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Urban centralities: proposed classification based on travel flow on Belo Horizonte, Brazil

Centralidades urbanas: proposta de classificação com base no fluxo de viagens em Belo Horizonte - MG

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ABSTRACT
Some recent urban problems, especially deficiencies in urban mobility and spatial concentration, present themselves as challenges to researchers and public managers. In this context, when there is an increase of distances and travel times traveled by citizens, it suggests the promotion and support of polycenters, decentralizing equipment, services and activities. This measure has the potential to reduce distances and travel times, thus contributing to the improvement of mobility and accessibility, as well as the quality of urban life. This research is structured to develop and apply a methodological proposition for classification of centralities based on travel flow. By using geoprocessing techniques and spatial analysis methods, it aims to propose indicators able to classify urban centralities, divided into local, regional and municipal. The application to Belo Horizonte, Brazil, proved that the proposal is viable, having been classified 38 centralities in conformity with the Master Plan, having, therefore, capacity to support the management and development of public policies.

RESUMO
Os recentes problemas urbanos, notadamente as deficiências em mobilidade urbana e a concentração espacial, apresentam-se como desafios aos pesquisadores e gestores públicos. Neste contexto, quando há o agravamento das distâncias e dos tempos de deslocamentos percorridos pelos citadinos, aponta-se para a fomentação e a manutenção de policentros, desconcentrando equipamentos, serviços e atividades. Tal medida possui potencial para redução das distâncias e dos tempos de deslocamentos, contribuindo, assim, para a melhoria da mobilidade e acessibilidade, bem como da própria qualidade de vida urbana. Essa pesquisa está estruturada para desenvolver e aplicar uma proposta metodológica de classificação de centralidades com base no fluxo de viagens. Ao se utilizar de técnicas de geoprocessamento e medidas de análise espacial, tem como objetivo propor indicadores capazes de classificar as centralidades urbanas, discriminadas em local, regional e municipal. A aplicação para Belo Horizonte - MG, demonstrou que a proposta é viável, tendo sido classificadas 38 centralidades em conformidade com o Plano Diretor, possuindo, assim, capacidade para subsidiar a gestão e elaboração de políticas públicas.

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1. INTRODUCTION

In the face of an urbanization process characterized by late industrial acceleration (starting from the 1950s) and profound changes in city space. The larger Brazilian cities reached the status of metropolis, before the regulatory framework that took place only in 1973 (Monte-Mór, 2006; Izaga, 2009). With urban growth, certain places start to act as attraction centers and, in

this sense, the formation process of centralities gains relevance as these spaces demonstrate: importance and spatial reference; increase in land value; concentration of activities, equipment and services and provision of urban mobility through transport networks and the road system (Sposito, 1991; Villaça, 2007; Mayorga, 2013). The identification of these central areas has gained visibility not only in the academic field (Kneib, 2008) but also in the governmental field (UFMG, 2011), as in the case of Belo Horizonte, which such policy is present in the Master Plan (Belo Horizonte, 2019a), where initiatives to encourage polycenters are identified.

In this sense, it is necessary to use instruments for the classification of central areas that are reliable, serving as support for urban and transport planning. The central question of this work is: How to classify the centralities of a metropolis based on its urban travel flow? For that, the hypotheses are: (i) the origin of the trips allows the classification of centralities; (ii) the length of trips enables the classification of centralities, and (iii) the percentage of attraction of the neighborhoods, enable the classification of centralities.

The objective of this work is to develop a methodology for the classification of centralities based on urban travel flows. For that, the developed methodology was applied in Belo Horizonte, and the results complied with centralities pointed out by the new municipality Master Plan (2019), demonstrating the importance and reliability of the study. As a contribution, we demonstrate the potential of spatial analysis tools for urban mobility, such as the use of travel flows, to identify, classify and access the level of attraction of centralities, offering relevant information for management and urban and transport planning.

2. THEORETICAL FRAMEWORK

2.1. Spatial structure and urban mobility

A tendency to change the location of industries to the then peripheral areas began to exist in large Brazilian cities as the population started to grow in urban areas. This trend changed urban morphology and promoted spatial expansion (Mattos, 2015). Transport systems and communication networks favored such movement, which contributed to changes in the dynamics of spatial production (Silva et al., 2017). The changes in the industry location and the changes in the transportation system also impacted the real state market, changing the workers' mobility and people's behavior (Cardoso et al., 2020). As a result, the activities started to move to new sub-centers throughout the territory (Mattos, 2015), which can promote a decline in the importance of traditional centers and a transformation in the functioning of the city.

This tendency towards the weakening of a single center and the formation of multiple centers can also be understood as a contemporary condition of large cities. In this context, the polycentric structure is considered an alternative to mitigate urban growth externalities related to accessibility and congestion. This structure is more resilient and economically competitive (Rauhut, 2017) and contributes to environmental and social issues (Liu Z., and Liu S., 2018). This polycentric structure is defined as more than a single grouping of places of activities and services in the urban territory, and it opposes to the monocentric concept and structure (Sat, 2018).

Urban mobility, in this context, can be indicated as the possibility of moving an individual, given the performance of transport networks and the road system and their social and economic conditions (Lessa et al., 2017). So, urban mobility is the main part of the development and territorial structuring of a city, constituting an essential part of policies and urban life (Raia Jr., 2000).

2.2. Methods to identify and classify centralities

The purpose of this section is to present a list of methods, selected through a systematic literature review, to identifying centralities in the urban context. From the knowledge and synthesis of some existing methods, it became possible to advance the production of the present methodology which, and in addition to identifying the centralities they were classified. It is important to point out that the articles that follow in this section do not classify the centralities, only identify them, thus, the present methodology, which will be presented below, aims to fill this gap under the Brazilian reality.

Therefore, the concept of centralities used here considers the existence of more than one central location, which presents levels of concentration of economic activities higher than the neighboring areas (Cladera et al., 2009). Contributing to this concept there is the possibility of identifying the centralities from the interaction of places from the perspective of flow data, thus describing the urban structure (Liu Z., and Liu. S., 2018).

Among the main methodologies for identifying centralities, several studies point to the relationship between the conformation of centralities and central areas and the concentration of jobs (Pinheiro, 2014; Lessa, 2019). Villaça (2007) points out that the main center of a metropolis is also the largest agglomeration of jobs and services and, the lower-level centralities, in turn, are smaller reproductions. Vilela (2006) shows that, in Belo Horizonte, its Central Area acts as a polarizing center for the job offers and the presence of commercial and administrative equipment. The same relationship is demonstrated for the capital of São Paulo by Ramos (2004), revealing a pattern of concentration of jobs in central areas.

Kneib (2008) presents contributions to centralities identification, as he points out some methodological proposals: population data, interviews with experts and, from the database and information from municipal bodies. It is noteworthy, that data on land use and occupation may have limited use, especially in developing countries such as Brazil, due to the lack and difficulty of data updating (Jayasinghe et al., 2017).

The use of accessibility and urban mobility data for the construction of these methodologies allow the identification of the urban spatial structure, but in the Brazilian context the update periodicity can be a barrier. In this sense, the works by Zhong et al. (2013; 2014) identified elements of the urban structure from population displacement data. In this direction, the use of data on the number of trips attracted and generated for each spatial zone of urban areas can, in addition to identifying current centralities, identify locations with potential for establishing a future centrality (Kneib, 2008). The bibliography also reports that the urban structure detected from mobility data represents the use of space (Zhong et al., 2013). Travel data also indicate the distance people travel to reach the services available at the centralities (Zhong et al., 2013), which is an important indicator of the centrality's reach and impact. Travel patterns, time travel and distance travel, can change the structure and urban form, with reflections on the quality of life of residents and environmental impacts.

Another important driver of methodologies to identify central areas is the use of government surveys of population displacements, in the Brazilian case, the Origin and Destination Survey (OD). Zhong et al. (2013) used data from local research in Singapore, for the years 2004 and 2008, verifying the evolution of density and attractiveness of local centers. Making a parallel to the Brazilian case, the Origin and Destination Survey is traditionally updated every 10 years, and also allows the construction of methodologies for the identification and classification of

central areas (Lessa, 2019). More recently, with the insertion of electronic ticketing and the monitoring of the collective transport fleet by GPS, various data are generated, which can contribute to mobility research. Also, for the city of Singapore, Zhong et al. (2014) present a model and carry out its application based on information recorded by the public transport system. In the same context, Jayasinghe and Munshi's (2014) proposal used data from public transport stops, and demand at these, to measure the centralities of the city of Ahmedabad.

To support the use of these databases, the application of Geographic Information Systems (GIS) tools and the use of Exploratory Spatial Data Analysis (ESDA) are indicated. Such tools and techniques aim the spatial description of data and its distribution (Mendonça Neto and Kneib, 2016).

Traditionally, studies related to the identification and classification of urban centers are based on the concentration of urban activities, services and equipment. Other more recent studies indeed linked the centralities to population displacements, taking into account the number of trips generated and attracted by such spatialities, some even identifying the density and attractiveness of local centers, however, these works did not classify the centralities from the travel flow. In this context, this article proposes an alternative to traditional methodologies, as it seeks to identify the centralities based on travel flows and economic data. Also, it proposes to classify the centralities based on travel flows, filling a gap referring to the classification of these areas. For this purpose, we used data from government surveys, of easy and free access, which enables the reproduction of the proposed methodology.

3. METHODOLOGICAL APPROACH

In this section, the methodological course of the method proposed by this manuscript for classification of centralities is detailed. Figure 01 illustrates the flowchart that will be described in this section.

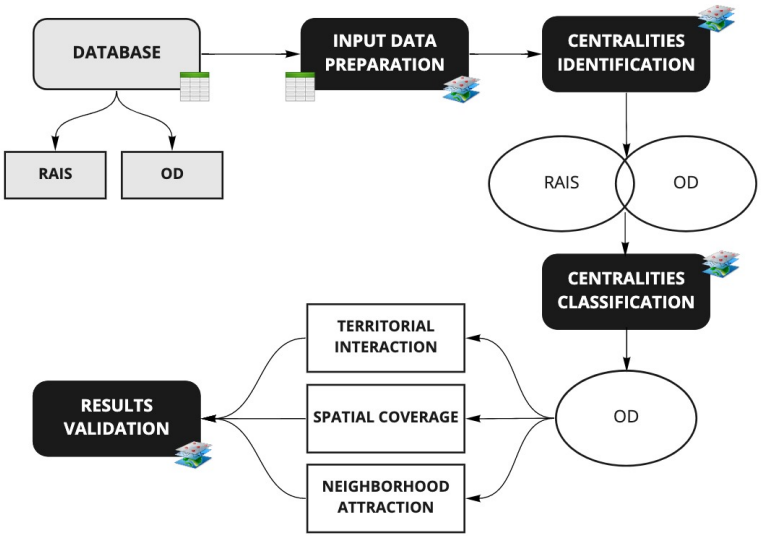


Figure 1. Flowchart of the methodological approach

3.1. Database, spatial cutout, and analysis spatial unit

To achieve the proposed objective and the capability of reproducibility in other Brazilian cities, this methodological proposal uses the database focused on two government surveys.

The first is the Annual Social Information Report (RAIS), carried out at the federal level, and aims to understand the Brazilian labor market, providing data for statistical studies (Brazil, 2020). This base was used to obtain the number of employees by economic sector and the data about economic activities. The second government survey is the Origin and Destination (OD), carried out at a province level, and aims to assess the characteristics and volumes of daily displacements of the population (Minas Gerais, 2013). The data provided by this research allows us to verify the origins, destinations, and volumes of travel, thus relating the centralities to places with greater travel attractiveness.

The spatial cut-out for the application of the proposal will be in Belo Horizonte, capital of Minas Gerais, Brazil, which registered, in 2019, about two and a half million inhabitants, being the third-largest Brazilian agglomeration in the number of inhabitants (Brazil, 2019). The last OD in the city was carried out in 2012. Therefore, data from the 2012 RAIS will also be used to allow for smaller temporal disparities. The spatial unit of analysis used in all stages of this research will be the Homogeneous Area (HAs) as it presents the lowest level of spatial disaggregation, establishing minimum samples for socioeconomic and transport research (Minas Gerais, 2013). The data obtained from the RAIS and the OD were aggregated in the spatial unit of the HAs, to enable the work on a GIS-type platform. Thus, the database used for this methodological application is resumed in Table 1.

Table 1 – Data source, variable, selected attributes and description of data used

Data Source	Variable	Selected Attribute	Description
RAIS (2012)	Economic sector	Industry, commerce, and service	Number of employees
OD (2012)	Origin and destination	Belo Horizonte	City of origin and destination
	Motive	Shopping, school, health, and work	Declared reason for travel
	Transportation mode	All	Travel mode of transport

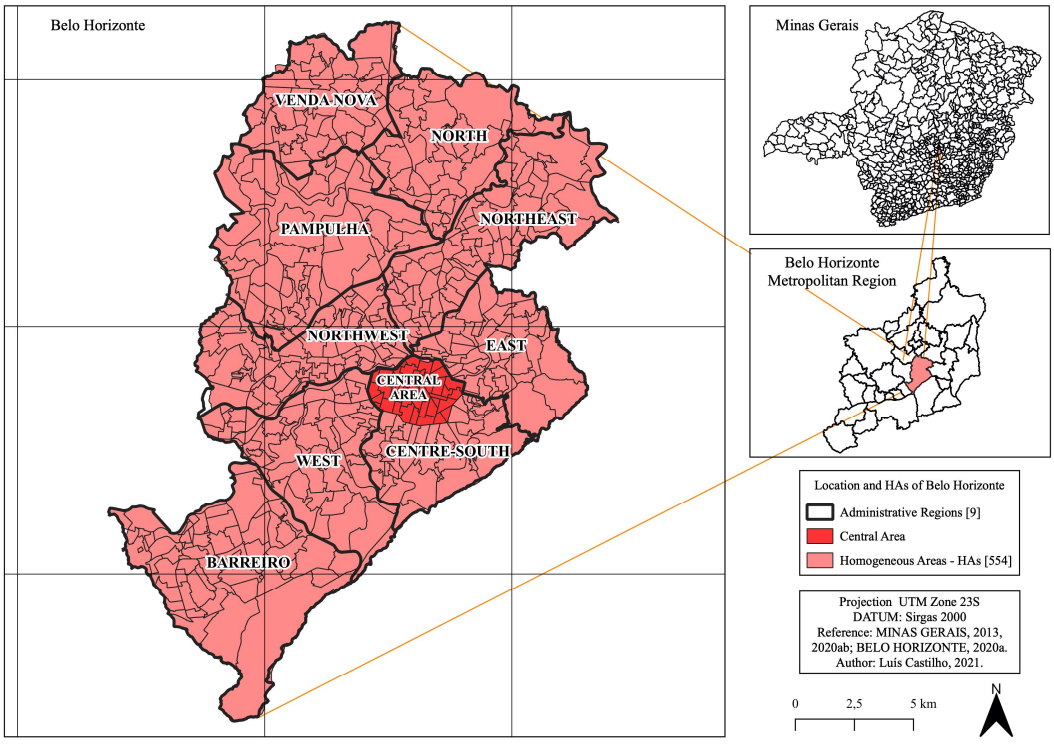


Figure 2. Location, Administrative Regions, Central Area and Homogeneous Areas of Belo Horizonte - MG

Belo Horizonte (Figure 2) is divided into 554 Homogeneous Areas grouped into nine Administrative Regions, namely: Centre-South, Barreiro, East, West, Northwest, Northeast, North, Pampulha and Venda Nova (Minas Gerais, 2013). The Central Area exerts a strong influence throughout its territory, concentrating 14.8% of all commercial establishments in the capital (Belo Horizonte, 2019b) and establishing influence as the main center of its entire Metropolitan Region (UFMG, 2011; Leiva et al., 2019; Lessa and Lobo, 2020).

3.2. Centralities identification

We used RAIS and OD dataset for the centralities identification. This step is an adaptation of Lessa's (2019) proposal for identifying centralities from the economic data of RAIS by adding the OD travel attraction data.

Due to the influence of the Belo Horizonte Central Area and its consolidated main centrality role of the municipality, the data related to the 41 HAs inserted in this region were excluded. For the present methodological proposal, the adopted representative data for the identification of centralities was that referring to 20% of the highest values, since this percentage brought the best results for application in Belo Horizonte.

The first identification of centralities based on economic data was obtained from the weighting of data on employees in commerce, industries, and services by each HA. Then the data was georeferenced and classified into 10 spatial classes by the quantile method, where its first class had HAs between 0 and 24 employees and its last class between 885 and 2499. The identification of centralities based on the attraction of trips was obtained from the OD dataset choosing the travel motives: work, shopping, school, and health. Data expansion factors were used, which were worked spatially. Similarly, the data were classified into 10 classes by the quantile method, where the first-class registered between 0 and 177 attracted trips and they last between 4341 and 19713. With these two classifications, we proceeded to the identification of the centralities, defined here as the intersection of both indicators. Such identification was performed by superimposing the results in the QGis software, using the intersection geoprocessing tool.

3.3. Centralities classification

The centrality classification step consisted of the elaboration of three indicators, calculated from data from the OD and for the 38 areas previously identified.

The three indicators, Territorial Interaction, Spatial Coverage and Neighborhood Attraction, were calculated from equations applied in Microsoft Excel and QGis software. After calculating the indicators, they were divided into three classes, based on the natural break method, as this method considers the natural grouping of data about their similarities (Matsumoto et al., 2017). The first class, called local, is the one whose interrelationships take place on a smaller scale, with smaller distances; the second, regional, whose interrelationships are on an intermediate scale, and the last, municipal, whose interrelationships go beyond regional boundaries, reaching the entire municipality and with greater distances.

3.3.1. Territorial Interaction - TI

The first indicator, Territorial Interaction, measures the origin of the trips attracted by the centralities and establishes the centrality's interaction with the attracted trips. The product of this indicator makes it possible to identify the level of attractiveness and the connection of

centrality with the other HAs. The indicator is defined by the quantity of HAs originating from trips towards the centralities, data obtained through the pivot table tool in the OD 2012 spreadsheet.

3.3.2. Spatial Coverage - SC

The Spatial Coverage indicator analyzes the spatial extent of the attraction exerted, measured by the weighted average distance of trips received. In this case, the weight was established by the trips volume. The indicator is calculated from Equation 1.

$$SC = \frac{\sum_{i=0}^{n}(d_i \times vt)}{\sum tt_j^i} \quad (1)$$

$SC:$ spatial coverage;

$di:$ euclidean distance from the HA_j towards the centrality i;

$vt:$ trip volume towards the centrality i and;

$tt:$ total of trips towards the centrality i.

To obtain the euclidean distance from the HA_j towards the centrality i, three steps were performed in the free software QGis: first, the centroids of each of the HAs that had the origin of the trips to each centrality were identified; then, the centroids of the centralities were generated and; finally, based on the centroids, the distances, in meters, between the centroid of the origins of the trips and the centroid of the destination centrality were stipulated. The vt and tt data are displayed in the OD spreadsheets.

3.3.3. Neighborhood Attraction - NA

The Neighborhood Interaction indicator analyzes, for each centrality, the volume of trips attracted based on the immediately neighboring spatial influence, defined by all the HAs that touch the HA that represents the centrality (edge neighborhood). For such calculation, a proportion was performed following Equation 2.

$$NA = \frac{\sum_{i=0}^{n}(vv_i + vi_i)}{\sum tt_j^i} \times 100 \quad (2)$$

$NA:$ neighborhood attraction;

$vv:$ trip volume from the HAs immediately neighbors towards the centrality i;

$vi:$ intern trip volume towards the centrality i and;

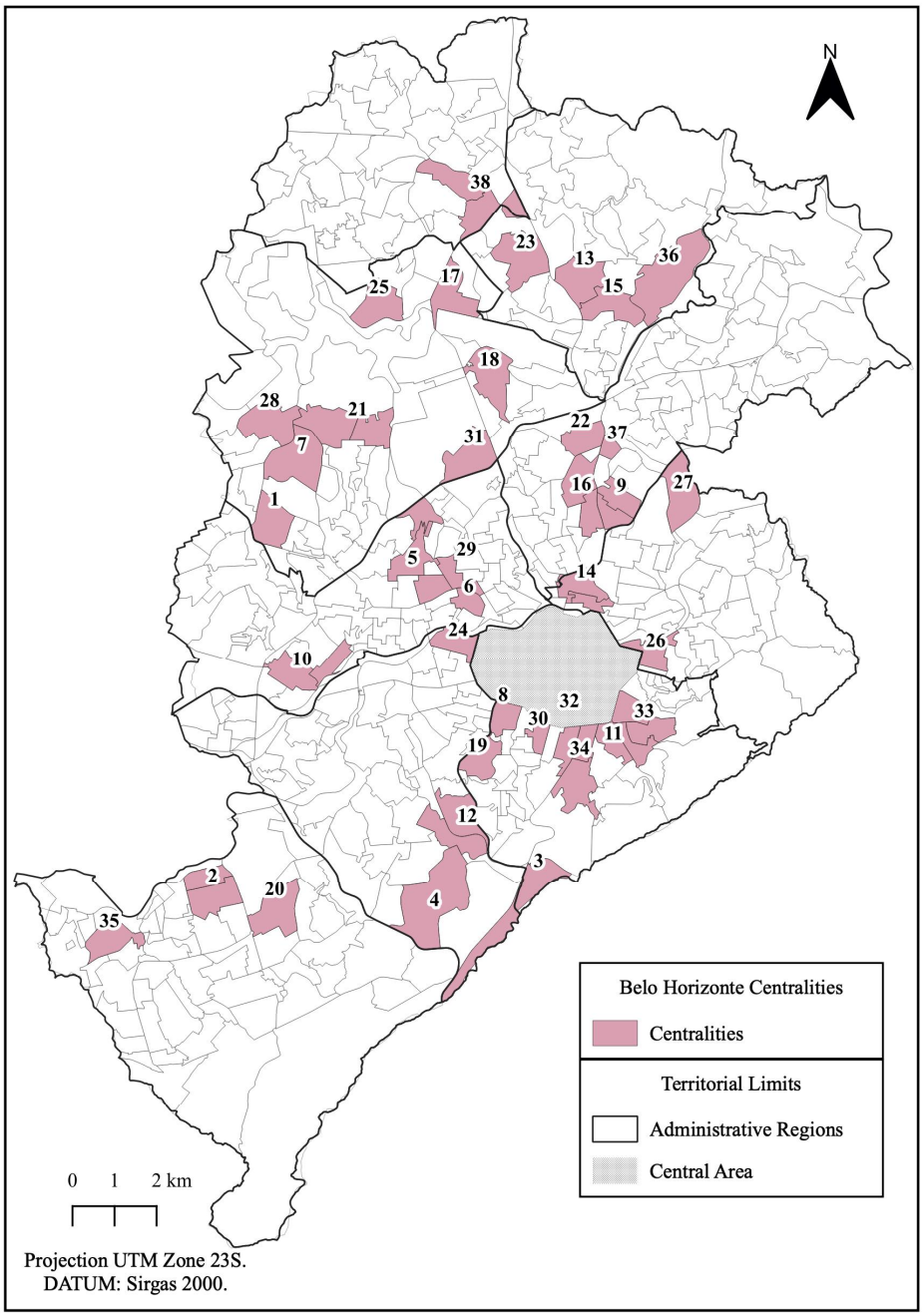
$tt:$ total of trip towards the centrality i.

All data required for Equation 2 are available in the OD spreadsheets. The application of the Neighborhood Attraction indicator brings its results in percentage. The higher the percentage, the greater the influence neighboring the centrality. In this way, the smallest percentages represent centralities with greater spatial influences and, consequently, more municipal and less neighborly.

4. RESULTS ANALISIS

4.1. Centralities identification

Figure 3 shows the centralities identified for the intersection of the two databases. For the RAIS database, 103 HAs were identified and for the OD database, another 103 HAs were identified. At the intersection of the two databases, 52 HAs were identified. They were then grouped into 38 centers, named according to the name of the neighborhood (Belo Horizonte, 2020).



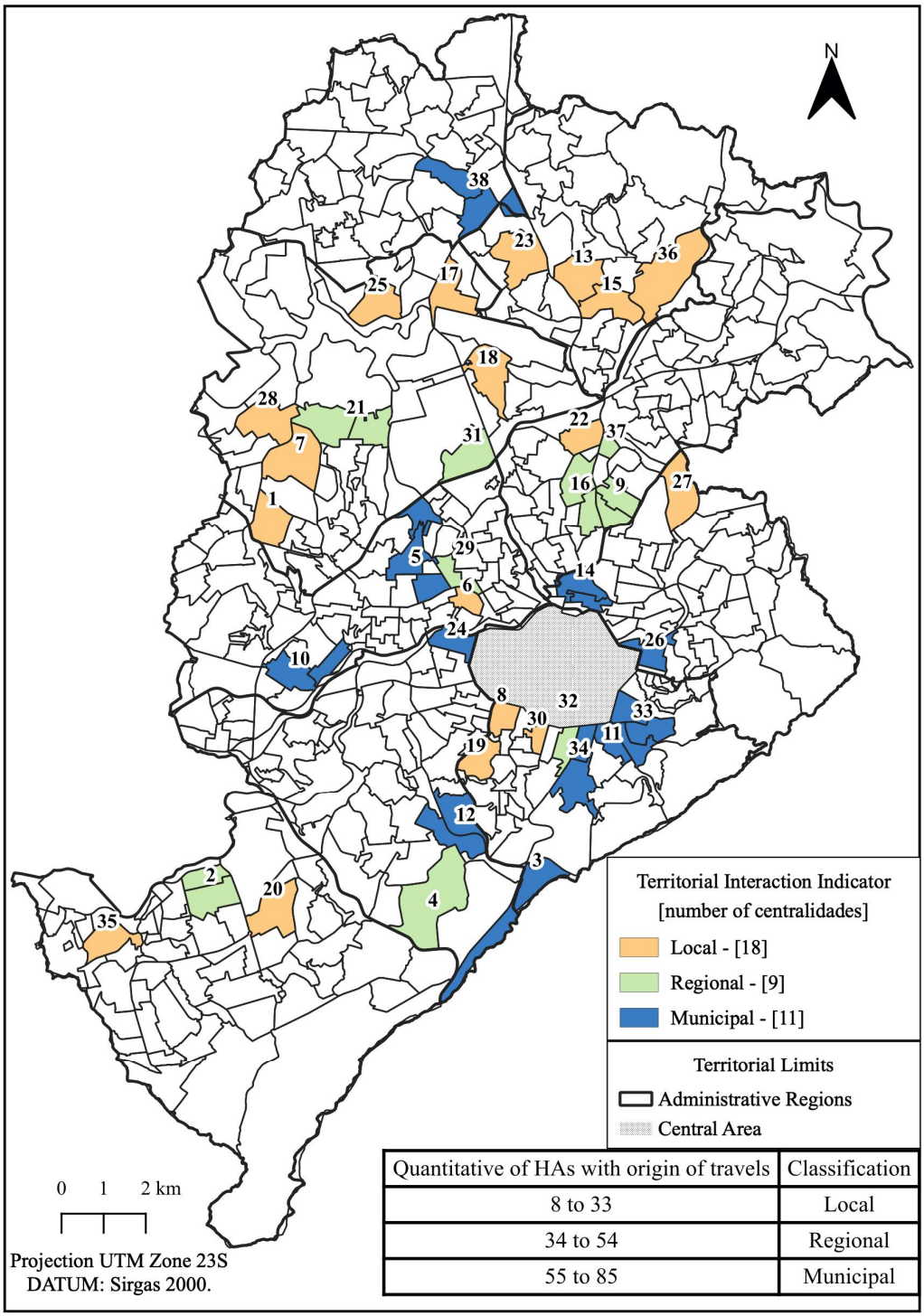
ID	Name
1	Alípio de Melo
2	Barreiro
3	Belvedere
4	Buritis
5	Caiçara
6	Carlos Prates
7	Castelo
8	Cidade Jardim
9	Cidade Nova
10	Coração Eucarístico
11	Cruzeiro
12	Estoril
13	Floramar
14	Floresta
15	Guarani
16	Ipiranga
17	Itapoã
18	Jaraguá
19	Luxemburgo
20	Milionários
21	Ouro Preto
22	Palmares
23	Planalto
24	Prado
25	Santa Amélia
26	Santa Efigênia
27	Santa Inês
28	Santa Terezinha
29	Santo André
30	Santo Antônio
31	São Francisco
32	São Pedro
33	Serra
34	Sion
35	Tirol
36	Tupi B
37	União
38	Venda Nova

Figure 3. Centralities identification

4.2. Centralities classification

In the Territorial Interaction indicator, the Milionários centrality presented the lowest value, attracting 8 HAs. In contrast, the Caiçara centrality presented the highest value attracting 85 HAs. Thus, the data were worked using the natural break method and divided into 3 classes. This indicator pointed to 18 local centralities, nine regional centers, and 11 municipal centralities (Figure 4).

The Venda Nova centrality (38) was the centrality attracting the second-largest number of trips from HAs, 84. This may have occurred because it is the only centrality in its administrative region. This observation is also supported by the location of two integration stations its interior: Venda Nova and Vilarinho.



Quantitative of HAs with origin of travels	Classification
8 to 33	Local
34 to 54	Regional
55 to 85	Municipal

Figure 4. Quantitative of HAs with origin of travels and classification of centralities by the Territorial Interaction indicator

Of the 11 centralities identified as municipal in the TI indicator, six borders the Central Area, and they are Cruzeiro (11), Floresta (14), Prado (24), Santa Efigênia (26), Serra (33) and São Pedro (34). This fact is due to the vast influence of the main center of the capital, which goes beyond its territorial limits towards neighboring areas. Of the other municipal centers, in three there are malls: Belvedere (3), Caiçara (5) and Venda Nova (38). The fourth center, Coração Eucarístico (10), is located on the main campus of the Pontifical Catholic University of Minas Gerais, which can impact the attraction of trips at the municipal level.

In the Spatial Coverage indicator, the values, after applying Equation 1, varied between 562 meters, in Tirol centrality, and 10171 meters in Belvedere centrality. In this way, the data were divided into three classes using the natural break method. The classification and the spatialized result are shown in Figure 5. According to the aforementioned values, the classification of the SC resulted in 14 local centralities, 18 regional, and six municipal.

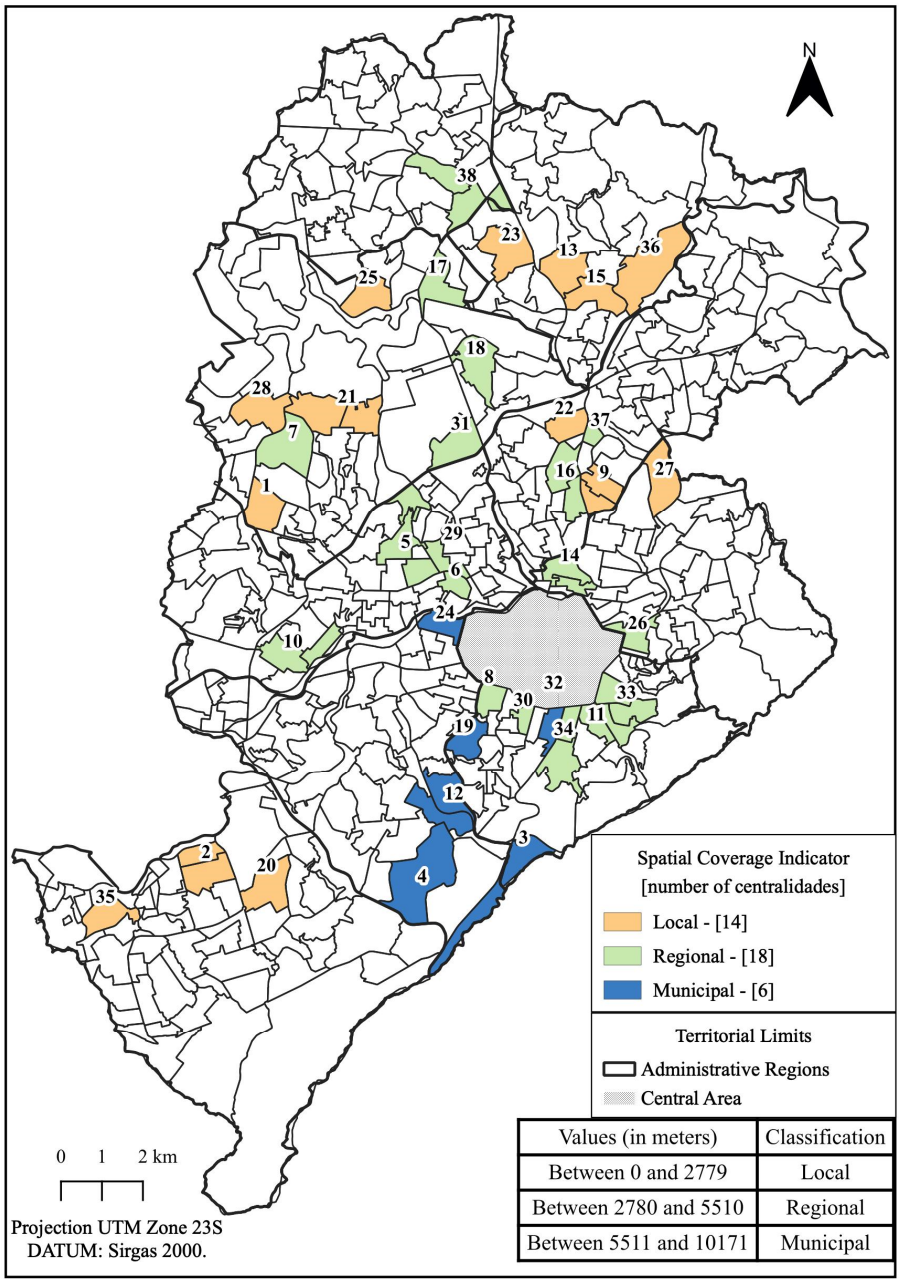


Figure 5. Values (in meters) and classification of centralities by the Spatial Coverage indicator

The six municipal centralities were located in only two Administrative Regions of the city: Center-South and West. This is due to the disposal of commercial establishments in the municipality, which, in percentage terms, present higher values in these regions, 24 and 13%, respectively (Belo Horizonte, 2019b). In contrast, all the centralities of the North region (Floramar (13), Guarani (15), Planalto (23) and Tupi B (36)) were classified as local, as this region has the lowest percentage (6%) of commercial establishments (Ibid).

In the Neighborhood Coverage indicator, the centrality Milionários (20), in the Barreiro administrative region, presents the highest coverage, since 92.87% of the trips attracted are originated from the immediate vicinity. In contrast, Buritis (4), in the Western region, presents only 1.14% of trips attracted originating from its immediate vicinity. This way, like the process of the previous indicators, the centralities were divided into three classes by the natural break method. So, the NC presented 11 local centralities, 14 regional, and 13 municipal (Figure 6).

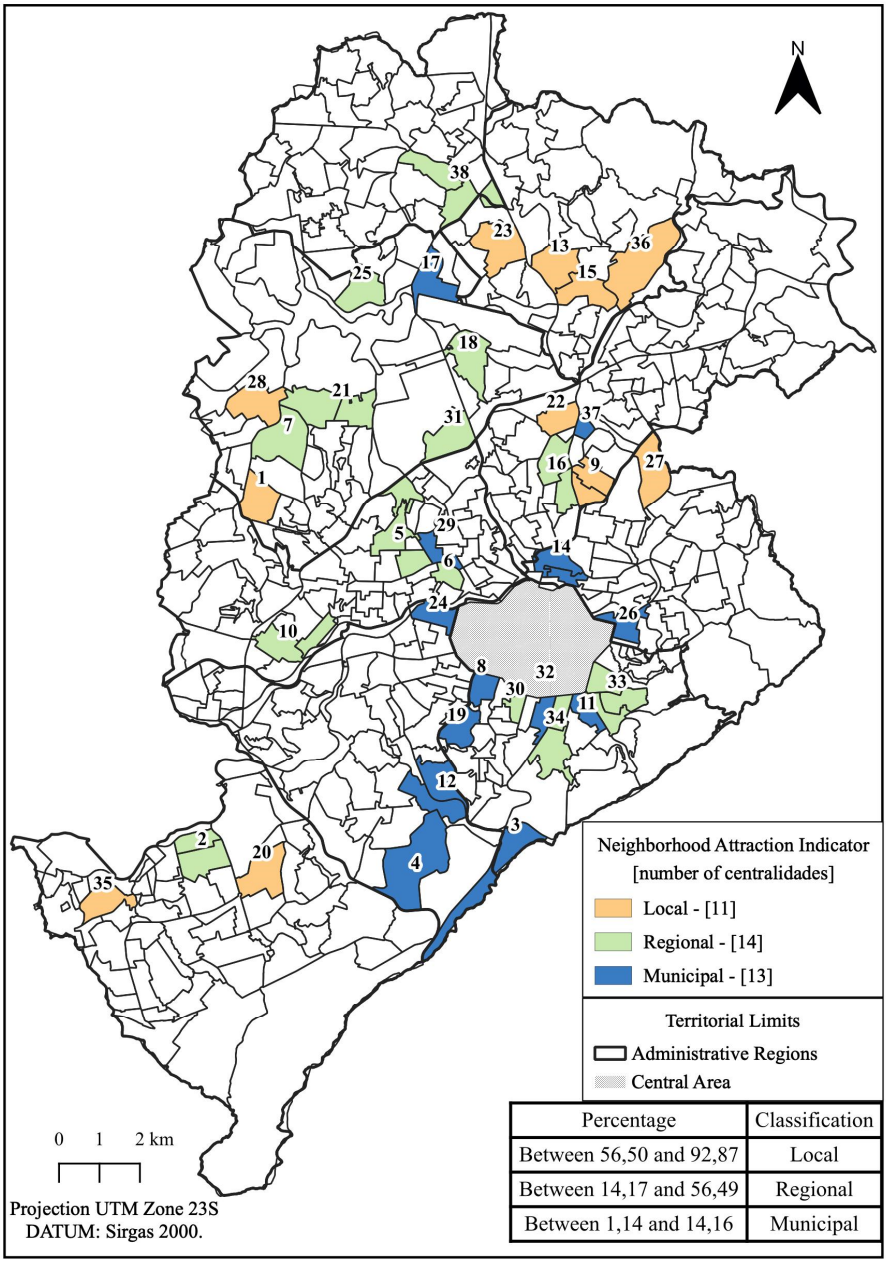


Figure 6. Percentages and classification of centralities by the Neighborhood Attraction indicator

Like the previous indicators, there is a concentration of municipal centralities in the Center-South regions (Belvedere (3), Luxemburgo (19), Cidade Jardim (8), São Pedro (32) and Cruzeiro (11)) and West (Buritis (4), Estoril (12) and Prado (24)). The concentration of such centralities around the Central Area is also characteristic of this indicator, where six of the 13 municipal centralities are located adjacent to Avenida do Contorno. Floresta (14) and Santa Efigênia (26)

were classified as municipal and bordering on the Central Area, reinforcing the previously reported prominence of this region. Carlos Prates (29) and Itapoã (17), classified as municipal, are located at important road junctions in the city. In turn, at the União centrality (37), a mall is located, as mentioned above.

As expected, each indicator presented a result with different numbers of centralities in the local, regional, and municipal classes. Table 2 summarizes the quantity of each indicator to compare them. The Territorial Interaction indicator was the one with the highest number of local centralities, while the other two indicators identified a greater number of regional centralities. There was a 50% disparity between the number of regional centers identified by the Territorial Interaction indicator (9) and the Spatial Coverage (18). In turn, the Neighborhood Attraction indicator showed the most uniform results in the division by natural break. These differences may be related to the specific characteristics of each centrality, as well as to the different selection of data used and the classification method adopted. For example, the disparity in the number of regional centers between the Territorial Interaction and Spatial Coverage indicators can be interpreted in the face of centers that attract trips from the HAs (low TI) but more distant locations (high SC). Despite attracting trips from fewer origins, these centralities impact a greater weighted average distance.

Table 2 – Quantitative and classification of centralities by TI, SC and NA indicators.

	Territorial Interaction	Spacial Coverage	Neighborhood Attraction
Local	18	14	11
Regional	9	18	14
Municipal	11	6	13

To confirm the methodological approach proposed by this manuscript, relationships were established between the data obtained and the city's urban legislation and, finally, crossings with updated data referring to the structuring road system in the capital.

According to the consulted bibliography, the nine centralities bordering the Central Area of the capital of Minas Gerais present high SC, which indicates that they attract longer distance trips and low IT, indicating more regionalized or municipal influence than local. This data indicated that the concentration of jobs and the attractiveness of travel in the Central Area is expanding to neighboring regions. The centrality Prado (24), for example, is classified as municipal in the three indicators. Of the other eight centralities, seven are classified, in all indicators, as regional or municipal. The only exception is Cidade Jardim (8), which has Territorial Interaction with few HAs, being classified as local, but with low attractiveness of its neighborhood, being classified as municipal in TI.

To ratify the results obtained, they were crossed with the zoning provided for in the Master Plan in force in the city, promulgated by Law No. 11.181, of August 8, 2019, and regional centrality. The identification of these zones was mostly formed by corridors and other components of the road system (Belo Horizonte, 2019a). All 38 centralities identified and classified here are circumscribed or permeated by the forecast of the urban legislation (Figure 7), which confirms the methodological steps proposed here and corroborates the information obtained.

The Belvedere centrality (3) was classified as municipal in the three indicators, which indicates the great influence of this region. In the Master Plan, the region fits into an Area of

Special Guidelines (ASG), due to the intense occupation aimed at high-income housing in recent decades. Currently, more restrictive urban parameters are foreseen for the location (Ibid). The Buritis (4) centrality is also inserted in an ASG, whose objectives are to restrict population density and encourage displacement on foot (Ibid). Such legislative forecast can be related to the centrality's Neighborhood Attraction, the smallest in the city, attracting only 1.14% of trips from neighboring HAs, which reflects in its high spatial coverage, of 9,309 meters, the third largest among the studied areas.

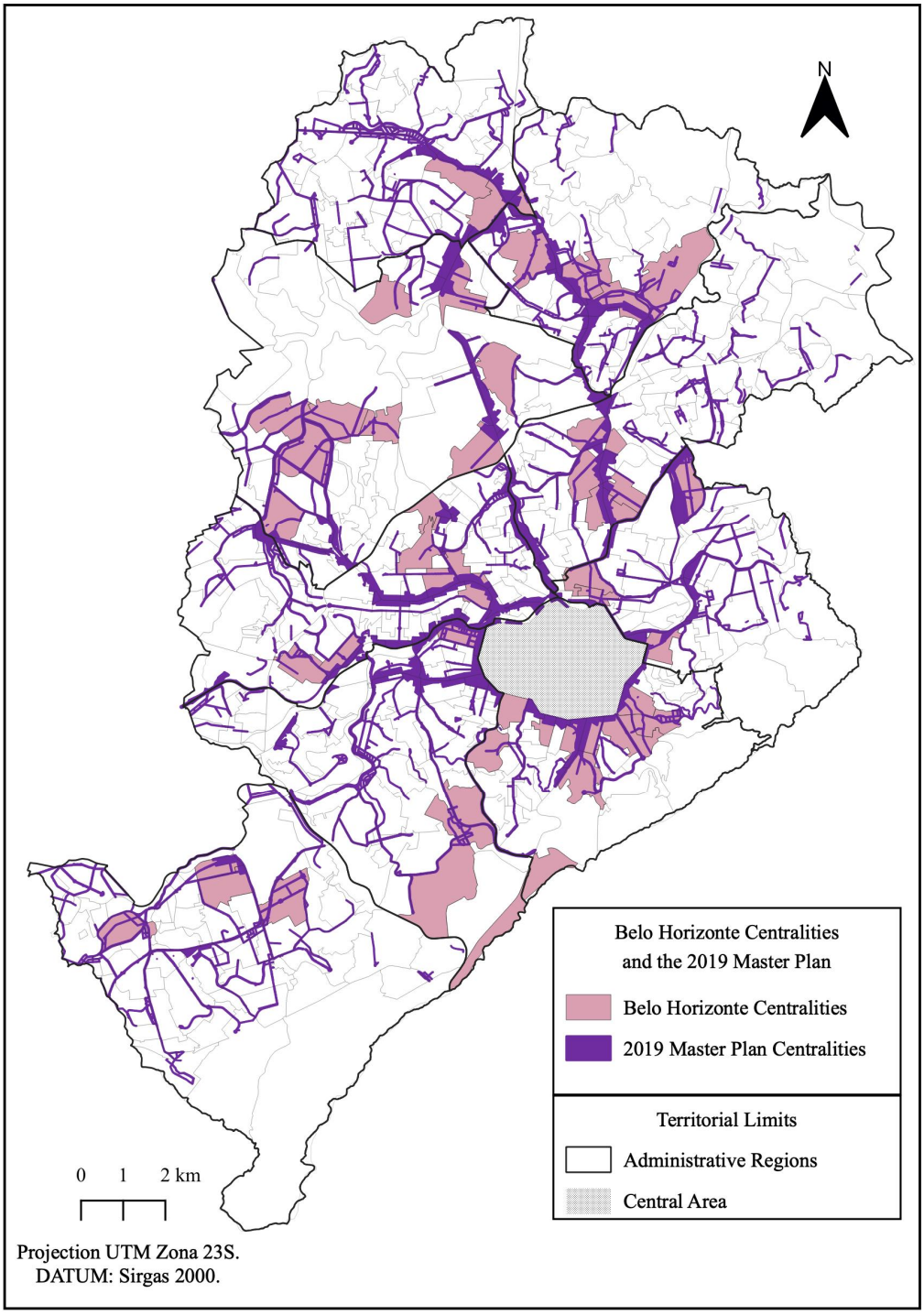


Figure 7. Belo Horizonte Centralities and the 2019 Master Plan

When analyzing the identified and classified centralities with the structuring road system network in the capital, it is also possible to find coincidences, as all centralities are crossed by the structuring road system.

Among the smallest spatial coverage by the structuring road system, the centrality São Francisco (31) is classified as regional in the three indicators. It is pointed out that the two road boundaries of this centrality are formed by Avenida Antônio Carlos, classified as an arterial street and an important corridor in the capital, and by the Anel Rodoviário, the municipality main road connection with the rest of the Brazilian territory. Avenida Major Delfino de Paula, also part of the structuring road system and internal to the centrality, makes the connection between the aforementioned roads. The other bordering points are land belonging to the federal government. Thus, despite the limited coverage by the structural road system, this centrality is located in an area with privileged access, which corroborates its IT, attracting trips from all the Administrative Regions.

In contrast, the centralities Alípio de Melo (1) and Tirol (37) have low coverage by the structuring road system. This data reinforces the classification of both as places in all indicators.

5. CONCLUSIONS

In this work, based on the travel flow data, 38 centralities for the capital of Minas Gerais were classified. Based on information on the origin, destination, reason, and volume of trips, from the OD Survey, information on distances travelled and percentages between neighboring and total origins were tabulated, with the support of formulas and geoprocessing. Such information was obtained from three indicators.

It was concluded that the application of the indicators of this methodological proposal showed that it is possible to classify the centralities based on the flow of urban travel, when associated with parameters of spatial analysis, answering, thus, the central question of the work. In turn, the hypotheses that (i) the origin of the trips, (ii) the extent of travel, and (iii) the percentage of attraction of the neighborhood, which allows the classification of centralities, proved true in face of the results.

Using the proposed method, it is possible to support its application in public policies, as it provides two important pieces of information. The first is the spatial location of the centrality, which allows the public manager to identify where the main centralities that need investments are located, directing urban and transport management. The second piece of information is the degree of influence of this centrality, which allows the manager to prioritize investments according to their objectives. As an improvement to urban planning and management processes, it is possible to point out the use of the method in the elaboration and monitoring of policies aimed at urban structure and centralities.

However, future work regarding the issue is still possible and necessary, notably through the application of the methodological proposal described in other Brazilian cities. There must also be reservations regarding the data selected herein, of trips with origin and destination in the capital and, in future works, the use of data originating in any city in the Metropolitan Region may present new results, contributing to the understanding of issues related to centralities.

REFERENCES

Belo Horizonte (2019a) Lei nº 11.181/2019, de 31 de agosto de 2019. *Aprova o Plano Diretor do Município de Belo Horizonte e dá outras providências*. Available on: <https://www.cmbh.mg.gov.br/atividade-legislativa/pesquisar-legislacao/lei/11181/2019> (access on: 08/20/2021).

Belo Horizonte (2019b) *Atividades econômicas*. Available on: <http://bhmap.pbh.gov.br/v2/mapa/idebhgeo> (access on: 02/17/2022).

Belo Horizonte (2020) *Bairros*. Available on: <http://bhmap.pbh.gov.br/v2/mapa/idebhgeo> (access on: 02/17/2022).

Brazil (2019) *IBGE Cidades*. Available on: <https://cidades.ibge.gov.br/brasil/mg/belo-horizonte/panorama> (access on: 02/17/2022).

Brazil (2020) Relação Anual de Informações Sociais - RAIS. Brasília – DF.

Cardoso, L.; G. C. Leiva; J. G. de Mendonça and D. A. Lessa (2020) *Descentralização urbana, mobilidade residencial e movimento pendular na metrópole belo-horizontina*. In: LOBO, C.; CARVALHO, P. F. B. Migração e a mobilidade espacial da população em Minas Gerais. Belo Horizonte: Letramento. p. 239-266. DOI: 10.29327/214826.1-9.

Cladera, J. R.; C. R. M. Duarte and M. Moix (2009) Urban Structure and Polycentrism: towards a redefinition of the sub-centre concept. *Urban Studies*, v. 46, n. 13, p. 2841-2868. DOI: 10.1177/0042098009346329.

Izaga, F. G. (2009). *Mobilidade e centralidade no Rio de Janeiro*. Tese (Doutorado) - Curso de Urbanismo, Universidade Federal do Rio de Janeiro, Rio de Janeiro.

Jayasinghe A. and T. Munshi (2014) "Centrality Measures" as a tool to identify the Transit Demand at Public Transit Stops: A Case of Ahmedabad City, India. *International Journal of Advanced Research*, v. 2, p. 1063-1074.

Jayasinghe, A; K. Sano and K. Rattanaporn (2017) Application for developing countries: estimating trip attraction in urban zones based on centrality. *Journal of Traffic and Transportation Engineering*, v. 4, n. 5, p. 464-476, 2017. DOI: 10.1016/j.jtte.2017.05.011.

Kneib, E. C. (2008) *Subcentros urbanos: contribuição conceitual e metodológica à sua definição e identificação para planejamento de transportes*. Tese (Doutorado) - Curso de Transportes, Universidade de Brasília, Brasília. Available on: <https://repositorio.unb.br/handle/10482/1765?mode=full> (access on 08/20/2021).

Leiva, G. C.; R. D. Orrico Filho and M. G. Oliveira (2019) (Des) metropolização ou descentralização da metrópole Belo-Horizontina/MG: análise do padrão de mobilidade por intermédio do diagrama de fluxos. *Anais do 33º Congresso de Pesquisa e Ensino em Transporte da ANPET*, p. 3366-3377. Available on: <https://anpet.org.br/anais/documentos/2019/Planejamento%20Territorial%20do%20Transporte/Transporte%20e%20Uso%20do%20Solo/6_579_AC.pdf> (access on 08/20/2021).

Lessa, D. A.; C. Lobo; L. Cardoso and B. A. Matos (2017) Transporte por ônibus em Belo Horizonte: acessibilidade e mobilidade espacial da população. *Anais do 21º Congresso Brasileiro de Transporte e Trânsito*. Available on: <http://files.antp.org.br/2017/7/6/transporte-por-onibus-em-belo-horizonte-acessibilidade-e-mobilidade-espacial.pdf> (access on 02/17/2022).

Lessa, D. A. (2019) *Mobilidade e acessibilidade ao transporte coletivo por ônibus: evidências e contradições no caso de Belo Horizonte - MG*. Tese (Doutorado) - Curso de Geografia, Universidade Federal de Minas Gerais, Belo Horizonte. Available on: <https://repositorio.ufmg.br/handle/1843/31654> (access on 08/20/2021).

Lessa, D. A. and C. Lobo (2020) Mobilidade e a atração de viagens de ônibus da área central de Belo Horizonte. *Revista Brasileira de Gestão Urbana* - URBE, v. 12. DOI: 10.1590/2175-3369.012.e20190229.

Liu, Z. and S. Liu (2018) Polycentric Development and the Role of Urban Polycentric Planning in China's Mega Cities: an examination of Beijing's metropolitan area. *Sustainability*, v. 10, n. 5, p. 1588-1602. DOI: 10.3390/su10051588.

Mattos, C. A. (2015) *Redes, nodos e cidades: transformação da metrópole latino-americana*. RIBEIRO, Luiz César de Queiroz. Metrópoles: entre a coesão e a fragmentação, a cooperação e o conflito. 2. ed. Rio de Janeiro: Letra Capital, 2015. p. 157-196.

Matsumoto, P. S. S.; R. C. Catão and R. B. Guimarães (2017) Mentiras com mapas na geografia da saúde: métodos de classificação e o caso da base de dados de LVA do SINAN e do CVE. *Revista Brasileira de Geografia Médica e da Saúde*, v. 13, n. 26, p. 211-225. DOI: 10.14393/Hygeia132618.

Mayorga, M. (2013) *Espacios de centralidad urbana y redes de infraestructura*. Tese (Doutorado) - Curso de Engenharia e Infraestrutura de Transportes, Universidade Politécnica da Catalunha, Barcelona. Available on: <https://www.tesisenred.net/handle/10803/128674> (access on 08/20/2021).

Mendonça Neto, W. L. and E. C. Kneib (2016) Centralidades urbanas e oferta de transporte público coletivo em Goiânia-GO, 2014. *Transportes*, v. 24, n. 1, p. 42-50. DOI: 10.14295/transportes.v24i1.916.

Minas Gerais (2013) Relatório Completo Pesquisa OD 2012. Belo Horizonte. Available on: <http://www.agenciarmbh.mg.gov.br/pesquisa-od-2012/> (access on 08/20/2021).

Monte-Mór, R. L. (2006) *O que é o urbano, no mundo contemporâneo*. Belo Horizonte: Universidade Federal de Minas Gerais – UFMG. 14p.

Pinheiro, J. M. (2014) *(Re) apropriando a centralidade na metrópole*. Dissertação (Mestrado) - Curso de Arquitetura e Urbanismo, Universidade Federal de Minas Gerais, Belo Horizonte. Available on: <https://repositorio.ufmg.br/handle/1843/MMMD-9UFP9S?> (access on 08/20/2021).

Raia Jr., A. (2000) *Acessibilidade e mobilidade na estimativa de um índice de potencial de viagens utilizando Redes Neurais Artificiais e Sistemas de Informações Geográficas*. Tese (Doutorado) – Curso de Engenharia de Transportes, Universidade de São Paulo, São Carlos. DOI: 10.11606/T.18.2000.tde-10112001-160812.

Ramos, F. R. (2004) *Análise espacial de estruturas intra-urbanas: o caso de São Paulo*. Dissertação (Mestrado) - Curso de Sensoriamento Remoto, Instituto Nacional de Pesquisas Espaciais, São José dos Campos. Available on: <http://mtc-m12.sid.inpe.br/col/sid.inpe.br/marciana/2003/04.14.11.38/doc/publicacao.pdf> (access on 08/20/2021).

Rauhut, D. (2017) Polycentricity – one concept or many? *European Planning Studies*, v. 25, n. 2, p. 332-348. DOI: 10.1080/09654313.2016.1276157.

Sat, A. (2018) Monocentric or polycentric? Defining morphological structure of Nuts – 2 regions of Turkey from 2000 to 2016. *Geographica Pannonica*, v. 22, n. 1, p. 1-13. DOI: 10.5937/gp22-15726.

Silva, K. A. A.; J. M. P. Cunha and G. M. Ortega (2017) Um olhar demográfico sobre a constituição da macrometrópole paulista: fluxos populacionais, integração e complementaridade. *Cadernos Metrópole*, v. 19, n. 40, p. 721-748. DOI: 10.1590/2236-9996.2017-4002.

Sposito, M. E. B. (1991) Centro e as formas de expressão da centralidade urbana. *Revista de Geografia*. v. 10, p. 1-18.

UFMG (2011) *Plano Diretor de Desenvolvimento Integrado da Região Metropolitana de Belo Horizonte - PDDI-RMBH*. Sumário Executivo. Belo Horizonte – MG.

Vilela, N. M. (2006) *Hipercentro de Belo Horizonte: movimentos e transformações espaciais recentes*. Dissertação (Mestrado) - Curso de Geografia, Universidade Federal de Minas Gerais, Belo Horizonte. Available on: <https://repositorio.ufmg.br/handle/1843/MPBB-6XRKL9> (access on 08/20/2021).

Villaça, F. (2007) *Espaço intra-urbano no Brasil*. 2. ed. São Paulo: Studio Nobel: Fapesp: Lincoln Institute, 379 p.

Zhong, C.; S. M. Arisona; X. Huang and G. Schmitt (2013) Identifying spatial structure of urban functional centers using travel survey data: a case study of Singapore. In: *Proceedings of The First ACM SIGSPATIAL International Workshop on Computational Models of Place*. p. 28-33. DOI: 10.1145/253488.2534855.

Zhong, C.; S. M. Arisona; X. Huang; M. Batty and G. Schmitt (2014) Detecting the dynamics of urban structure through spatial network analysis. *International Journal of Geographical Information Science*, v. 28, n. 11, p. 2178-2199, 2014. DOI: 10.1080/13658816.2014.914521.