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Urban structure to determine equitable city growth for spatial justice: A case study of Chía-Bogotá, Colombia

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A R T I C L E I N F O

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A B S T R A C T

The evolution of land use occupancy in various cities worldwide is swift. Land-use planning processes are still recent in most Latin American countries with significant socio-spatial inequalities. Due to rapid urban growth and real estate pressure, peri-urban areas of metropolises become susceptible to economic interests that can disrupt land use and municipal planning. Therefore, considering spatial justice, it is crucial to analyse possible future urban scenarios regarding socio-economic activities and their spatial distributions. This research seeks to define optimal locations and suitable urban growth areas, ensuring socio-spatial equity and justice. The study area is the municipality of Chia, on the outskirts of the metropolis of Bogota, Colombia, where the research proposes an analysis of urban morphology and the (social) intensity of activities and infrastructure. As a methodology, space syntax and the distribution of residential and non-residential activity data are applied through a predictive model. The study concludes that future mitigation of urban inequalities based on land use will be difficult to achieve owing to the location of urban sprawl areas.

1. Introduction

Cities have grown markedly in recent decades so that some urbanization processes have intensified land use, focusing on urban spaces with sometimes high population density or urban/monofunctional functions located in peripheral urban areas (Rodríguez-Pose & Griffiths, 2021; Wu, Zhao, Zhu, & Jiang, 2015). These areas are ordinarily associated with urban development and forms of expansion mainly identified by social and spatial differences with difficult accessibility to public transport (de Duren, 2018; García-Ayllón, S., 2016; Inostroza, 2017; Liao, Yeh, & Gil, 2021). Moreover, they are characterized by scarce work opportunities and urban infrastructure, reflecting these urban expansion areas' social and spatial weaknesses. Usually, such areas require fundamental urban resources to ensure balanced urban growth (Guite, 2019).

Against this background, social inequalities highlight urban challenges that local governments must address to provide more effective urban management (Mendonça et al., 2020). Therefore, the desired urban development is identified as unequal regarding the urban services available to citizens, creating an additional urban management policy challenge. This characterization defines urban growth in Latin America, often in peripheral areas, which is accentuated by informality. In addition to social and economic inequalities, spatial inequalities are evident in most cities (Falavigna & Hernandez, 2016; Unceta, Hausleitner, & Dąbrowski, 2020). The term refers to the socioeconomic activities and spatial organization degree, where the urbanization processes are produced without government support of housing and public infrastructure for the new urban populations (Jabareen, 2014; McFarlane, C., 2012; Okyere & Kita, 2015). This phenomenon represents an unequal urban system with direct relationships between the built-up space and the social and economic constraints, configuring an urban pattern.

Thus, a city's urban structure is the spatial element that local governments should pay close attention to (Sun et al., 2019). It is relevant to express that local governments follow land use plans as a public urban planning policy as urban development aims for socio-spatial equity (Herzog & Hamm, 2021; Kong, Yin, Nakagoshi, & James, 2012) and proximity to a set of urban services to support their lives as structuring parts of the city (Irazábal, 2021; Santoro, 2019). Regarding urban

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structure, it refers to the city's urban form, that is, the morphology, which is understood as the relationships between the various road axes that configure a global space of the city, which can be attributed to the road network (de Rijke et al., 2020; Levy, 1999; Rickwood et al., 2008). The urban equity in the growth of a city is an important issue due to the impact it can have on citizens, whether at a social, economic, or environmental level (Vaughan, Jones, Griffiths, & Haklay, 2010). Whilst land use plans pertain to the organization and distribution of urban activities, urban morphology plays a role in the possible spatial interpretation of the urban network and its relationships, whether with peripheral areas or with neighbouring cities.

Thus, it is necessary to understand the characteristics and effects of urban activities, which are researched according to the structure and urban network of the city, to gain a holistic understanding of possible urban development and growth scenarios. Recently, urban equity in the growth of a city has been an important issue due to the impact it can have on citizens, whether at a social, economic, or environmental level. Considering spatial justice as a mitigator of urban inequalities, the study aims to identify urban growth areas where the most suitable urban activities can be specifically identified in the infrastructure road network.

This study seeks to contribute to inclusive urban planning from the perspective of socio-spatial integration defined by the urban morphology and the urban activities that characterize the city. Furthermore, this research identifies future scenarios that, on the one hand, mitigate potential inequalities in the location of activities at the local level and, on the other hand, contribute to defining spatial planning policies through municipal plans. This approach is related to one of the United Nations Sustainable Development Goals (SDGs), namely 'Sustainable Cities and Communities (SDG 11)' (OECD, 2020).

1.1. Literature review

The intense process of urbanization that has taken place in many cities around the world has generated land use changes that have caused an intense process of urban sprawl, with some studies addressing the theme of the intensification of urbanization as a spatial segregation factor (Nuissl & Siedentop, 2020; Wu, Zhang, & Shen, 2011), characterized by public policies guided by market bias (Colsaet, Laurans, & Levrel, 2018). The main drivers of urban sprawl are the result of segregated land uses (Guastella, Pareglio, & Sckokai, 2017), such as low building densities and high square meter dwellings, high land prices, population density, gross domestic product, accessibility, and environmental factors (Angel et al., 2005; Meng, Sun, & Zhao, 2020). Thus, urban sprawl is not only a product of population growth, but it is also related to a variety of factors that are difficult to observe comprehensively at the global level, including capital flows, the informal economy, land use policy, and generalized transport costs (Seto, Fragkias, Güneralp, & Reilly, 2011; Thoene, 2015). Changes in land use influence urban spatial organization (Ewing, 2008; Lenormand et al., 2015), and it is the essential instrument for defining the location, design, and functional character of urban growth, representing a physical manifestation of social and economic stratification (Bourne, 1976). Therefore, the urban plan plays a crucial role in the planning and regulation of urban growth. In other words, the price of land indicates changes in spatial structure and socio-economic variations caused by urban development (Cho, Moon, & Lee, 2016).

In small and medium-sized cities, proactive land-use planning is needed to ensure that urban sprawl is not located on strictly rural land and is equitable and affordable (d'Amour et al., 2017). Further research has found that the greater the economic linkage, the slower the speed of urban land expansion and the more sustainable and intensive land use can be achieved (Chen, Wu, Huang, & Yang, 2020). Land use change provides many economic and social benefits but incurs substantial economic costs to society and requires a balance between private property rights and public interest (Wu, 2008). The complex demographic, geographic, and economic pressures on land use patterns are a global challenge, particularly in Latin American cities, resulting in pronounced urban sprawl, which has made it easy for local authorities to indiscriminately re-zone rural into urban land (Grau & Aide, 2008; Lungo, 2001).

An additional and linked aspect that influences the urban economy is spatial configuration, the location's morphological characteristics that help us understand urban phenomena concerning practical land use (Min, Moon, & Kim, 2007). From this perspective, the relationship between land use and the spatial structure of neighbourhood street networks provides evidence of how spatial arrangements influence the distribution of land uses, energy use, service demand, and urban traffic patterns, and hence how these factors shape sustainability (Alalouch, Al-Hajri, Naser, & Al Hinai, 2019). Furthermore, Aziz and Nilufar (2019) explore the correlation between urban morphology and land use patterns and how urban areas emerge in which commercial and business land uses have developed naturally in the most integrated part of an urban network in a Bangladeshi city. Likewise, the interrelationship between land use intensity and residential density at different scales is essential for urban planning and design. Based on the interrelationship, we can improve location, accessibility, and other attributes (Mashhoodi & Berghauser Pont, 2011).

However, these studies do not consider the social dimension of the urban structure as a potential element of spatial analysis according to the value of land and urban accessibility, which determine the city's growth and expansion (D'Acci, 2019). Furthermore, they do not interrelate with different activities and urban uses simultaneously. Thus, they reveal a gap in current research. In addition to being expansive, urban sprawl is extensive (Qiao et al., 2019); that is, dynamic agglomerations generate a positive relationship between urban scale and land use intensity (Hui et al., 2015). Urban form affects urban land use efficiency as a function of regional heterogeneity and city size (He et al., 2020). These spatial transformations result in uneven urban land expansion geographies (Akubia & Bruns, 2019). Therefore, the level of intensive land use is a function of the level of urbanization development (Yang et al., 2019). Policy decisions and transportation lines affect the intensity of land use development and the expansion speed (Huang et al., 2020).

Since spatial structure is quantifiable through spatial syntax attributes, the impact of land uses can be assessed and used as a dynamic procedure in urban planning and management and land use planning processes (Xia et al., 2019). The relationship between land use distribution and spatial structure of street networks of newly developed neighbourhoods in Muscat City, Oman, using the theory of spatial syntax and a group of land use variables (Commercial, Residential and Mixed Use), found that spatial attributes significantly influence residential land use distribution and that a grid road network structure has no effect on the relationship between the variables (Alalouch et al., 2019). Berhie and Haq (2017) showed that for the cities of Boston, Pittsburgh, Lubbock, and Salt Lake City, retail locations and commercial areas affect residential locations and transportation mode choice using space syntax analysis. The research by Ye et al. (2014) develops a spatial classification system for various types of urban areas and quantifies their socio-economic performance in terms of street network integration, building density and land use mix. De Koning et al. (2017) show that consolidated centres have higher values for street network integration, building density, and land use than new housing developments.

In summary, studies that relate the morphology of transport networks and land uses allow planning authorities to establish policies or implement actions to mitigate, or preferably avoid, some undesirable impacts of land uses on planning and land use processes. It can also provide information on the potential demand for infrastructure and services that are important for particular land uses, which can create an opportunity for planning authorities to optimise the allocation of services and resources according to the intended land uses. The method works well as a diagnostic tool to suggest ways to improve socio-economic performance in urban areas.

The urban structure is directly related to urban morphology, in which space syntax furthers the understanding of social space (Hillier, 2009; Yamu, van Nes, & Garau, 2021). This characteristic is fundamental to the claim of urban socio-economic equity. Thus, this research aims to determine suitable areas for urban growth by adequately allocating urban activities that allow for equitable development in the municipality of Chía, on the outskirts of Bogotá, Colombia. In this context, two research questions are addressed: i) What is the effect of the morphology of the transport infrastructure network on the location of specific activities? ii) In which arcs do the morphological conditions of the network exist that enhance the most significant number of specific activities (trade, primary services)? To date, studies have not shown research related to the following factors: land use, urban morphology, and allocation of urban activities.

Therefore, the study addresses the possibility of urban scenarios to specifically identify urban areas and roads for the city's new activities, focusing on the most appropriate elements to achieve spatial equity in urban growth, which is particularly important as input information for the municipal plan. It is possible to obtain the spatialization of which urban activities are most appropriate from the perspective of land use factors and urban morphology. In that case, it becomes viable to establish urban growth scenarios and a balance concerning spatial justice, which makes it possible to avoid and mitigate real estate pressures from the local government. Urban planning in Colombia has been marked by policies that emphasise social, economic and spatial segregation, allowing the market to determine the growth and infrastructure of the city freely (Muñoz & Fleischer 2020). In other words, no comprehensive planning model exists in which urban and conservation land are directed towards constructing the social fabric. Moreover, spatial segregation in Latin American cities is a strategy to increase real estate value in the long term. Thus, in the Colombian context, urban land management and land use planning are the primary tools to mitigate urban inequalities (Restrepo, 2019).

2. Methodology

This research aims to show how a methodology that applies information on land use and urban form contributes to identifying a possible structure of activities in the new expansion zones defined in the territorial instruments. From this vantage point, the contribution is crucial to urban management processes given that currently, only the definition of expansion land exists, and the distribution guidelines are reflected in other instruments. Considering that the analysed territory is part of a future metropolitan region (Jimenez Aguilar & Thoene), municipal planning must be generated to balance the supra-municipal scale.

2.1. Study area

By the mid-twentieth century, Bogotá began to experience accelerated urban growth that demanded housing, public services, road infrastructure, community services, and employment. Subsequently, by the 1990s, this process was intensified by trade liberalization (Jimenez Aguilar & Thoene, 2021). However, this change occurred without an organized urban planning process, which went beyond the city limits and spread to the immediate municipalities that began to receive people from Bogotá seeking a better quality of life (Romero Novoa, 2010; Jaramillo González, 2018). The municipality of Chía, which this case study focuses on (Fig. 1), is in the Department of Cundinamarca and has a population of approximately 105,509 inhabitants in the urban area and 26,672 in the populated centres, according to the 2019 population census conducted by the Colombian National Administrative Department of Statistics (DANE). Chía has eight rural areas plus the urban area and is characterized by its socio-spatial solid dynamism. The urbanization process in Chía results from the demand for land in Bogotá, where land is highly valued. The main factors that have accelerated this process are as follows: population migration, the construction of new housing, and improved mobility and connectivity with Bogotá (Contreras Ortíz, 2017).

In the municipality of Chía and its surroundings (Fig. 2), the expansion process started to accelerate in 2002 with the construction of closed housing complexes emphasizing typologies that promote low density, large built-up areas, and the arrival of high socio-economic strata in the municipality from the more traditional areas of Bogotá initiating a process of urban renewal and the construction of new facilities. High socio-economic strata in the municipality (Socio-economic strata in Colombia is a tool used to classify and differentiate urban areas according to their level of socio-economic development, which has direct implications for the provision of public services and urban planning. Different residential areas are classified or strata numbered from 1 to 6, where stratum 1 represents the lowest socio-economic level and stratum 6 is the highest). Different social, environmental, urban, and rural impacts have been identified in the medium and long term due to socio-spatial segregation and increased urbanization (Angarita Gúzman, 2015). Real estate processes in Chía involve private agents and sectors of the local administration, contributing to an 80% increase in the built-up

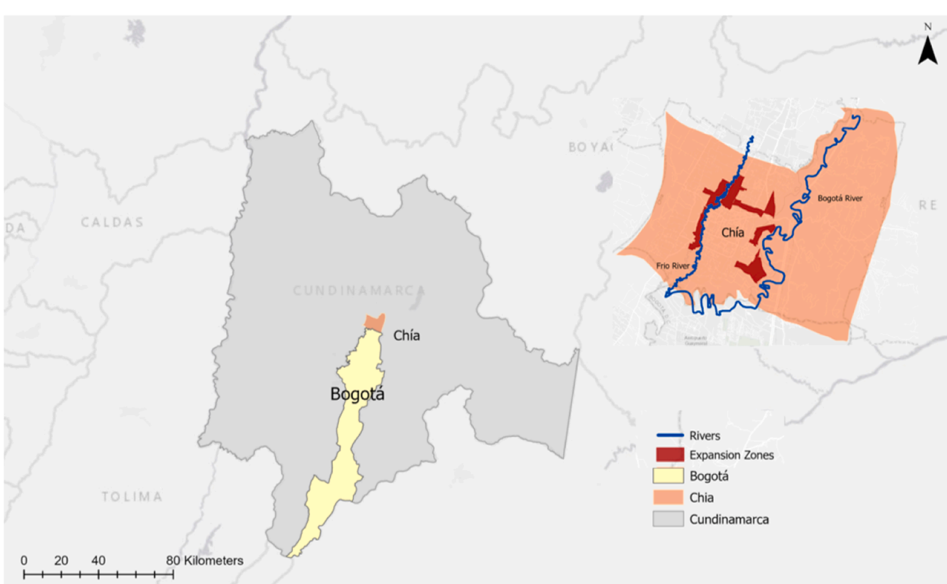

Fig. 1. Location of the municipality of Chía. Source: Authors.

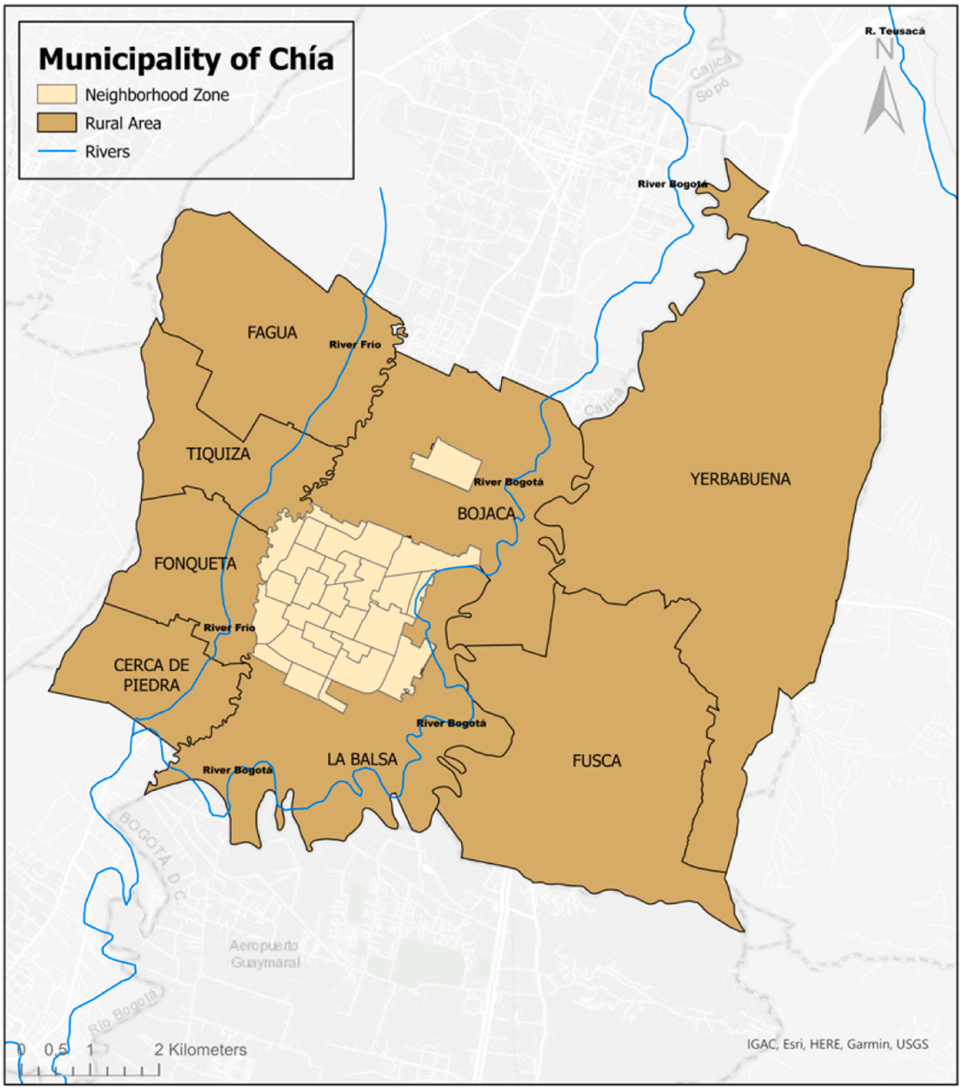

Fig. 2. Municipality of Chía: built-up area and their surroundings. Source: Authors.

area, especially in the urban area of the municipality (Mendoza Jaramillo, 2016). The size of the municipality increased by 708,067 hectares of urban land due to its different social, environmental, economic, housing, and geographic needs, generating problems in management, organization, and urban planning (Romero Mejía, 2017).

According to the 2000 Land Use Plan of Chía, the municipality covered a total of 7,923 hectares in 2000, of which 608,028 formed part of the urban perimeter and 7,314.72 hectares of the rural area, which allowed for the construction of housing, infrastructure, and urban facilities. However, by 2010, the administrative Agreement 100 of the municipal council of Chía delimited the urban perimeter and defined the expansion areas in response to the new urban dynamics (Consejo Municipal de Chía, 2016). Connectivity between the two territories is necessary. Nevertheless, the road infrastructure offer is currently not sufficient, generating an insufficient connectivity model, so it is necessary to consolidate an organized and planned mobility model for the region, which allows for the generation of new urban dynamics (Alcaldía Mayor de Bogotá D.C., Cámara de Comercio de Bogotá, & Universidad de La Sabana, 2017).

Migration from Bogotá to neighbouring municipalities was mainly driven by prospects of improved quality of life and attracted people mainly from Bogotá's higher socioeconomic strata (Alcaldía Municipal de Chía, 2015). Parts of the population of Bogotá migrated to Chía for five specific reasons: strategic spatial location given its proximity to Bogotá, less road congestion at the place of residence, urban growth, and the economic expansion of the municipality. The population of Chía grew by approximately 43% in the urban area and 4.6% in the rural area, according to data from the 2005 and 2019 population censuses conducted by DANE. Functionally, the process identified the importance of the relationship between the two territories, showing a network of supra-municipal relationships that intensify levels of use and occupation of the municipality's territory due to its proximity to Bogotá (Zorro Pinzón, 2020).

2.2. *Equitable urban structure: urban morphology and land uses*

2.2.1. *Urban morphology*

The space syntax methodology is applied to study urban morphology, which allows analysis of the structure and urban form through its mobility axes and road structure. Considering that this method is already widely developed (Jabbari, 2018; Rashid, 2017), the logic of space and future scenarios can be understood through the spatial organization because either individual analyses of the roads or their set of urban scale can be established (Freire de Almeida et al., 2021).

Regarding urban morphology, space syntax is applied to the urban network to provide spatial data on connectivity and choice. These parameters are the most suitable for analysing the equity of urban growth, given their direct relationship with urban accessibility (Pafka, Dovey, &

Aschwanden, 2020). Space syntax is a method that allows us to infer results about the social logic of urban space in terms of human behaviour (Penn, Hillier, Banister, & Xu, 1998). To this end, an axis map of the city area's road network has been produced (Fig. 3), which allows us to obtain the spatial configuration of the city through a graph.

The study area is selected from an aerial photo to generate an axial map, and the road network is drawn along intersecting axes. All street axes must intersect to ensure correct calculation by the depth-map software (Turner, 2001).

Regarding the parameters to be analysed, it is essential to mention the following. In mathematics, connectivity is one of the basic concepts of graph theory, as it measures the number of neighbour axes directly connected to a space. It specifies the number of immediate neighbours of an axis. It is a local measure (parameter $k = 0$). A street with many connections to its side streets has a high connectivity value, whereas a street with few connections has a low connectivity value, which corresponds to *deg(i)* as the number of connected neighbours between $j=1$ to n paths through *ij* representing the intersections of these same paths (Klarqvist, 2015). The connectivity parameter refers to the number of intersections in the urban road network and is calculated according to the following equation: equation 1)

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

The choice parameter defines the accessibilities with the most significant potential for urban mobility depending on the distances to be covered in the urban network. Among all the shortest paths in a street network, the choice of a street refers to the number of shortest paths which contain the given streets over the number of all the shortest paths. The metric calculus of choice is elaborated and defined by the equation below. equation 2)

$$Choice\ C_i = \sum_j \sum_k g_{jk}(i) \Big/ g_{jk}(j < k)$$

Where *gjk (i)* is the shortest path between segment *j* and *k* containing *i,* and *gjk* is the shortest between *j* and *k* (Conroy-Dalton, 2007).

2.2.1. Residential and non-residential activities

The uses of territory are traditionally analysed from the perspective of the activities located therein, considering that they show the level of

Fig. 3. Map of urban axes of aerial photo of the urban area of Chía. Source: Authors and Google Earth.

profit capture that can be achieved in these locations (Van Cao & Cory, 1982).

Within the non-residential uses, we identified activities whose rent is mainly for local consumption (such as shops and services), uses whose rent has more of an inter-communal or regional logic (industrial use), and finally, activities that do not rent land, such as vacant sites (without activity or construction) and parks and green areas. As mentioned above, residential and non-residential uses have been considered in this study. Within the scope of non-residential uses, we considered local income activities, inter-communal or regional income uses, and activities that do not provide income from the territory. These different activities are considered to respond to very different types of land use, which will differentiate the relationships with the morphology parameters. This analysis considers residential, commercial, industrial, and green land uses throughout the study area, which allows for the identification of morphological parameters and, therefore, provides more significant potential and diversity to support public policies.

The information collected for these variables corresponds to the number of units in the blocks according to information from the population census (DANE, 2019). Population information regarding socio-economic level or strata was also considered based on educational level. Particularly in Colombia, socio-economic stratification is a classification of residential properties that should be provided with public services at differentiated rates for residential and public services and to facilitate subsidies. Thus, those with more economical purchasing power pay a higher rate for public services, so the lower strata can receive a subsidy to pay their bills (Yunda, 2019). The processing of this information corresponded to the quantification of the different variables within a 60-metre buffer of each arc of the road network analysed. This approach seeks to unify the study element, focusing on the arc of the road network and not on the traditional blocks.

A 'relative specialization index' was then calculated based on the following equation: equation 3)

$$ASI_k = \frac{\left(\frac{A_k}{\sum_A A_k}\right)}{\left(\frac{\sum_k A_k}{\sum_{Ak} A_k}\right)}$$

Where:

ASIk: Index of specialisation of activity "*A*" in the tranche *k*, for each arc of the road network. *Ak*: Number of "*A*" activities in bracket *k* in the *arc. k*: Commerce, services, industries, wasteland sites, parks, houses, and flats.

As can be seen, the specialization index is a quotient of the proportion of activity 'A' in the total number of activities in leg k, and the proportion of the total number of activities 'A' in the total number of activities for the whole network. The result of the indicator ranges from 0 to infinity, and the higher the value, the higher the specialization of activity 'A' in the tract. For the population and housing variables, a weighted average was constructed whose higher value indicates higher socio-economic characteristics (strata and educational level) and, in the case of housing, a higher share of flats than houses (higher intensity of residential use).

2.3. Statistical relationship between morphology and urban activities to predict the gap in activities

The prediction of a given variable is based on the use of an ad-hoc predictive model. When a prediction is contrasted with the actual value, the concept of "gaps" emerges. Many of these gaps can be attributed in part to the calibration error of the model, but under specific criteria, it can be used as an indicator of potential development. Based on this approach, a matching learning model called "XGBoost" (Extreme Gradient Boosting) was applied to predict each urban activity variable based on the morphological parameters obtained for each arc of the road network.

The XGBoost model has the particularity of being a categorical prediction model, which forms groups based on the behaviours of variables and not on continuous values (as traditional econometrics models). Technically, XGBoost is used for a supervised training process (with multiple features) to predict a specific variable with a high fit percentage.

Thus, an XGBoost model was calibrated to a base of 1.962 arc (considered an independent sample of adjustment of 30%) to predict the specialization indexes of commerce, services, industries, wasteland sites, parks, and houses based on the morphological indicators of Choice and Connectivity.

Subsequently, the model was used to predict each urban variable for all 1.962 arcs. With this prediction, the gap between the prediction and the real value of each arc (prediction-real value) was calculated. At this point, it was considered that an arc with a positive gap (predicted value more significant than the real value) greater than two standard deviations from the average of the gaps indicates a potential situation for more activity development. These arcs of the road network were identified on the map and were contrasted with the urban plan.

3. Results and discussion

3.1. Urban morphology

Based on the analysis of urban morphology, that is, connectivity, the highest values are located on the diagonal road that gives access to the city centre from the highway, followed by a road in the central area and two roads on the north and south sides, which are both on the periphery of the urban area (Fig. 4). The main urban expansion areas, whether to the north, east, or west, either contain roads or are close to roads with low levels of connectivity, which should make road accessibility for citizens more difficult. It can also be said that the urban expansion areas to the north and west present roads with the lowest connectivity values, and the area to the east is located adjacent to the Frío River. It helps to interpret the following maps: spectral colour from blue to red is used for visualization, with red lines representing the highest value and blue lines representing the lowest value.

Based on the choice parameter (Fig. 5), the results obtained indicate as a function of the distance to be covered that there is a variation between urban roads for a route of 800m until the election of a route of 10.000m or even in the entire urban area (n). The urban expansion area to the east is closest to a road with a higher choice value. For intermediate distances of 2500m and 5000m, the roads with average values are close to the northern expansion area. These distances were previously defined according to the literature (Pafka et al., 2020; Salheen & Forsyth, 2001; Sharmin & Kamruzzaman, 2018) and intended to contribute to understanding the spatial behaviour of the choice variable in urban space. The results show a difference in the probability of selecting routes for 800m distance journeys compared to the other distances. However, there are no marked differences between distances of 1.200m and 10.000m, which may suggest limited alternatives in the road structure.

Fig. 4. Axial map of Chía urban space with the spatial variable connectivity. Source: Authors.

3.2. Land uses activities

After calculating the spatial variables of the value of land use and considering the type of rent and land-use activities, values are obtained and then individually expressed as results. Table 1 shows the descriptive statistics of the final database at the tract level. Regarding the descriptive statistics, the following can be stated: The specializations of shops and services (high local rents) behave similarly with average values of less than 1, no highly high maximum values, and moderate variability of the values (on a CV basis), which implies that, whilst there is specialization, it is more likely distributed in the network sections. Industrial, brownfield, and park specialization (regional rent or no rent) have both significantly high average and maximum values, with a consequent high variability of values, which denotes extreme polarization of these specializations in some parts of the network. The housing (long-term income) and socio-economic variables present average values with maximum values close to the average and, therefore, low variability in the sections. The analysis is being carried out at the transport infrastructure axes level. When the specialisation coefficient is applied, values above 1 show a specialisation concerning the specific activity analysed, i.e. the activity is concentrated on the axis. For values below 1, it is interpreted that there is no specialisation, i.e. the activities are homogeneously distributed along the analysed axis, i.e. there is spatial dispersion. In addition, the coefficient of variability is used to check the levels of dispersion; high CV values indicate greater spatial dispersion, and low values indicate spatial concentration, which allows for more accurate identification of whether an axis is specialised.

The dominant spatial condition is not the concentration of activities in one area of the city or road arch but rather a spatial distribution considered to have an irregular pattern of all urban activities. Figs. 6 and 7 show the location across the urban road network and its axes." the second sentence is ", These figures show the degree of specialisation of the transport axes in the municipality of Chía. The red and yellow colours correspond to the axes that concentrate different activities, i.e. they are specialised. Residential use is found throughout the municipality but is more intense in the consolidated centre and the Bojacá district. Industrial use is predominant within the limits of the centre of the municipality, with the village of La Balsa and in some sectors of the villages of Bojacá and Fagua. Commercial use is concentrated in the centre, generally in all the hamlets, especially in Bojacá, Fusca, Fagua and La Balsa. Green areas are generally located in the outer sectors of the municipality near the basins of the Río Frío and Río Bogotá. Vacant land is located in the peripheral areas of the hamlets, and services cover the centre of the municipality. This activity is very unbalanced.

The statistics below do not account for the spatial pattern of the values, so the following figures (Fig. 6, Fig. 7) are presented below for further clarification. These figures show the degree of specialisation of the transport axes in the municipality of Chía. The red and yellow colours correspond to the axes that concentrate different activities, i.e. they are specialised. Residential use is found throughout the municipality but is more intense in the consolidated centre and the Bojacá district. Industrial use is predominant within the limits of the centre of the municipality, with the village of La Balsa and in some sectors of the villages of Bojacá and Fagua. Commercial use is concentrated in the centre, generally in all the hamlets, especially in Bojacá, Fusca, Fagua and La Balsa. Green areas are generally located in the outer sectors of the municipality near the basins of the Río Frío and Río Bogotá. Vacant land is located in the peripheral areas of the hamlets, and services cover the