multiplicity of the tissues because of the multiplicity of the actors and the change in the urbanization logic every time, resulting in clear gaps at the level of the tissues.

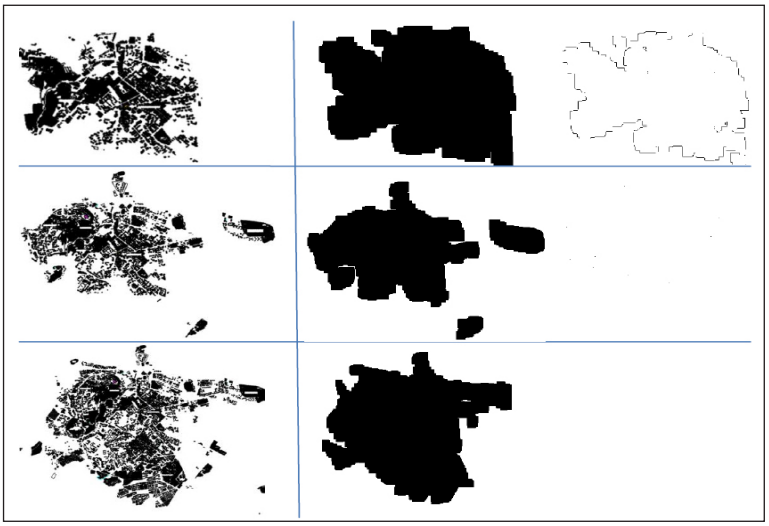


Figure 12. Steps boundaries extraction

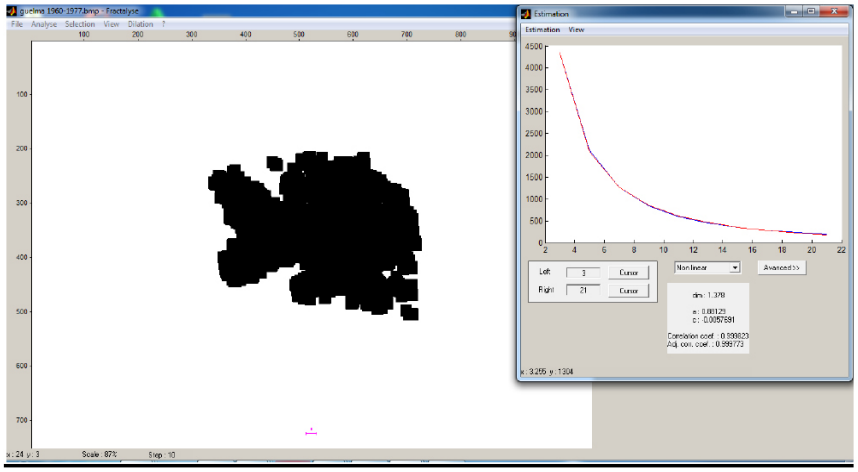


Figure 13. curve of 1966

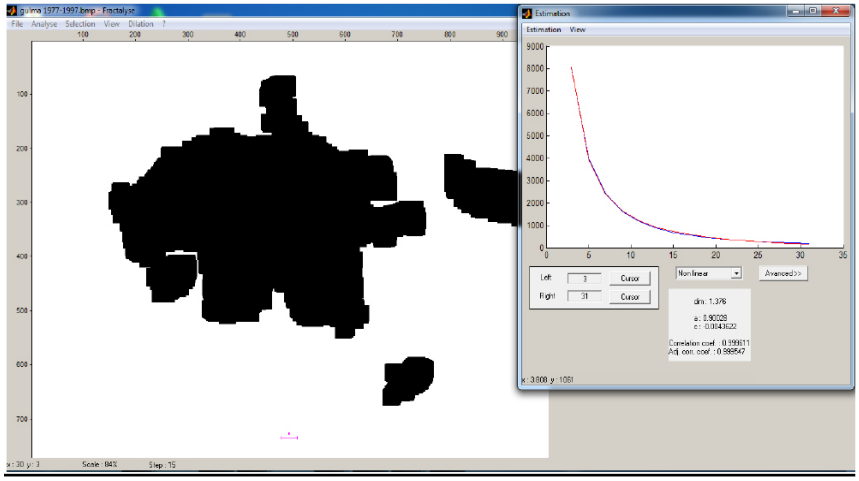


Figure 14. curve of 1977

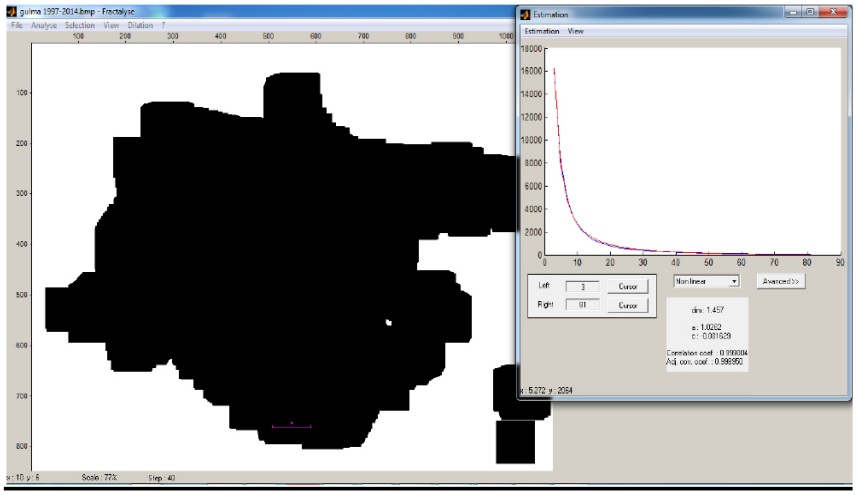
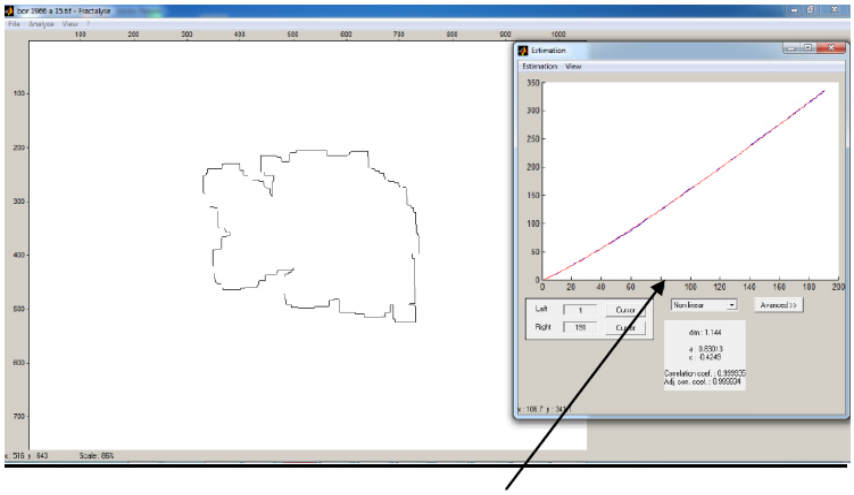


Figure 15. curve of 2014

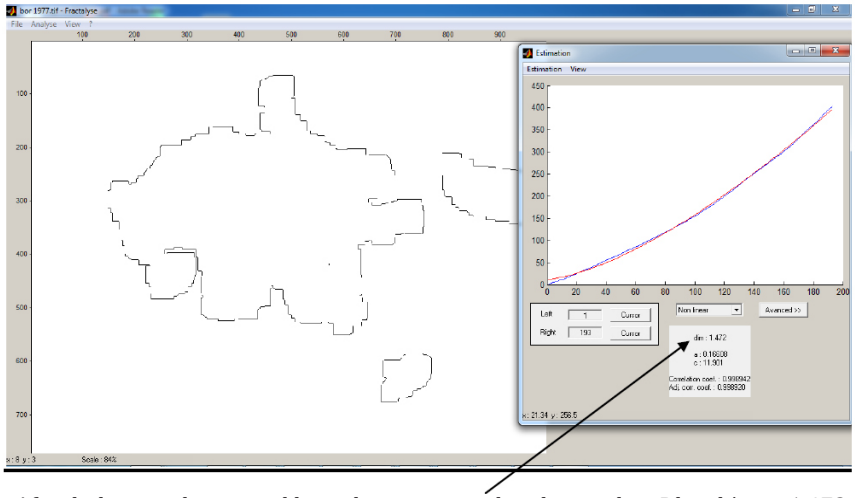
b- ***The degree of dispersion and fragmentation of urban boundaries***

Through the following curves (See figure 16, 17, 18) we try to determine the value, after linking to the general boundaries of Guelma City for the three years, and then calculate the fragmentation index, the bifurcation index and the composite index:



After linking to the general boundaries, we read in window Dbord/tot = 1.144

Figure 16. The value after linking to Guelma City general boundary in 1966



After linking to the general boundaries, we read in the window Dbord/tot = 1.472

Figure 17. The value after linking to the general boundaries of Guelma City in 1977.

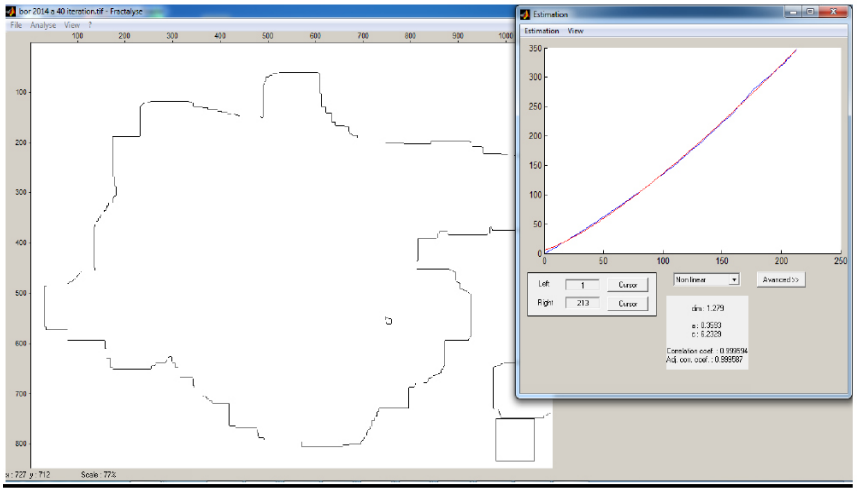


Figure 18. The value after linking to the general boundaries of Guelma cityin2014.

We can then calculate the following indicators: Fragmentation Index, dispersion index δ, and composite index. The results are explained in the following table:

Table 1. Correlation dimensions and related indicators

Composite Index Is	Dispersion index δ	φdivision index	Dbord/ agre	Dbord/tot	Dsurf	
0.785	0.608	0.204	1.144	1.378	1.593	1966
0.794	0.926	0	1.472	1.376	1.582	1977
1	0.703	0.204	1.279	1.457	1.659	2014

Through the table and the analysis of the results for each indicator, and determining the morphological nature of the field.

- **For the division index φ**

From the table, we note that the division index is equal to 0.204 for the year 1966, 0 for the year 1977 and 0.204 for the year 2014. These values indicate that the urban spot is often made up of a large island that controls most of the urban area.

- **Dispersion index δ**

From the previous table, the value of the index approaches the value of 1 (0.608.0.926.0.703). This is what coincides with the fractional model (the Sierpinsky Carpet).

- In addition, Dbord/tot values and Dbord/agre values for the three years, have greater values than one, i.e., the field is very fragmented (fragmente) and serrated boundaries (dendricity).
- As for the composite index, it is close to one for the years 1966 and 1977 and equal to one in the year 2014. Here, we must identify the values of both Dsurf and Dbord/agre, where the value of each of the two indicators exceeds 1.5. And thus, we emphasize the diversity of the area of the field, i.e., heterogeneity and curvy boundaries.

CONCLUSION

The city of Guelma has experienced continuous and rapid urban growth, where the tracker of this urban area from its inception to the present day confirms the reality of the factors that led to its installation, and the factors that lead at the same time to its growth and recombination are often due to the changing conditions of its development. The re-composition of the city is particularly evident through its urbanization, which is very visible on the morphological and formal side. So, through this study we wanted to distinguish the morphological shape of Guelma city, through the analysis of the fractal analysis, as well as to know the extent of homogeneity between the urban tissues, from the city center to the new expansions and the extent of their interdependence.

Through the analysis, we have come to confirm that there is a clear fracture in the urban tissue, resulting from the lack of interconnectedness between the various expansions. The radial analysis and the graphic curve of the sizing behavior, through which clear oscillations have emerged, are translated by a decrease in the curve as we head towards the peripheral areas, indicating the expansion and enlargement of the city, which has been done according to a certain logic of the production and at different stages, as well as the existence of some physical, topographic, and geomorphological obstacles, which were the reason for the loss of the morphological homogeneity on the level of the urban tissue of the city.

The latter acquire such complexity, as do the new city's expansions, which exhibit a kind of randomness in their urbanization.With regard to the value of the general correlation, we found a confirmation of previous results, where its value decreases with an increase in the shape coefficient as we move towards the peripheries, and thus, the complexity of these tissues increases.

With regard to the value of the general correlation, we found a confirmation of previous results, where its value decreases with an increase in the shape coefficient as we move towards the peripheries, and thus, the complexity of these tissues increases.

The calculation of both the fragmentation index and the gradient index (dispersion index) and the composite index, by which we were able to classify the urban spots of Guelma city, as corresponds to the fractional model (sierpinsky carpet). This model, in which the city appears dense, then branches out along the main and secondary transport axes,

which affirms that the city extends and expands towards the peripheries in a dispersed and fragmented manner, in addition to the specificity of the field of the study, as the city is known by the location which is surrounded by the natural obstacles, on one hand, and the agricultural lands on the other hand.

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