USE OF SPACE SYNTAX FOR CHARACTERISING TRIP GENERATING DEVELOPMENTS IN THE CAPITAL OF BRAZIL – BRASILIA

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ABSTRACT

This article explores the use of Space Syntax to identify centralities in the AR 1 (Administrative Region 1 – Pilot Plan) of Brasília, based on the comparison of three strategies: (a) the map resulting from the Technique of Experts (Delphi), (b) images of Google Earth from the year 2002 to 2012, and (c) the global axial maps of the Federal District and the Pilot Plan of Brasília originating from the Theory of Space Syntax. As a case study, we used the area located at the end of the North Wing of the Pilot Plan, where there is a shopping mall. The results show that the configurational analysis is feasible for studies that relate the Trip Generating Developments (TGD) and centralities, since the potential of movement identified through the axial maps coincide with those from the other readings.

Key words: Trip Generating Developments, Centralities, Space Syntax, Spatial Configuration, Brasilia.

INTRODUCTION

It is known that the centralities are elements inherent to any urban settlement, as stated by Villaça (2001), Holanda (2002) and Medeiros (2006). Some studies highlight the strong relationship between the implementation of large projects and activities - the so-called Trip Generating Developments - with the formation or consolidation of centralities, due to the impact and changes associated with the development (Kneib, 2004; Kneib *et al.*, 2010). In other words, these are places to

which the city's movements converge, whether of people or vehicles. In addition, such developments encompass a significant diversity of use.

The identification of centralities as a location that both gathers and disperse activities and people is essential for an urban planning focused on sustainable mobility. In other words, the identification of centralities can help define a set of policies for transportation and displacement of people which aims to provide a broad and democratic access to the urban space, by means of prioritizing non-motorized means of transportation and public transport.

This is aligned with the definition of sustainable urban mobility presented by the Ministry of Cities (2004)[1], which states that the formation and consolidation of urban subcentres is related to the efficiency and organization of cities, since the polycentrality provides citizens with access to essential services. Thus, the identification of the urban spatial structure of Brasília and the 29 administrative regions that it comprises, with its network of centres and sub-centres, is extremely important, as it helps drawing the guidelines related to land use and transportation planning to foster people's mobility.

Among the several strategies for identifying the centralities, one is of particular interest to this study: it is that called Space Syntax, which identifies potentially aggregating areas of urban settlements, resulting from the potential configuration of the places, and based on the topology of these spaces. According to Barros (2006), there is a significant relationship between the potential of movement and the actual flows in the cities, which shows the potential such studies.

In this light, the Space Syntax was used in this work to characterise the relationship between the centralities and Trip Generating Developments, investigating to what extent these are located in areas of easy access or not.

THEORETICAL BACKGROUND

Centralities, TGDs and the urban structure

There are several authors who define, conceptualize and work with the terms subcentres and centralities, and even connect them to the spatial structure of cities (Villaça, 2001; Rochefort, 1998; Kneib, 2008). In order to consider this wide range of concepts, this paper presents some approaches in order to contribute to the understanding of this relationship, as well as analyse the impacts of the TGDs over the centralities.

For Villaça (2001), urban structure refers to a whole comprised of elements which relate to each other, in a way that, if a change is to happen to one element or

[1] Government Agency which, amongst other things, coordenates the Urban Development Policy in Brazil.

relationship, it would affect all other elements and relationships. This hypothesis is corroborated by Correa (1995), according to whom such spatial structure is both fragmented and articulated, since each of its parts has spatial relationships with all other parts, although in varying intensities.

In addition, Villaça (2001) considers the main centre of the metropolis (the largest agglomeration of jobs or commerce and services), the sub-centres of commerce and services (smaller replicas of the main centre), residential neighbourhoods and industrial areas as elements of the urban spatial structure.

In turn, Rochefort (1998) emphasizes the unity of organization of the city consists of the set of centres needed to provide all services and activities required by the population. According to the author, the organization of space results from the location of the different centres. And due to the differences between the centres, geography leads interdependence between the centres, which allow us to extrapolate from the concept of one single centre to the concept of a network of centres, forming the basis for the definition of the so-called urban networks, or an urban area system.

On the relationship between TGDs and centralities, the work of Kneib (2004) discussed the strong relationship there is between the TGDs and the creation or consolidation of a new centrality, which ultimately has an impact on the whole network of centres and sub-centres, that is to say, it impacts the urban spatial structure itself.

It is important to highlight that the TGDs are described as having the potential to generate impacts in the street and transportation systems, as well as in the socio-economic development and in the population's quality of life (REDPGV, 2010). Kneib (2004) points out that these developments are closely related to the creation and consolidation of centralities and may impact not only the street and transportation systems, but also the surrounding land use and occupation.

According to the studies of Kneib (2008) and Kneib *et al* (2010), when correlating the TGDs and the subcentres, it is possible to observe that the main features of the TGDs is the impact in trip generation. According to the authors, if the polycentrality tend to decrease the time and distances of commuting, the creation of a new centrality that arises from the implementation of a TGD may be beneficial to the structure of the city. However, if the new development leads to the creation of a new centrality and the transportation system does not follow this new centrality, such situation may have a negative impact in the region surrounding this TGD and in the new centrality itself.

Thus, based on these approaches, we highlight the centrality as an essential element for the analysis of urban structures, taking into account the location of these great developments and their impacts, in these structures.

Subcentres and centralities: theories and processes of urban structuring

The study made by Correa (1995), working with the concept of urban space, does not define its elements, but the spatial processes, as forces whereby the movement of transformation of the social structure are spatially effective.

Kneib (2008), based on studies of Ramos (1976) and Novaes (1981), highlights four classifications of theories of urban space: culturalist, based on the concepts of garden city of Ebenezer Howard; ecological, linked to the work of the Chicago School of Urban Sociology; functionalist, with theories arising from the works of Von Thünen, from 1826: Alonso, Muth and Mills; and socio-political, which are based on the work of Castells (1971). In order to relate the urban spatial structure with TGDs, the ecological and functionalist theories must be highlighted, because they are considered the precursors in this area.

The ecological approach sought to explain the complexities of the urban community and discover patterns of regularity. The related theories treat the organization of space from the interaction between the human species, the instruments created by it and the natural environment (Castells, 1983). Based on these studies, theories to explain the forms of urban growth were developed, among which is that of Burgess (concentric zones); Hoyt (sectors) and Harris and Ullman (multiple cores).

Burgess model explains how land uses are organized by distinct zones, being located in defined orders from the city centre (Central Business District, CBD). Hoyt's approach, based on sectors, explains that the internal structure of the city is dependent on the provision of routes radiating from the centre and giving different accessibilities (Garner, 1971). Thus, the sectors grow from the centre along the main roads, prioritizing transportation among the urban functions. The Theory of Harris and Ullman, or multiple cores, suggests that in most cities, the structures of land use are not organized solely around a single centre, as alleged in previous models, but it also develops around several distinct centres within the urban area.

Therefore, with respect to the ecological theories, it is worth highlighting (1) the processes that shape the urban structure - centralization and decentralization - with the consequent formation of subcentres, (2) the role of transport and, consequently, accessibility, in these procedures; and (3) the reasons for the formation of subcentres, based on the need for clustering of activities.

In that sense, the subcentres are balanced and diversified agglomerations in terms of commerce and services, and stand as an alternative to the main city centre. They can also be a replica in smaller size of the main city centre, however, not measuring up to it. Thus, the subcentres and the main city centres share the same features (Villaça, 2001).

On the other hand, centrality may be defined as a priority of the public space, that consists in the ability of locating the most mentioned pathways, between the pairs of portions of constructed forms (Krafta 1994, *apud* Krafta 2001).

The second relevant group encompasses the functionalist theories, focused on the spatial ordering of activities as well as their ranking, which are not random phenomena, but governed by certain laws (Novaes, 1981). Within this functionalist classification we can find the theories derived from the work of Von Thünen, from 1826: Alonso, Muth and Mills, considered the most popular and important on the subject of urban structure (McMillen, 2001; Baumont, et al., 2004).

METHODOLOGY

The study is developed with the articulation of approaches, in order to investigate the configurational aspects under the scope of the Space Syntax interpretation of TGDs. For such, the (a) Technique of Experts (Delphi) and (b) the analysis of satellite images from Google Earth over a period of 10 years (from 2002 to 2012) are considered.

The first to be considered is the Technique of Experts - developed by Kneib (2008) – that is based on 03 phases: *i)* selecting the experts, based on the profiles suited to the research at hand; *ii)* spatial identification of the subcentres, using a combination of the Delphi method and the Spatial Analysis, which enables the spatial identification based on the consensus of a group of experts, by using several questionnaires and a process of feedback about the answers; *iii)*measuring the level of importance of the subcentres, using a Point Scale for assigning a value to the importance of the subcentres identified in each of the rounds of the Delphi method.

From this technique we used the map resulting from the indications of the location of centralities by experts in the area of the AR 1 (Pilot Plan) of Brasília, in order to choose the projects to be analysed. Later, as a case study, we chose only one centrality, the area where Boulevard Mall is located.

The second technique was based on the use of Google Earth imagery between the years of 2002 and 2012, in order to verify the changes of occupancy in the urban development in the existing study throughout this period.

Finally, we adopted the methodological strategies connected to the Space Syntax theory. This theoretical and methodological approach is constituted by several techniques that seek to comprehend how the built space, that is, the form of the city or part of it, interferes in movement patterns by means of its topology relations – the study of spatial relations which take into account the articulation between space and roads regardless of form and size – and not just geometry relations – description of component physical elements as to dimension, proportion, scale, etc. (Medeiros, 2003).

Amidst these techniques, the one adopted for this study is that of axiality, indicated for dealing with flow movement potentials in a given urban space. There are four steps the researcher goes through in the generation of axial maps: (a) the linear representation of space (axial map); (b) a computerized analysis of the representation (calculation of the mathematical matrix); (c) correlations (association of the axial map with other data); and, lastly, the simulations (new maps) (cf. Hillier and Hanson, 1984 for details).

The global axial maps of the Federal District and the Pilot Plan (AR 1) were used to characterise the developments under study in order to identify their potential use in terms of accessibility based the shape of Brasilia.

As it can be observed, the method proposed in this paper is exploratory and the tools are based on the particular view of the people who are part of the research (the experts), therefore it must take into account the familiarity of each one of them with the methodological procedures.

TGDS AND CENTRALITIES: THE CASE OF THE FEDERAL CAPITAL

In order to identify of urban centralities, the AR 1 (Pilot Plan) of Brasília was chosen, because it is emblematic for urban mobility, due to its modernist design which sometimes makes the displacements complicated and hence the placement of large trip generating developments is a hard task to undertake. However, although the place chosen has very peculiar characteristics, the analysis presented for the AR 1 of Brasília can serve as a basis for other cities.

Characterisation of the area under study

Brasília reaches the 21st century with the natural pressures from the rapid growth of its outskirts and according to PDAD (2012), the estimated urban population is of 214.529 habitants. Brasilia's Pilot Plan is one of the 29 Administrative Regions (AR) of the Federal District. This region, called Brasilia, concentrates 44.80% of the jobs in the Federal District (Pires, 2008).

The AR 1 of Brasília is composed for North Wing, South Wing, Station Road, Sector Official garages, Sara Kubitschek Park (City Park), Department of Graphic Industries, Camping Area, Monumental Axis, Ministries, Embassies Sector North and South, Urban Military Sector, Vila Planalto, Club Sector, among others (Figure 1). Brasilia also includes the isolated areas of Torto and Barra Alta (CODEPLAN, 2006).

According to CODEPLAN (2002), out of the daily trips originating in the AR Brasilia, 54.33% are destined for the region itself and the most used means of transportation

is the automobile (59.75%). This proves that there is a concentration of trips in this AR, causing traffic problems.

Application of the Methodology

The following are the results of applying the methodology, starting with (a) Technique of Experts, then (b) the comparison between the Google Earth images from 2002 to 2012, and, finally, (c) analysis of centralities through axial maps of Space Syntax.

In the first technique, the experts identified a significant amount of centralities (Figure 1) in the Pilot Plan (AR 1), which are: the Ministries Esplanade, South Commercial Sector (SCS) / Patio Brazil Shopping Mall, South Hotel Sector (SHS), Activity Centre (CA) / Iguatemi Shopping Mall, Hospital Sector South (SHS), Hospital Sector North (SHN), Extra Supermarket / Shopping Boulevard, Hotel Sector North (SHN), Airport, UNB, Restaurants Complex in Ponte JK (Juscelino Kubtischek), Commercial Centre Gilberto Salomão (South Lake), Shopping Mall Brasília, Local Government Sector South (SAS), Local Government Sector North (SAN) and the Bus Station of the Pilot Plan. Based on these indications, the experts ranked each according to the importance each holds, using a scale from 1 to 7, going through the number 3 and 5, which goes from the lowest to the highest importance.

Therefore, we decided to choose just one centrality, so it was possible to perform a more detailed analysis of a landmark enterprise for a consolidation process. Boulevard Mall - located in front of a hypermarket, Extra – was chosen due to its strategic location between the ARs Brasilia and Lake North, as well as for being close to the highway EPIA (Estrada Parque de Indústria e Abastecimento), considered the busiest in terms of vehicular traffic coinciding therefore with the potential for movement from the topological standpoint (Barros, 2006). Moreover, it is considered a centrality of importance 5 for the Experts (Figure 1), therefore to be considered relevant to the spatial structure of the city.

Using the second technique - Google Earth images (Figure 2 and Figure 3) - it can be seen that there was a significant change in the spatial structure of the area in which the project under study is located. The development is located at the end of the North Wing - where there is also the presence of a hypermarket and Hospital Sector North (SHN). Such projects lead to a strong vehicular flow in the area, and the location is considered the main entrance to the North Wing for those coming from the north, such as Lake North, Sobradinho and Planaltina.

Figure 1 – Identification of the centralities in Brasilia.

It is known that the area was originally designed to house a public transportation terminal – that, in 2002, existed under bad conditions and was unable to fit its purpose (Figure 2). Later, by government decree of Law n° 3.719/2005, the functionality of the space was changed. This change confirmed the area's potential for attraction and trip generation (mostly in private vehicle), fostering, therefore, problems of traffic jam, especially during peak hours.

Figure 2 – Location of the old bus station

Source: Google Earth (2002)

Figure 3 – Location of the Boulevard Shopping

Source: Google Earth (2012)

In order to ratify the attraction of trips fostered by TGDs, a comparison can be made with the work of Barros (2006), which includes the traffic simulation and assignment

in the region before and after the implementation of the Northwest Sector[2] (Figure 4). The author found that the flow of vehicles prior to the existence of the sector was less impressive, with only 1025 c/h (car per hour). After the implementation of the TGD, however, there was a significant increase in the flow (2097 c/h) on the road that leads the Extra supermarket - the same one that accesses the Boulevard Mall and Northwest Sector (Figure 5).

Figure 4 – Location of the Boulevard Shopping, Extra supermarket and Northwest Sector.

Source: Adapted from Barros (2006)

After the analysis of the two techniques, the next step involves the application of the methodology recommended by Space Syntax. However, prior to the specific analysis the TGD, it is important to contextualize the position of the Pilot Plan in the Federal District from the perspective of the space syntax analysis.

[2] The Northwest Sector is a development project by architect Paulo Zimbres (2005), characterised by the similarity to the blocks of the Pilot Plan (see Barros, 2006).

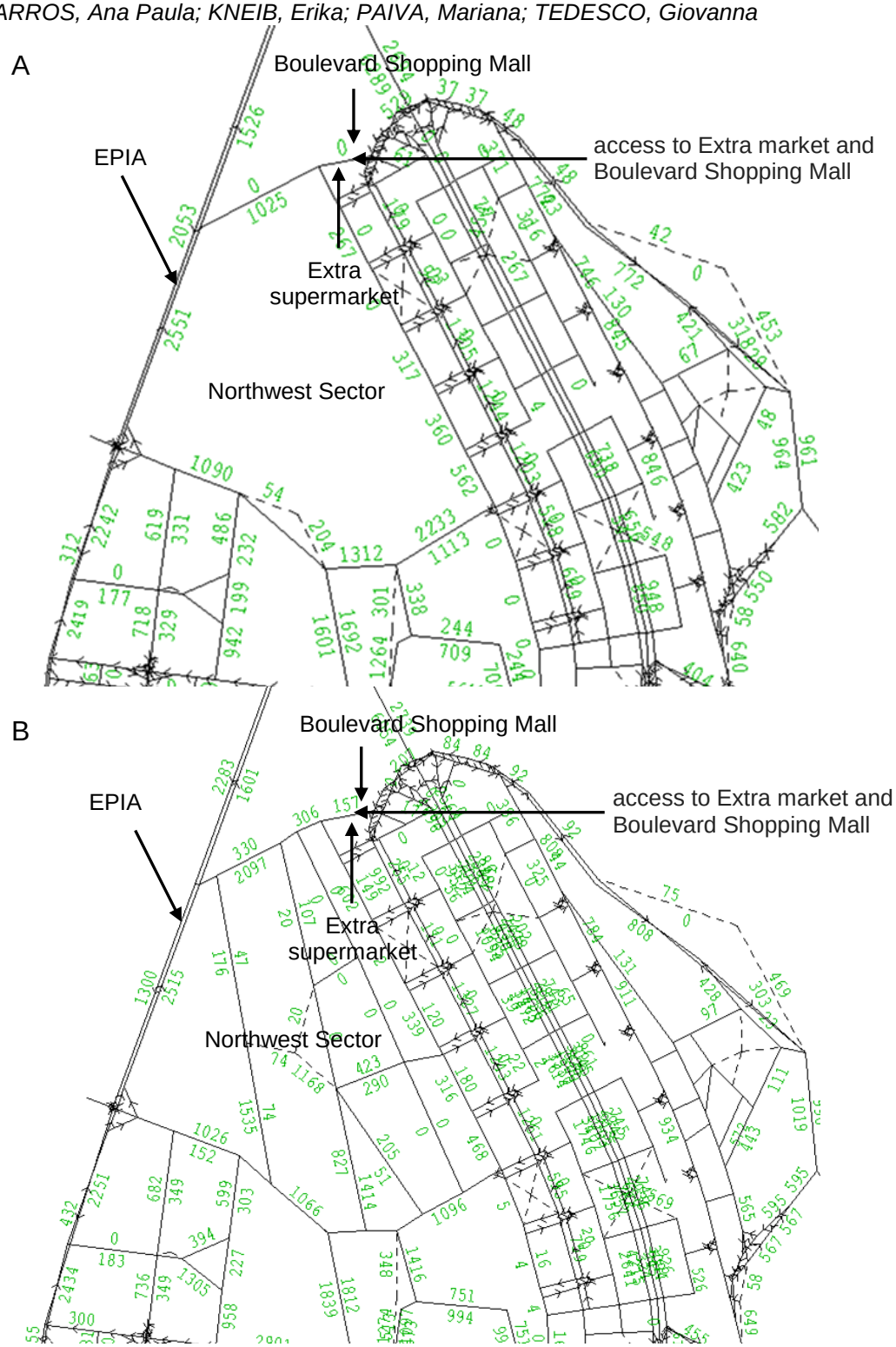

Figure 5 – Trips simulation and assignments in SATURN (Simulation and Assignment of Traffic to Urban Road Networks) of vehicular flow (A) before and (B) after the implementation of the Boulevard Mall, Extra supermarket and Northwest Sector

Source: Adapted from Barros (2006)

In the Federal District (Figure 6), the functional centre is the Pilot Plan, because the most important activities and greater availability of jobs are concentrated there. The

topological centre, however, are the roads EPIA and EPTG (Estrada Parque Taguatinga Guará), avenues that have the largest values of integration and thus greater potential for generating flows and movements in the system (Figure 6).

The Monumental Axis has three levels of integration (Figure 6). The first section - (red) more integrated - concentrates a significant vehicular flow that must be distributed to the SMU (Urban Military Sector), Southwest and Cruzeiro, as well as the remaining areas of the Pilot Plan, because it is located near the EPIA (integration value 0.9605). The following section - orange - shows a reduction of vehicular flow, apparently due to the distribution of flows to the North and South wings (integration value 0.8182). And the final section - in blue - presents the low integration of the Ministries Esplanade with the system since, to access other areas of the city, one does not necessarily need to go through it (integration value 0.7488) (Barros et al., 2005).

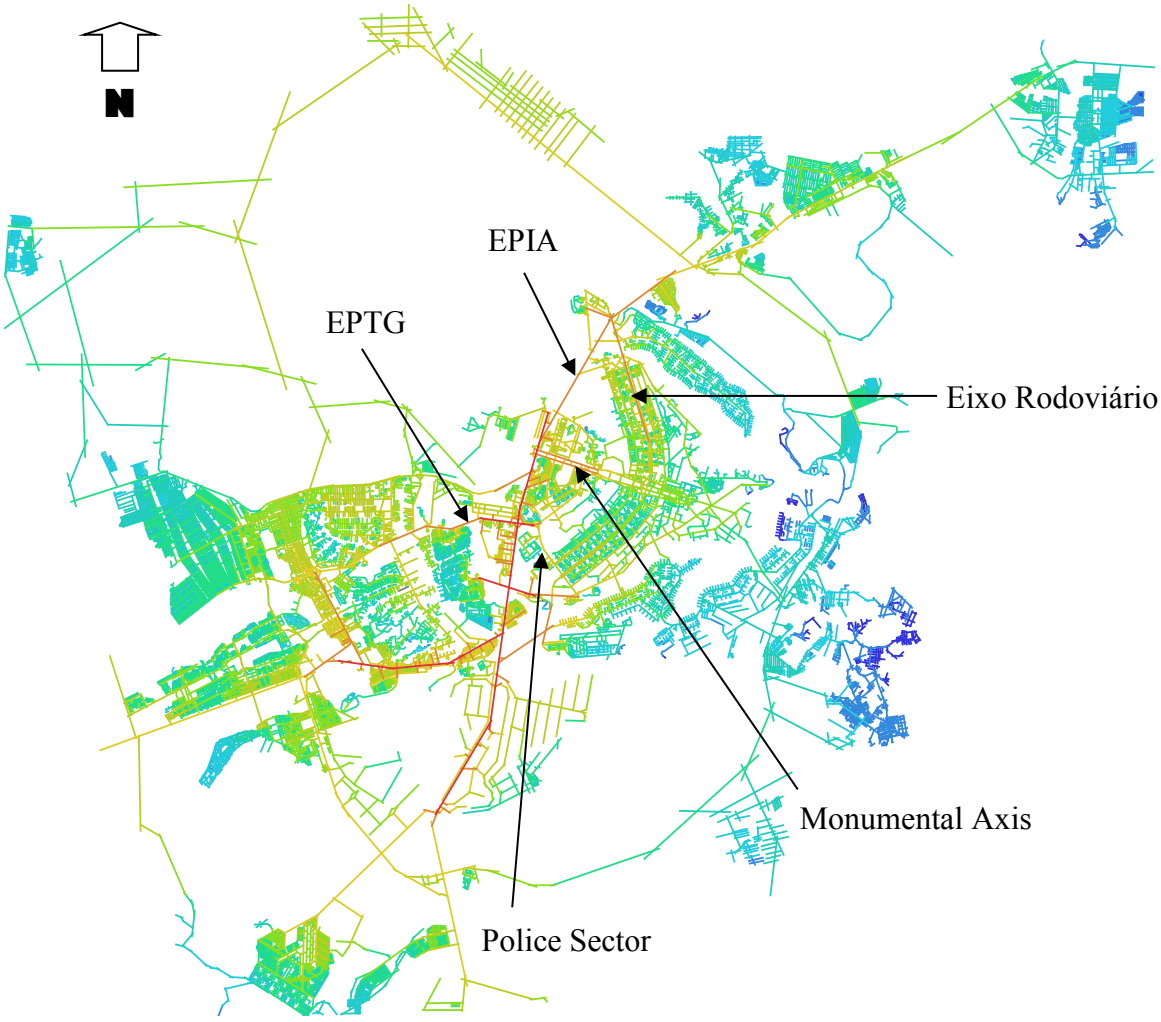

Figure 6 – Axial Map R*n* of the Federal District (partial)

Source: Group DIMPU/UnB (2009) – scale not indicated

Moreover, analysing only the Pilot Plan (Figure 7), we notice that the most integrated roads are: Monumental Axis (integration value 1.28), Eixo Rodoviário (integration

value 1.25), EPIA (integration value 1.31), EPTG (integration value 1.20) and Police Sector (integration value 1.97).

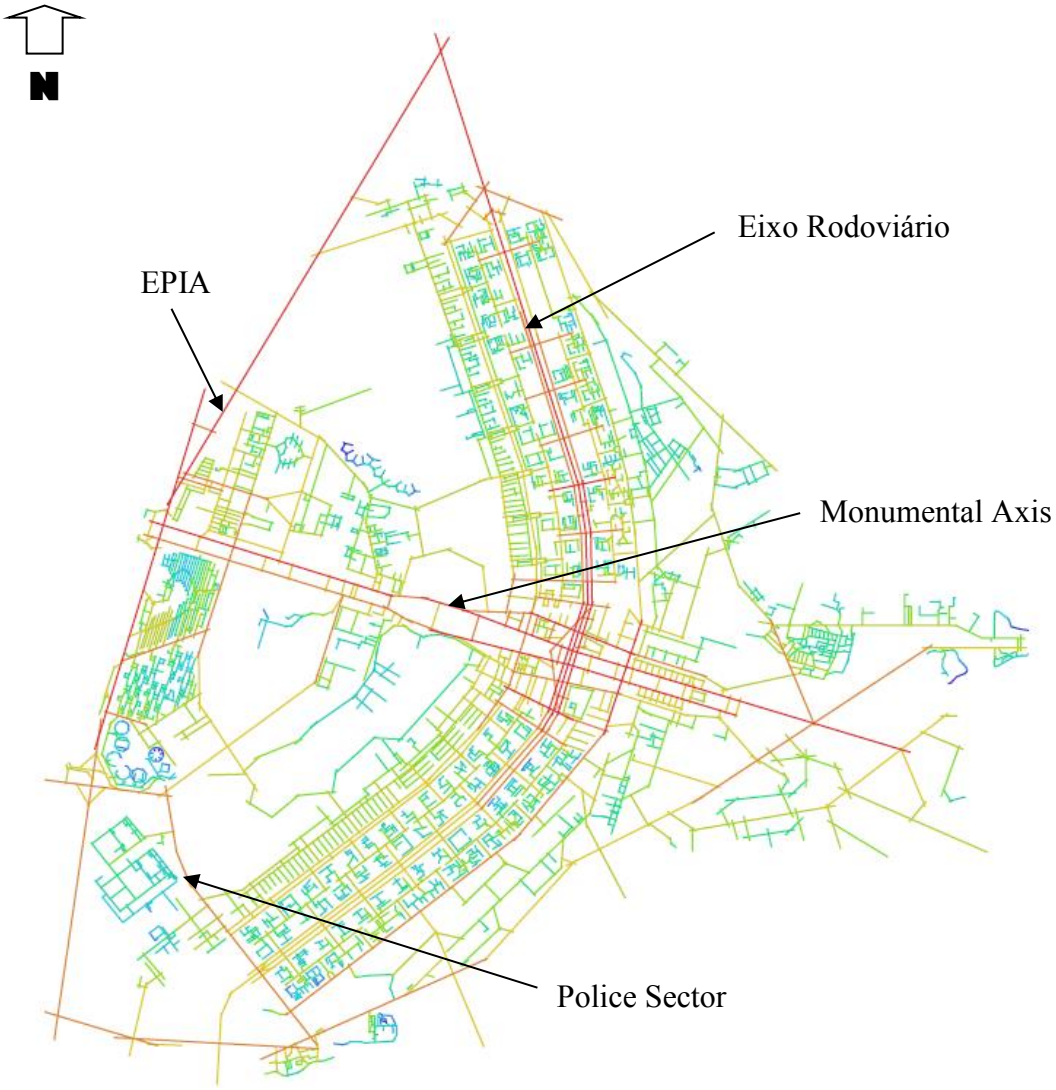

Figure 7 – Axial Map R*n* of the Pilot Plano of Brasilia

Source: Barros (2006) – scale not indicated

Boulevard Shopping (TGD under review) is located in this scenario, and is considered by experts as a degree 5 centrality (Figure 1). For the Space Syntax, the development is also considered one of the most accessible - from the topological point of view – amongst the other trip generating developments of the Pilot Plan.

The Boulevard Mall presents an index of global integration of 0.938[3] in the context of the Federal District; and 1.084 in the context of the Pilot Plan (AR 1). Such rates are much higher than the average global integration of the DF, which is 0.680. This means that, for the set of possible paths to be travelled originating in that TGD, there

[3] It is important to clarify that the TGDs are considered polygons and their relationship to the Space Syntax is by means of the axes that cross this polygon. Therefore, for this study only the most integrated axis connected to the TGDs was used. In the case of Boulevard Shopping, this axis was W3 North.

is a certain ease in accessing the more integrated areas in the system. This happens due to its location in the most central area from a topological point of view, which means that there are less conversions in the displacement from its origin to reach the more integrated axis in the urban infrastructure, such as the EPIA.

5 FINAL CONSIDERATIONS

Results show that by configuring the spaces it is possible to analyse, amongst other things, the extent to which trip generating developments can interfere with the performance of urban space. As an example, the high levels of integration of Boulevard Shopping in the context of the Federal District (0.938) in relation to the average of the overall system integration (0.680) should be highlighted, confirming therefore the possibility of using these strategies for analysing the spatial configuration for studying centralities. That is, the centrality where Boulevard Shopping is located is considered very accessible and, as there are several empty areas in the surroundings, we can estimate a tendency for attracting new activities.

Such aspects corroborate the need to learn more and analyse the centralities and the existing TGDs, as well as the areas with great accessibility (identified by the Syntax) which tend to attract new TGDs and which must be incorporated in the process of transportation planning and land use ordering. Such procedures enable a better use of the centrality's potential where desired, or hinder the further development of centralities in areas which are already saturated and unable to take new impacts.

In view of this, we can infer that the analysis of spatial configuration is important not only for the identifying the location of centralities, but also for the simulation of future locations for TGDs. In turn, it is possible to simulate the growth of the city over time, observing the rearrangement of hierarchies and thus anticipating the importance of certain areas in which future TGDs can foster future centralities. Such analytical strategies may be the foundation of proposals for altering the urban spatial structure, by fostering the desired centralities. At last, these strategies may also help in the decision making process for promoting mobility to urban centres.

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