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# Space syntax evaluation of green infrastructure in Bogotá: territorial planning and the challenge of urban greening in Latin America

**Vasco Barbosa**

vascobarbosa@upt.pt

Universidade Portucalense

**Mónica Suárez**

Escuela Colombiana de Ingenieria Julio Garavito

**Samara Marin**

Universidad Pedagógica y Tecnológica de Colombia

**Jhojan Solano**

Universidad Pedagógica y Tecnológica de Colombia

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# Space syntax evaluation of green infrastructure in Bogotá: territorial planning and the challenge of urban greening in Latin America

Increasingly, cities are spatially complex areas, characterized in recent decades by high growth with greater intensity in the Global South. This growth is also evident in Latin America, and there are constant conflicts over socio-urban and environmental management in the urban spaces. As one of the regions with the greatest biodiversity, the urban green landscape in Latin America needs to be included in municipal planning instruments. In this context, this study aims to assess the green infrastructure of the city of Zipaquirá, located in the metropolitan area of Bogotá and how this urban element is distributed in the municipal space. This study seeks to understand the distribution of green infrastructure and its relationship with the road structure as the main element of spatial growth. Regarding the chosen methodology, space syntax was used integrated with remote sensing with aerial photo was used to calculate the degree of dispersion, consolidation, and frag-mentation of green infrastructure through FRAGSTATS implementation with ecological parameters. From the results obtained, we can identify a greater consolidation of the green infrastructure in the central urban zone, which changes to a fragmented green structure in the peripheral zones of the cities, that is, in the new areas of urban growth. This data allows us to conclude that urban expansion is not being accompanied by green infrastructure as a spatial element that could facilitate greater urban sustainability.

Keywords: Green infrastructure; Space Syntax; Urban development; Sustainable growth; Green transition;

## Introduction

Cities have been growing intensely in recent decades, especially in Global South where there is extensive urbanization (Caldeira, 2017; Follmann, 2022). This rapid urban growth, often not framed by public policies for urban development that are sufficiently adapted to the natural characteristics of the urban landscape, sometimes generates urban management problems (Zain et al., 2022). The impacts of this extensive urbanization are diverse and can be identified, for example, as the loss of green space in the city, reduction of natural elements and loss of urban biodiversity or even scarcity of green infrastructure. The relatively little importance at-tributed to the green landscape of the city in favour of the growth of built space is evidenced. Added to these problems, is the reduced effectiveness of urban planning and ordering instruments in the context of Latin America (Almandoz, 2010; Romero-Duque et al., 2020; Rojas., 2013). The urban well-being that can come from urban planning is still an illusion for citizens because it is not part of the

elaboration of technical instruments for management and urban planning [Cervero, 2023; Lungo & Baires, 2001; Parnel & Robinson., 2012).

The study of the effect of urbanization on the landscape has been developed from different fields of knowledge in which it has been identified that there are great ecological, physical, and socioeconomic implications related to the fragmentation of the landscape (Grau & Aide., 2008; Romero-Ruiz et al., 2012), making it increasingly complex to reliably quantify the variations that occur at the level of land use (Pauleit & Duhme, 2000). However, the use of metrics associated with the field of ecology allows for a broader understanding of the ecological function of green spaces (Luck & Wu, 2002) and limits the focus to a specific scale where it is easier to identify functional effects such as surface stormwater runoff and urban heat island among others (Allen, 2022; Meerow & Newell, 2017).

Evaluating these metrics will allow for a better understanding of the ecological function of green spaces and therefore plan and manage such spaces to conserve biodiversity and contribute to restoration activities (Matsuoka & Kaplan, 2008; Uneamaa et.,2009). Enhancing the conservation of green corridors and green infrastructure is essential for sustainability, resilience, and mitigating climate change (Hostetler et al., 2011). Urban planning efforts to conserve urban biodiversity have often focused on the creation of protected natural areas and corridors (Foster et al., 2011). Green infrastructure should be articulated with biodiversity; urban ecological networks and connectivity, without neglecting multifunctionality, redundancy, and adaptive design (Ahem, 2013).

The most important axis is urban sustainability, which focuses on urban ecosystem services and their relationship with human well-being (Niemelä, 2014). The multifunctional and multiscale nature of urban green infrastructure makes it difficult to categorize services and benefits, as the interactions between the various benefits are multiple and appear at different scales (Demuzere et al., 2014) and the benefits are not always positive (Wu, 2014). However, green infra-structure helps territories to adapt to climate change and constitutes a challenge for land use planning and urban planning in general (Matthews & Byrne, 2015; Zölch et al., 2016) which must also consider the distance and accessibility of these infrastructures to assess their effect on the quality of life of the inhabitants (Cetin, 2015).

With the expansion of urban areas, understanding how ecological processes function in cities is increasingly important to conserve biodiversity. Urban green spaces are critical habitats for biodiversity, but we do not yet have a good understanding of their ecology

and how they function to conserve biodiversity at local and landscape scales (Aronson et al., 2017; Lepczyk et al., 2017).

Cities play an important role in global biodiversity conservation, particularly through the planning and management of urban green spaces. However, the management of these spaces is subject to a complex array of interacting social, cultural and economic factors, such as governance, economics, social networks, multiple stakeholders, individual preferences and social constraints (Capotorti et al., 2019; Yang et al., 2019).

Green infrastructure also facilitates a range of products, technologies, and practices specific to natural systems (or that mimic natural processes) to improve the overall quality of the environment to be effectively implemented (Ying et al., 2022). Finally, although green infra-structure offers a low-cost approach to assisting disadvantaged communities compared to engineered solutions, maintenance and construction costs sometimes prevent green infrastructure projects from being implemented (Buijs et al., 2016; Gashu et al., 2020; Newman et al., 2022).

It is known that road infrastructure and its implementation or other urban mobility infrastructure are drivers of urban and spatial development (Hackney et al., 2007; Han et al., 2019; Sreelekha et al., 2016). In this context, given the current evolution of urbanization, an integrative analysis of both factors becomes relevant, that is, the landscape and its urban infrastructure, and road infrastructure for urban mobility (Fuentes et al., 2017; Segura, 2018). The combination of these two factors contribute to a sustainable and balanced urban growth, when they are considered in the simultaneous exercise of the planning and territorial organization of the city (Albrechts et al., 2020; Camagni, 2017). In this sense, the research intends to evaluate the existing green infrastructure in the city of Zipaquirá, metropolitan area of the city of Bogotá, and how it is distributed in its municipal scale. Therefore, the reflection of the study seeks to understand the city and its periurban area in relation to green infrastructure associated with the road network, so that it is possible to identify less integrated urban areas and thereby support urban planning instruments.

### *1.1. Case study*

Zipaquirá is a municipality located north of Bogota that is part of the Central Sabana Region (figure 1) and of the recently constituted Metropolitan Region; it is located at

2,550 m.a.s.l., has an average temperature of 18°C, and an average annual rainfall of 1631 mm. Its urban area is about 8 km², it has a population of 130,537 according to the 2018 census of DANE (National Administrative Department of Statistics of Colombia). Zipaquirá has an urban area in which two sectors are distinguished: the tourist area made up of the Historic Center of the city and the Salt Cathedral and the urban area, in which there are four communes made up of fifty-two neighbourhoods. The rural area is divided into two corregimientos in which there are 14 urban population centers and eleven periurban areas namely "*veredas*". The urban area has a predominantly semi-flat and undulating topography according to agreement of 12 June 2000 (CMZ, 2000).

The municipality has 64.88% of environmentally protected land, including the Guerrero Paramo, 50-meter buffer strips around the paramo and sub-paramos, and forests that adjoin agricultural land. In this sector, there are springs and riverbeds areas, streams, and lagoons that are directly connected to the Bogotá River. Zipaquirá is a logistic and regional node at the agricultural, agro-industrial, construction, energy, and tourism levels.

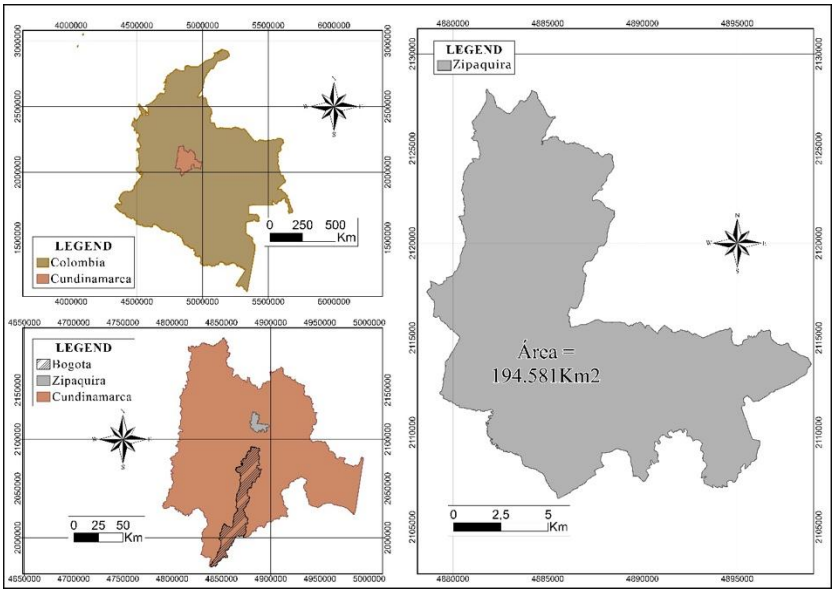



**Figure 1.** Location of the urban area of Bogotá, Central Sabana region. Source: authors.

According to the Land use Plan (LUP) of the municipality of Zipaquirá, the population rate has increased widely in recent years, due to the real estate supply that has been generated over the northern part of the metropolitan area. This has contributed to the consolidation of the urban area of the municipality of Zipaquirá and is reflected in the demographic decrease of the rural sector the above, evidences a process of consolidation

of urban activities against the loss of rural activities and traditional processes product of the requalification of lands and the emerging occupation as part of the metropolization process of the cities (Campolina & Vieira, 2016; Dockemdorff et al., 2000; Sabana, 2018; Wust et al., 2002).

The occupation model of the municipality evidences that the metropolitan dynamics of the Sabana de Bogotá have made its urban area behave as a sub-core of regional scale thanks to its connectivity not only with Bogotá but also with the rest of the region and the country. The municipality has grown from 93.1 to 263.8 urbanized hectares, which shows an important process of land development in response to the demand for housing in the region (Huang et al., 2021; Machado, 2005).

## 2. Methodology

The study refers to the municipality of Zipaquirá and as it intends to evaluate the urban green infrastructure and the road structure, for this, two areas were defined to better understand how these structures are spatially distributed in the city (figure 2). The first study area focuses on the consolidated urban area defined by its built environment and the second study area focuses on the peri-urban area of the municipality. This is due to the importance of an integrated understanding between the urban green landscape and road axes (Jimenez Aguilar & Thoene, 2021; Stessens et al., 2017; Zhou & Wang, 2011), so that it can be inferred about the consolidated area and the area of growth, either individually or together in terms of their functional spatiality (Hutton, 2006; Jing et al., 2018; Mosler, 2019).

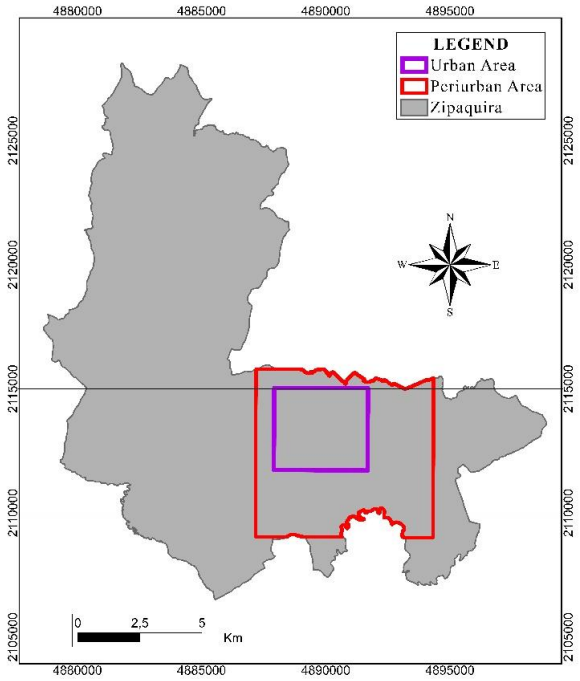


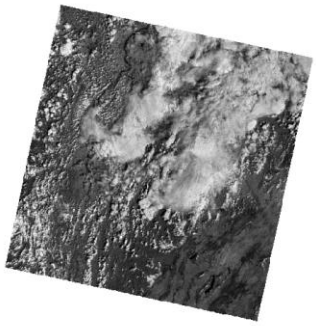

**Figure 2.** Study area. Source: authors.

### *2.1. Urban landscape*

To carry out this study, techniques of geographic information systems were applied: analysis of aerial photography by remote sensing through the coverage of land uses, metrics of analysis of landscape according to FRAGSTATS (McGarigal, 2015), in addition to analysis of the road structure according to space syntax theory (Hiiilier et al., 1976; Karimi, 2021; Van Nes & Yamu, 2021; Vaughan, 2007). These procedures are explained in more detail below.

The Landsat 9 satellite image of 2021 was used, and an atmospheric correction was performed with QGIS software to eliminate the effect of aerosols and intrinsic radiance that occurs when different calculations are made involving multispectral bands (Benavente & Botequilha-Leitão, 2012). Then, a basic processing was executed that allowed the cut of each of the bands, having as limit the municipality of Zipaquirá as shown in Table 1.

**Table 1.** Geoprocessing procedure. Source: Authors.

| **General aerial photo** (a) | **Clip aerial photo** (b) |
| --- | --- |
|  |  |

To classify the land cover present in the study area, a supervised classification was developed in QGIS (Level 1 according to the Corine Land Cover methodology adapted to Colombia), using the semi-automatic classification plugin (Congedo, 2016), which is based on a composition of spectral bands (table 1, a) and the assignment of samples that allow the identification of the classes or coverages present (Correa Valencia, 2018).

Likewise, based on the classes determined, a cut was made for each of the defined study areas, obtaining their respective coverages (table 1, b). Finally, to analyze the landscape of the study areas, different metrics were identified that provide a perception of it (Britto Nuñez, 2021; Frazier & Kedron, 2017; Lausch et al., 2015; McGarigal, 2006), to determine their respective calculation using FRAGSTATS.

Landscape analysis can be based on the determination of different metrics, which refer to a tool that provides spatial characteristics of the landscape, there is a significant amount of such metrics, which can make their analysis difficult and therefore it is of utmost importance to segment the metrics to be calculated, thus ensuring their correct use and interpretation (Grafius et al., 2018). The metrics applied in this study are related to shape, density and area of each of the tesserae or patches identified, thus, determining the metrics described in Table 2.

**Table 2.** Selected metrics. Source: Authors, adapted from Aguilera & Botequilha, 2012.

| Metric | | Spatial scale | Meaning | Data range |
|---|---|---|---|---|
| PLAND2 | Percentage of occupancy of each category | Urban and regional scale | Shows the percentage of occupancy that each category represents with respect to the total. | From 0 to 100% of the surface. Higher values imply higher dominance of the category. |
| NP | Number of total patches in each category | | Measures the number of patches in each category. | From 1 for a category with a single tile to infinite values. |
| DP | Patch density | | Expresses number of patches on an area basis which facilitates comparisons between classes. Number of patches/100 ha. | Values 0 for single tessellation category up to infinite values for sparse values. |
| GYRATE | Turning radius | | It measures the elongation of the tesserae. Higher values suggest more elongated and more connected tesserae. | From values of 0 for patches of a single pixel, to infinite values for longer plots. |
| SHAPE | Index of patch shape | | Measures the geometric complexity of the tesserae. Higher values indicate more complex shapes | From 1 for circular patches, to infinite values for more complex plots. |
| CONTIG | Contiguity index | | It measures the contiguity of pixels in each tessellation (orthogonal and diagonal adjacencies). Higher values indicate greater contiguity. | From values of 0 for single pixel values, up to 1 for maximum contiguity. |
| ENN | Average distance to the nearest tile of the same use | | Measures the average distance to the nearest tile of the same use. Higher values imply greater insulation. | 0 values for single tessellation category to infinite values for scattered values. |

It is important to present the equations for calculating the number of patches, patch density and patch index, since it is the main spatial element and what configures the urban space of the municipality. Below are the main formulas used for spatial pattern analysis of the urban landscape.

*equation 1: Number of patches.*

NP=N

Units: None

Range: NP ≥ 1, no limit

NP = 1 when the landscape contains 1 patch only.

Description: NP is equal to the number of patches in the landscape. NP does not include any background patches within the landscape or patches at the edge of the landscape.

*equation 2: Patch density (vector/raster).*

$$PD = \frac{N}{A}\ (10000)(100)$$

PD=N/A (10000)(100)

Units: Number per 100 hectares.

Rango: PD > 0, sin límite.

Descripción: PD equals the number of patches in the landscape divided by the total landscape, multiplied by 10,000 and 100 (to convert to 100 hectares).

*equation 3: Patch shape index (vector/raster).*

$$SHAPE = \frac{pij}{2\sqrt{\pi \circ aij}}$$

Units: None.

Range: FORM ≥ 1, no limit.

SHAPE = 1 when the patch is circular (vector) or square (raster) and increases without limit as the patch shape becomes more irregular.

Description: SHAPE is equal to the perimeter of the patch (m) divided by the square root of the patch area (m2), adjusted by a constant to conform to a circular (vector) or square (raster) standard.

### *2.2. Space Syntax*

Then, the concept of space syntax was applied to analyze the road network according to its urban axes (Turner, 2007), because they are one of the main drivers of spatial growth

in the city. This approach, based on morphological analysis, is related to the social logic of urban behaviour and has already been widely applied in other studies (Baran, et al., 2008; Li et al., 2017; Pafka & Aschwanden, 2020; Yamu & Van Nes, 2017). The process begins with the design of all the roads from the study area (figure 3) that define the urban accessibility road network and its morphology, which is considered an axial map.



**Figure 3.** Axial map with the urban morphology structure. Source: authors.

Given the existence of two areas of study, it is appropriate to analyze the urban morphology with the application of connectivity and global integration parameters. Spatial connectivity is related to the intersection of urban road axes and provides information about the possible flow of urban accessibility.

*Equation 4*:

$$Connectivity(i) = deg(i) = \sum_{j=1}^{N} (A_{\mathfrak{G}})_{ij}$$

Global integration, through the road network, informs how the urban space is integrated with each other in relation to the entire urban space of the municipality.

*Equation 5:*

$$Connectivity(i) = deg(i) = \sum_{j=1}^{N} (A_{\mathfrak{G}})_{ij}$$

These parameters are relevant when crossed with the analysis of green infrastructure because it allows calculating and visualizing areas with greater or lesser risk of losing this same infrastructure due to possible disorderly urban growth.

## 3. Results

### *3.1. Urban area*

From the calculation of the remote sensing analysis on the land cover, a map on the spatial patterns of the landscape, in relation to the urban area, is obtained (figure 4). The artificialized territories present an extensive occupied area and in its interior only reduced areas of Forests and semi-natural non-continuous areas, as well as areas of smaller scale of agricultural land cover. It is observed that the green areas are not spatially representative and do not configure homogeneous spatial forms.

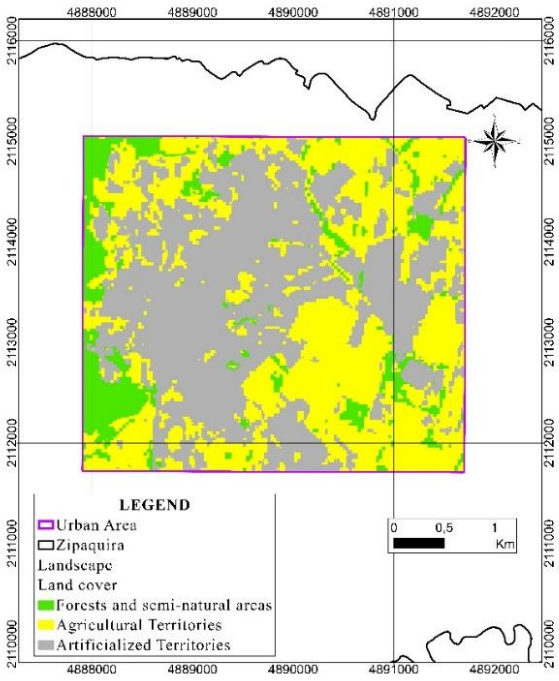



**Figure 4.** Land cover classes in the urban area. Source: authors.

In the case of the urban study area (table 3), it is determined that the coverage with the highest percentage of occupation is that of artificialized territories, with a total of 48.07, thus corresponding to the most compact class with a GYRATE value of 840.86 and to the same extent, with the lowest number of patches being between 50% and 60% less than the other classes, identifying a significant growth of the city. The forest and semi natural areas class is established as the least expansive and has significant fragmentation, which is directly attributed to urban growth.

**Table 3**. Land cover classes with the urban landscape metrics. Source: Authors.

| Land cover class (type) | Pland | NP | PD | Gyrate_ AM | Shape_ AM | Contig_ AM | ENN_A M |
|---|---|---|---|---|---|---|---|
| Forests and semi-natural areas | 10,58 | 113 | 9,01 | 257,541 | 2,685 | 0,811 | 54,1962 |
| Agricultural territories | 41,34 | 123 | 9,81 | 545,718 | 5,2499 | 0,8825 | 33,4685 |
| Artificialized territories | 48,07 | 68 | 5,42 | 840,864 | 6,5509 | 0,9223 | 32,5883 |

From the PLAND metric (figure 5), the land cover with forest and semi-natural areas occupies only 10% of the urban land, however the number of plots is 35%, in this case it presents a spatial fractionation of the urban green area. The result of the PD metric on the density of the plots is also 35%, and the Gyrate_Am metric that indicates the shape and possible spatial connectivity, in this case the value is 15%. Although the shape of the plots on the land cover of forest and semi-natural areas is not very complex, their reduced spatial interrelationship and connectivity is reduced. It shows a dispersion of areas and their green infrastructure in the urban space.

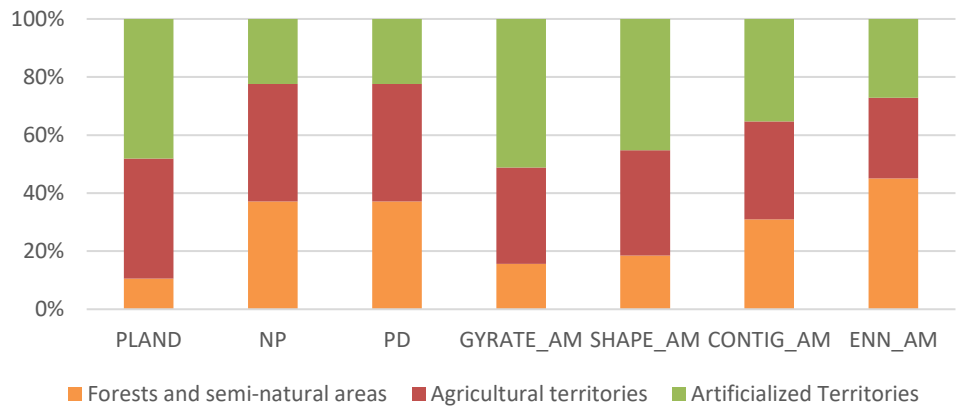



**Figure 5.** Urban landscape patterns across land cover classes in the urban area. Source: authors.

### *3.2. Periurban area*

From the spatial pattern in how the landscape is configured based on the land cover for the peri-urban area (figure 6), the results indicate that agricultural territories are predominant, followed by artificialized territories and lastly forests and semi-natural areas. These last two land covers show a non-continuous spatial pattern and with heterogeneous shapes. This spatial pattern irregularity highlights the fragility of a possible urban green infrastructure, which must be compact.

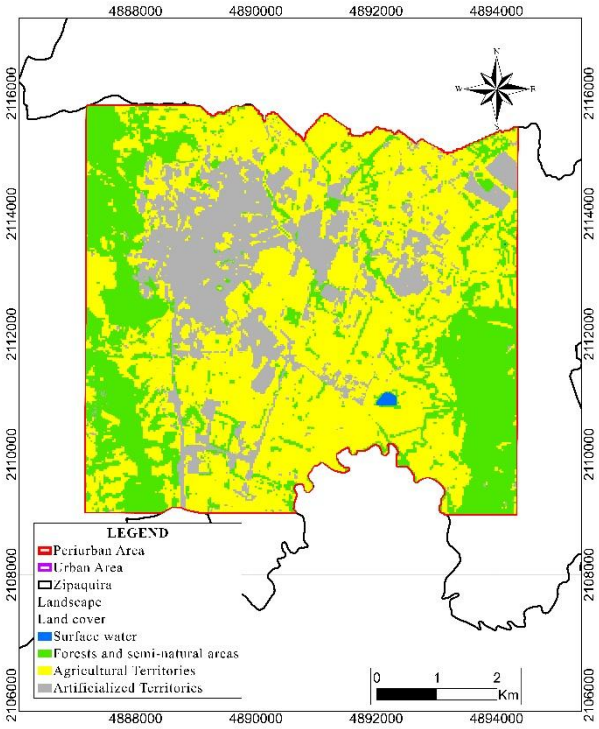



**Figure 6**. Land cover classes in the Periurban area. Source: authors.

For the peri-urban study area (table 4), it is identified that the cover with the highest percentage of occupation corresponds to agricultural territories, with a total of 52.5%, which is directly related to causal factors of fragmentation within the class of forests and semi-natural areas, this fragmentation is corroborated by identifying a high value in the ENN_AM index and to the same extent, to the number of patches attributed to this class, finding a total of 439.

In addition to this, a significant compactness is identified in the class of agricultural territories, finding the highest value in the GYRATE_AM metric (1457,740) which indicates the presence of elongated and connected tesserae or patches, denoting a significant expansion of the agricultural frontier.

| Land cover class (type) | Pland | NP | PD | Gyrate_ AM | Shape_ AM | Contig_ AM | ENN_A M |
|---|---|---|---|---|---|---|---|
| Forests and semi-natural areas | 27,57 | 439 | 9,94 | 1167,48 | 5,75 | 0,88 | 37,42 |
| Agricultural territories | 52,52 | 255 | 5,79 | 1457,74 | 11,86 | 0,91 | 32,64 |
| Artificialized territories | 19,76 | 277 | 6,25 | 706,97 | 5,99 | 0,89 | 35,42 |
| Surface water | 0,13 | 2 | 0,05 | 94,04 | 1,17 | 0,90 | 3102,24 |

**Table 4.** Land cover classes with the urban landscape metrics. Source: Authors.

From the spatial patterns occupied in the peri-urban (figure 7) area by the land class forest and semi-natural areas, the low value of 25% of the Shape_Am and Contig_Am metrics indicate that these are not very complex spatial shapes and that they are not contiguous. This result shows spatial continuity is reduced and does not allow configuring a spatially compact green infrastructure. Although the occupied area represents 25%, the value of the Gyrate pattern is 35%, highlighting the reduced spatial interconnectivity of this land cover.

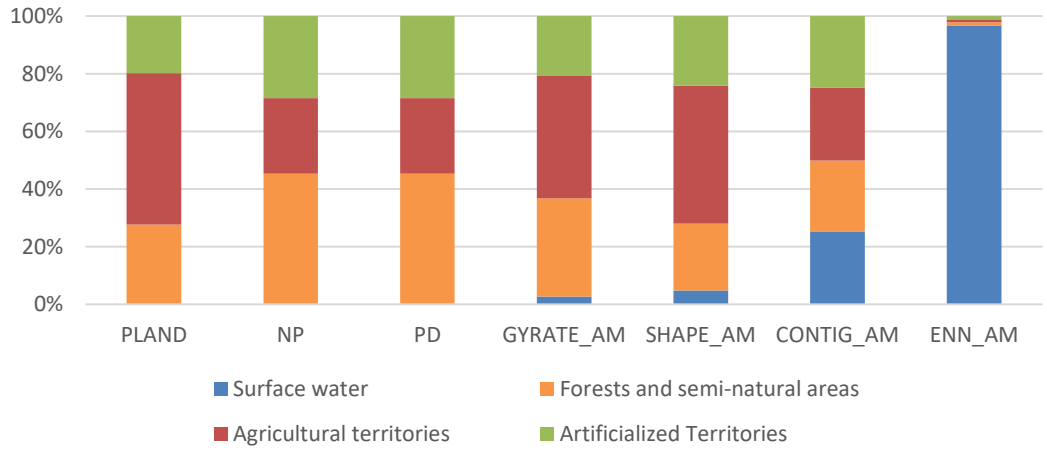



**Figure 7.** Urban landscape patterns across land cover classes in the Periurban area. Source: authors.

Considering the relationship of the results obtained for both the urban and suburban areas, it can be identified that the municipality of Zipaquirá has a dispersed growth of the urban area, which is reflected in a fragmentation of the classes of both artificial territories and forests and semi-natural areas.

### *3.3. Urban morphology: Space Syntax*

On the application of the space syntax and after calculating the axial map, the axial maps of the parameters previously defined for analysis, connectivity and global integration are obtained. From the Connectivity parameter (figure 7), the result shows that there is only one road with a maximum value of 22.0 located in the consolidated urban area and the remaining roads with average values between 7.0 and 16.0. About the peri urban area, only two roads both with values of 17.0, most with a degree of connectivity lower than the value of 3.0. The results show a greater degree of connectivity in the urban area when compared to the peripheral area, which allows inferences about how urban growth is developing.




**Figure 7.** Axial map of Connectivity parameter. Source: authors.

Regarding the degree of integration global (HH) based on urban morphology (figure 8), this parameter presents values between 0.8 and 0.9 in most of the road structure in the urban area, which shows a high degree of spatial integration. In the peri-urban area, 0.7 is the highest value and refers to only one urban road, the remaining road structure has values between 0.4 and 0.6. According to the urban morphology, the integration map shows a reduced degree in the peri-urban area, when compared to the urban area.




**Figure 8.** Axial maps of Integration global (HH). Source: authors.

The accessibility of an area in the urban morphology comes from the correlation between the choice parameters with connectivity, and the result allows us to state that the correlation is reduced, that is, there is no dependence between these parameters (figure 9). This result means a difference in urban morphology in the municipality in terms of its degree of accessibility, in spatial terms. The intelligibility of the urban system is understood in urban morphology by the correlation between connectivity and global integration. In this case, low connectivity values correspond to high global integration values, which indicates a spatial understanding of the reduced urban system on the intelligibility of that same system.

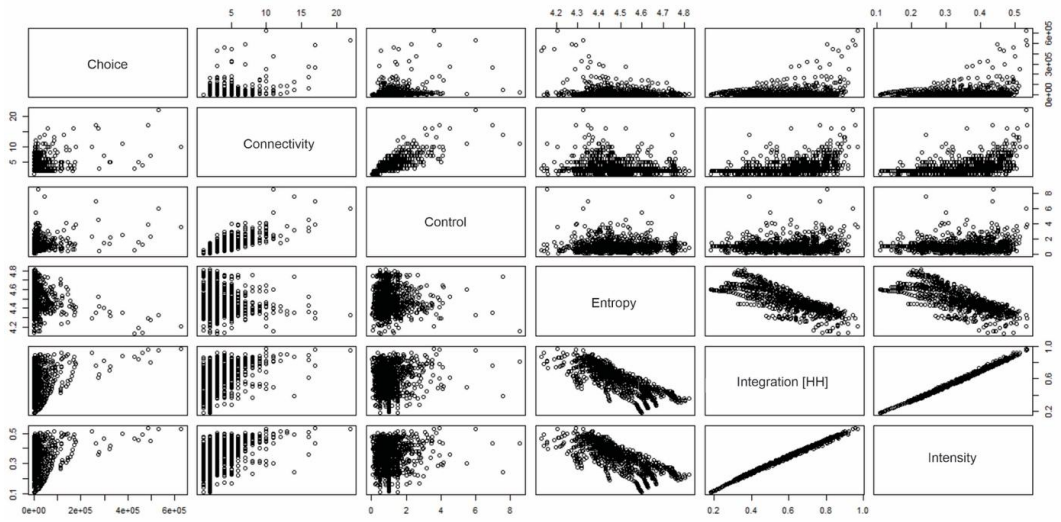



**Figure 9.** Plot descriptive statistic of urban space syntax parameters. Source: authors.

For spatial connectivity, the variation between values is high with 4.88, and in the case of integration, the value of 0.02 indicates a smaller variation (table 5). The values of 1.0 and 22.0 respectively represent the minimum and maximum for connectivity, showing the irregularity of the morphology in terms of its urban structure, while for integration the minimum and maximum values are 0.18 and 0.97. Spatially, it means an urban system that is more unbalanced in terms of spatial connectivity and accessibility, even if it is moderately integrated.

| Variable | Choice | Connectivity | Control | Entropy | Integration (HH) | Intensity | Mean Depth |
|---|---|---|---|---|---|---|---|
| Mean | 17,281.03 | 3.16 | 0.99 | 4.49 | 0.60 | 0.35 | 15.09 |
| Median | 2,46 | 2.00 | 0.83 | 4.46 | 0.61 | 0.36 | 13.48 |
| Mode | 0 | 2.00 | 1.00 | 4.16 | 0.59 | 0.39 | 13.97 |
| Standard Deviation | 50,178.09 | 2.21 | 0.76 | 0.13 | 0.16 | 0.08 | 4.89 |
| Variance | 2.52 X 109 | 4.88 | 0.58 | 0.02 | 0.02 | 0.01 | 23.87 |
| Skewness | 6.82 | 2.71 | 3.21 | 0.23 | -0.25 | -0.33 | 1.85 |
| Minimum | 0 | 1.00 | 0.04 | 4.13 | 0.18 | 0.11 | 8.92 |
| Maximum | 626,78 | 22.00 | 8.53 | 4.82 | 0.97 | 0.53 | 43.26 |
| Coefficient of variation (%) | 290.36 | 69.95 | 76.09 | 2.83 | 26.58 | 24.67 | 32.37 |

**Table 5.** Descriptive statistic of choice, connectivity, control, entropy, integration global (HH), intensity and mean depth. Source: Authors.

## 4. Discussion

When it comes to evaluating the existing green infrastructure, the results show differences between the study areas, that is, the urban area and the peri-urban area. This difference in analysis and urban scale to understand the patterns of the urban landscape thus becomes adequate. If in the urban zone the existence of forests and semi-natural areas ground cover is minimal, it is no longer minimal in the peri-urban zone. However, this area increase does not mean an improvement in the condition of the way the spatial pattern is defined, since the spaces referring to this soil cover are dispersed. This spatial occupation characteristic means that the green infrastructure is irregular in its urban morphology.

Regarding the urban morphology and the connectivity and integration parameters analyzed, the results can be interpreted as the possibility of identifying urban areas that favour the development of green infrastructure. Although the municipality has a reasonable degree of integration, this morphological characteristic is not accompanied by the spatial pattern of green areas. Faced with low connectivity values in the peri-urban area, the possibility of consolidating green infrastructure in this area becomes difficult due to the fragmentation that the road structure represents as a spatial pattern. These different behaviours of spatial patterns and the search for understanding between the urban infrastructure based on the different land covers with the main road axes that define the built and unbuilt space of the municipality reveal a reduced spatial overlap, even more so, it could assess the existence of a green infrastructure organized in its spatial occupation in the municipality.

## 5. Conclusions

The study intended to evaluate the green infrastructure and how it was spatially configured in the municipality of Zipaquirá. The fact of having considered two areas of study to analyze the green infrastructure, allows to define future public policies of more specific urban management.

From the urban study area and on the artificialized territories, it can be concluded that these, in addition to occupying the largest area, also do not contemplate the existence of reasonable, homogeneous, and compact green areas. Faced with this spatial irregularity of the green area, it can be concluded that in the urban area the green infrastructure does not have spatial characteristics or a spatial pattern to be considered infrastructure.

Regarding the peri-urban area, and with most of the land cover being defined by agricultural territories simultaneously with a low connectivity value, it is concluded that it defines an urban morphology with reduced potential to create a compact green infrastructure. Additionally, the fragmentation of artificialized territories associated with low spatial connectivity, leads to the conclusion that the ordering of the territory in the municipality is not structured. Now, this peri-urban area is considered an area of urban growth, and given the data obtained, the possibility of an urban green infrastructure to be consolidated is difficult. This study may, in the future, constitute relevant information in terms of spatial patterns of land occupation existing in the municipality, and constitute support for the improvement of public policy on territorial ordering.

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