Revista Nacional de
Gerenciamento de Cidades
ISSN eletrônico 2318-8472, volume 10, número 80, 2022

Study of Mobility Patterns in Metropolitan Region of Campinas, São Paulo, Brazil

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Gerenciamento de Cidades
ISSN eletrônico 2318-8472, volume 10, número 80, 2022

SUMMARY

The current model of Brazilian cities dependent on individual transport and the low coverage of collective systems in metropolitan regions has generated problems that make it difficult for the population to move and increase pollutant emissions into the atmosphere. This article aims to analyze mobility patterns and relate them to infrastructures and the urbanization process of the Metropolitan Region of Campinas (RMC). For methodological purposes, consultations were carried out on legislation, integrated urban development plans, master plans, metropolis statute and bibliographic review of scientific works on the themes, as well as a survey of the results of the Origin Destination Research, carried out in the region in 2011 and the use of geotechnologies (GIS). After document analysis and the calculation of indicators, it was identified that the pattern of urban-spatial organization in the region presents a strong socioeconomic polarization that directly affects mobility patterns and the absence of integration of public transport systems.

KEYWORDS: Mobility. Metropolitan Region of Campinas. Mobility patterns.

1. GUIDELINES

1.1 MOBILITY PROBLEMS IN METROPOLITAN REGIONS

The disorderly urban growth, together with the exponential increase in the vehicle fleet in recent decades, far above the capacity of existing infrastructure, today reflects the reality of citizens living in Brazilian cities and metropolitan regions. This lack of planning, together with the increase in the use of individual motorized transport, echoes in the standards and quality of urban mobility, generating several unfavorable aspects for the well-being of the urban population.

Mobility in Brazilian metropolitan regions, on a larger scale, has already presented the same problems found in large urban centers: sprawl of the urban fabric, major congestion, lack of safety in life, accidents, lack of integration with modes, among others. According to SANTOS et. al. (2015), Brazilian metropolitan regions represent about 80% of the metropolitan population and it is where commuting times for work reasons already reach the 2-hour mark, with an average time of 43-50 minutes.

Discussions on urban mobility have been the subject of several studies and events related to sustainability and environmental preservation, since the transport sector is responsible for approximately 40% of greenhouse gas emissions and other pollutants (WBCSD, 2021).

In this sense, studies that discuss the mobility problems faced in Brazilian urban centers are of great importance and must be linked to the search for measures and public policies that encourage the use of more sustainable and collective modes.

1.2 POLITICAL ASPECTS OF THE METROPOLITAN REGION OF CAMPINAS

The Metropolitan Region of Campinas (RMC), located in the State of São Paulo, was founded by State Complementary Lei nº 870, of June 19, 2000, being initially formed by nineteen municipalities and through Complementary Lei nº 1,234, of March 13 2014, there was the addition of the municipality of Morungaba.

The Metropolitan Region of Campinas is currently composed of twenty municipalities in São Paulo: Americana, Artur Nogueira, Campinas, Cosmópolis, Engenheiro Coelho, Holambra,

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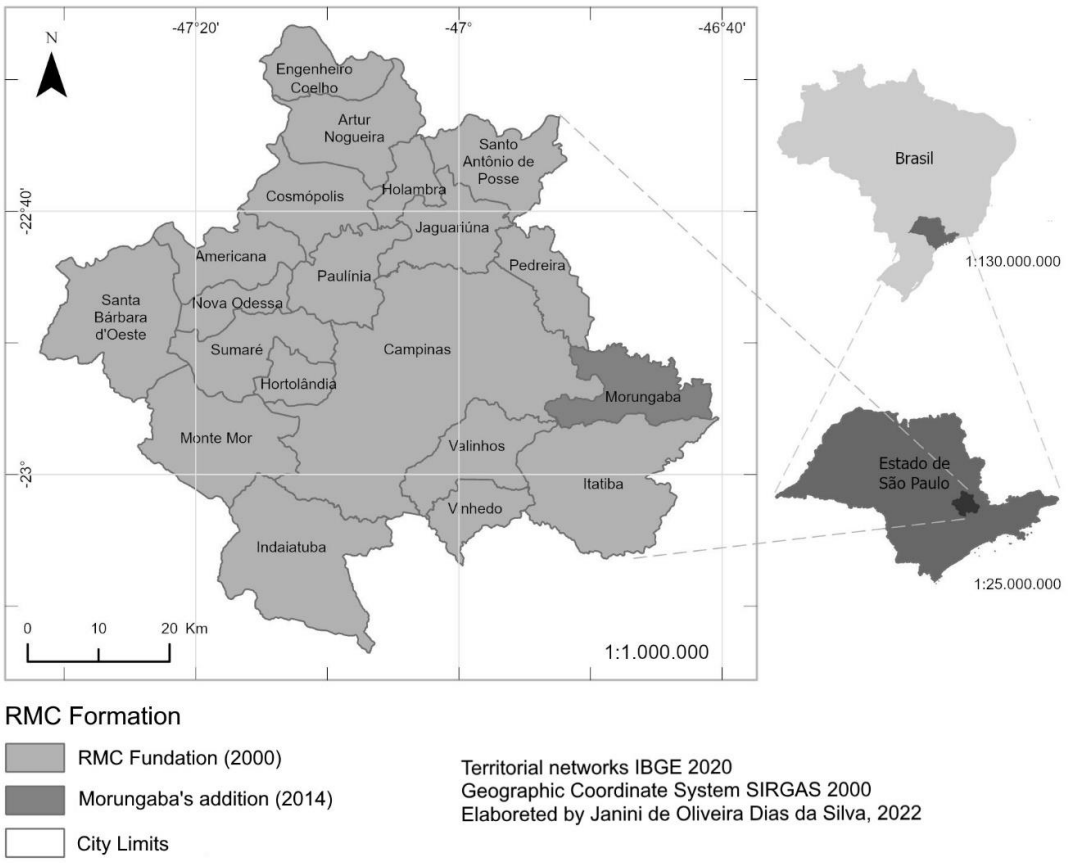
Hortolândia, Indaiatuba, Itatiba, Jaguariúna, Monte Mor, Morungaba, Nova Odessa, Paulínia, Pedreira, Santa Bárbara d 'Oeste, Santo Antônio de Posse, Sumaré, Valinhos and Vinhedo. It is the tenth largest metropolitan region in Brazil and the second largest metropolitan region in São Paulo.

Figure 1 – Formation of the Metropolitan Region of Campinas



Source: São Paulo (2000, 2014)

The RMC occupies a total area of 3,791 km² and has an estimated population of 3,231,033 inhabitants. The region is responsible for approximately 9% of the state's Gross Domestic Product (GDP) and 3% of the Brazilian GDP. It is one of the most important centers of research and technological development in the country. All cities in the region have a high municipal human development index (IDHM), making the RMC third in the ranking of the best metropolitan region in Brazil (SÃO PAULO, 2018).

The metropolization process of the RMC is recent, diversified and has developed linked to a very competitive road infrastructure, being served by important roads, railways and by the Viracopos International Airport, located in the city of Campinas, considered the second largest in the country in terms of cargo transport (MONTEIRO *et al*., 2020).

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1.3 HISTORICAL ASPECTS OF THE METROPOLITAN REGION OF CAMPINAS

The Metropolitan Region of Campinas is currently known by the title of "Brazilian Silicon Valley", due to its dynamism and vast economic activity. Having, since its foundation, its urban and economic developments related to the best transport and logistics systems (CAIADO and PIRES, 2006).

The city of Campinas was founded in the 1770s and a few years after its foundation, with the expansion in the demand for coffee in the country, the city became the first place in planting in the region. In 1868, with the inauguration of Companhia Paulista de Estradas de Ferro, Campinas became the largest railway junction in the empire, with rail connections to Jundiaí, São Paulo and Santos harbor. This factor was responsible for attracting large industrial and technological investments, in addition to other activities such as agriculture and agro-industry (MENDES, 2014).

Over the years, starting in 1970, with the industrial decentralization of Greater São Paulo, the Metropolitan Region of Campinas becomes one of the most important centers of attraction for São Paulo companies, bringing national and foreign investments due to its location, its infrastructure road and the proximity to the capital of São Paulo and the port of Santos.

With the expansion of industrial centers, road systems and, consequently, housing areas, Campinas, as the host city, developed a dynamism that reached neighboring municipalities, resulting in a large and dispersed urban sprawl. This process generated several clusters of cities connected by the urban area and interdependent both economically and in administrative matters (BAENINGER, 2001).

In the same period, there was a very intense urbanization process on the outskirts of Campinas, which culminated in the emergence of slums and irregular settlements in the southwest of the city, extending the poor population beyond the municipal limits towards the municipalities of Hortolândia, Monte Mor, Sumaré. , Americana and Santa Barbara D'Oeste (CAIADO and PIRES, 2006).

The conurbations found in the municipalities of the MRC were mainly due to the existing road structure in the place that facilitated the creation of industrial parks on the edges of the highways and later of housing settlements. The two largest conurbations currently exist are located in the southeast region towards Valinhos city and in the southwest region towards Sumaré, Hortolândia and Monte Mor. The latter represents a large peripheral area where most of the poorest population is located (CAMPINAS, 2014). Check figure 2.

The consolidation process of the RMC as the second industrial center of the State of São Paulo, attracted investments in the scientific and educational area, generating the structuring of a center with several technological activities highlighting the presence of important institutions such as Instituto Agronômico de Campinas, CPqD, Embrapa , Cati, and technology parks, such as Ciatec and Techno Park (Campinas); Tech Town (Hortolândia), Jaguari Center (Jaguariúna). And in the area of teaching and research support, the presence of renowned universities such as the State University of Campinas - UNICAMP and the Pontifical Catholic University of Campinas - PUCC (SANTOS JR. and PROENÇA, 2020) stands out.

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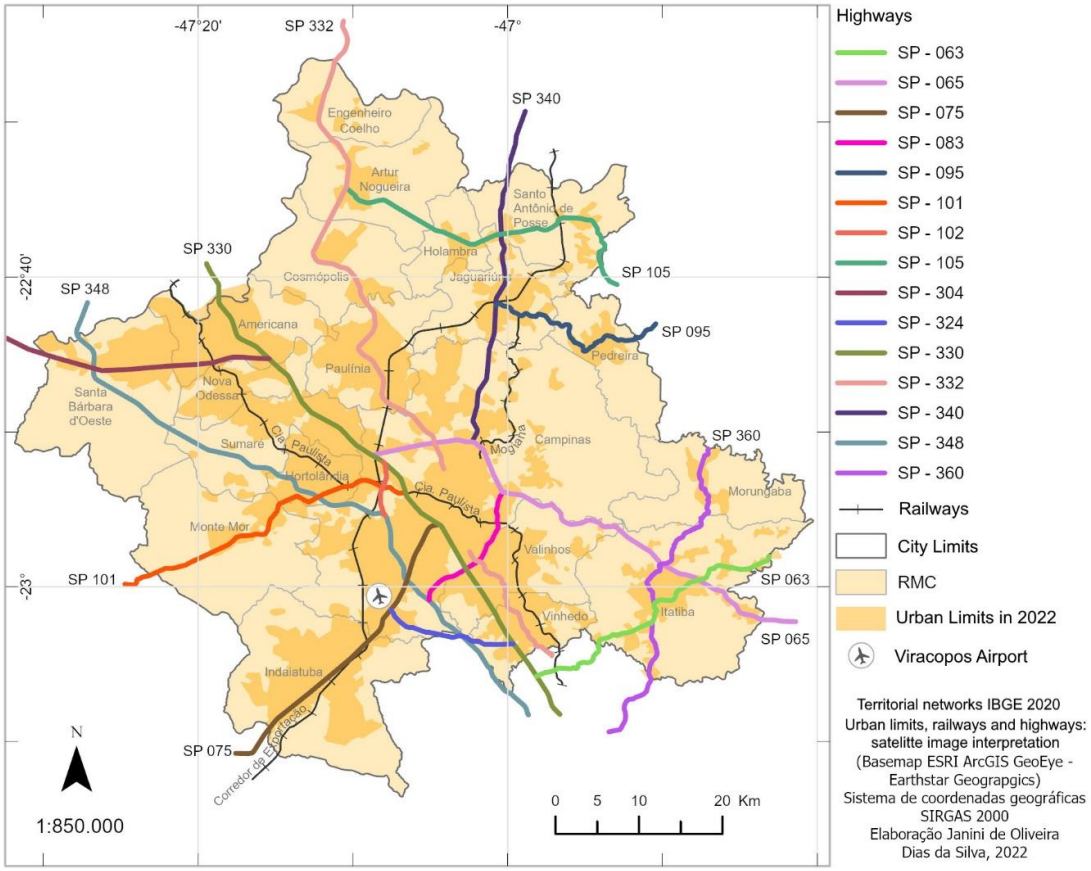
The intense processes of urbanization and industrialization that took place in the MRC caused very visible changes in the dynamics of cities. On the one hand, great potentialities and opportunities in relation to innovation and research activities were developed, but on the other hand, the absence of investments in social public policies and urban development accentuated the proliferation of slums, violence and poverty, revealing a growth pattern quite evil, which accentuates social inequalities (CAMPINAS, 2014).

1.4 EXPANSION VECTORS

The metropolitan territory of Campinas is consolidated by a dispersed and low-density urbanization: fragmented urban areas connected by highways that present themselves as linear axes of expansion, with rapid advancement of the urban fabric. Mainly with the increase in the presence of slums, industrial parks and residential condominiums along the highways, demonstrating a trend of urban-regional dispersion (SANTOS JR. and PROENÇA, 2020).

Figure 2 - Road, Rail and Urban Area Map of RMC



Source: Adapted by the author. São Paulo, 2018

1.5 THE ORIGEM DESTINO SURVEY

In 2011, the Origem-Destino Survey conducted in the Metropolitan Region of Campinas was published by the Metropolitan Transport Department (STM). This research aimed

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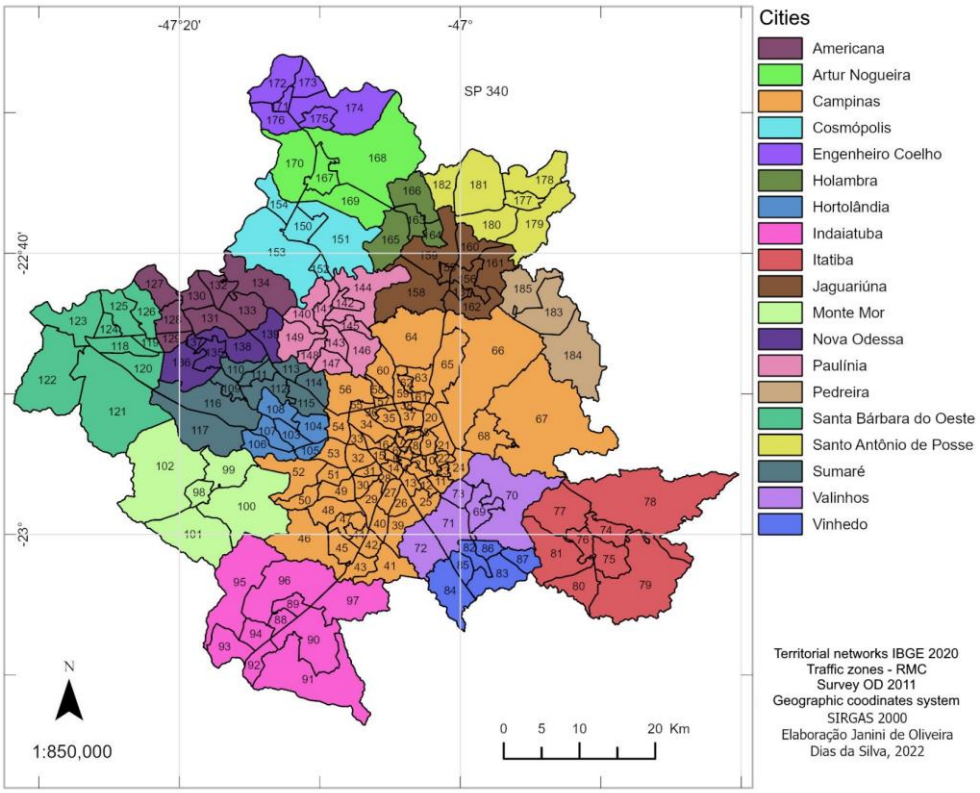
to collect information about the displacements carried out by the population within the metropolitan territory on a typical working day. The collected data presented in the report enable urban planning and mobility studies and allow the projection of future scenarios (SÃO PAULO, 2012).

The Origem Destino Survey presents a zoning for the 19[1] municipalities that made up the region at the time. In this research, 185 traffic zones were presented, which are defined based on their urban and socioeconomic homogeneity, in addition to other technical criteria. These zones are the basic territorial unit for which the statistical validity of the information is guaranteed, illustrated in Figure 3.

According to the O/D Survey Report, the criteria used to define the traffic zones were: compatibility with the zoning of the O/D Survey 2003; compatibility with city limits; and compatibility with the limits of census sectors of the Brazilian Institute of Geography and Statistics – IBGE in 2010. The zoning also considered the homogeneity in the use and occupation of urban space, the existing and future transport system, urban equipment, barriers physical and empty areas.

Of these 185 traffic zones defined for the MRC, 128 were surveyed because the others did not meet the criterion of a minimum value of 515 households. In relation to the research carried out in 2003, there was an increase of 38 traffic zones, that is, in a period of 8 years, there were expansions of urban perimeters and also changes in the use and occupation of the already consolidated territory.

Figure 3 – 2011 OD Survey Zoning Map



Source: São Paulo (2012)

[1] Morungaba city was added to the MRC in 2014 through Complementary Law 1234/2014.

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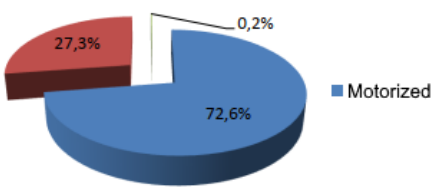
The research pointed out that around 4.7 million trips are carried out daily in the metropolitan region. About 107,000 trips are from or outside the region, leaving 4.6 million internal trips.

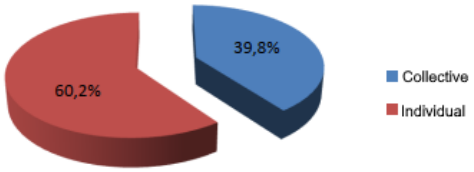
Of the total trips (4.7 million), around 72.6% (3.4 million) are carried out by means of motorized transport and of these, around 60% (2.07 million) take place by individual modes, pointed out in Figure 4. According to the report, there was an increase of about 8% in the number of trips carried out by individual motorized transport, in relation to the survey carried out in 2003 (SÃO PAULO, 2012).

Figure 4 - Resultados da Pesquisa OD 2011 da RMC

Transport mode	Travels	%
Motorized	3.444.536	72,6%
Non-motorized	1.294.187	27,3%
Others	7.624	0,2%
Total	4.746.347	100,0%

Motorized transport modes	Travels	%
Collective	1.372.274	39,8%
Individual	2.072.261	60,2%
Total	3.444.536	100,0%





Source: São Paulo, 2012

Regarding economic factors, it was found that the use of motorized collective transport modes and non-motorized modes are more used by the lower classes. In addition, the greater use of motorized individual modes is related to the increase in income.

The research also presents several results regarding travel motivation, time spent in each mode, mobility index (trips/person/day), percentage of gender participation in different modes, mobility rate relating to age group in different modes, rate of of mobility related to the interviewees' education, immobility index, use of non-motorized modes, among other data that deserve to be used and discussed in other works.

1.6 INTEGRATED URBAN DEVELOPMENT PLAN

The Integrated Urban Development Plan (PDUI) is a legal instrument for metropolitan and regional planning and management, provided for by the Metropolis Statute (Federal Law 13.089/15). This document aims to define guidelines, projects and actions that guide the urban, economic and social development of the Regional Unit, in addition to providing bases for joint action by the three levels of government and society, aiming at sustainable development and the reduction of inequalities (SAO PAULO, 2018).

The PDUI of the Metropolitan Region of Campinas is made up of representatives from AGEMCAMP (Agência Metropolitana de Campinas), the Secretariat of Regional Development of the State of São Paulo and the State University of Campinas (UNICAMP).

The results obtained from analyzes carried out in 2018 demonstrate that the territory of the region has a disordered occupation of the soil and has a radial configuration that is inadequate for urban dynamics. Regarding mobility, there are deficiencies in the planning of collective public transport, which were identified as unsatisfactory, having the need for integration with municipal and intermunicipal lines and relationship with land use, as they do not serve several areas of social housing.

The road structure, although well structured, presents intense and unsafe traffic due to the large volume of dangerous loads. Moreover, there is a predominance of the use of individual transport over the collective, due to the precariousness and distances between work and home, which generate an increase in atmospheric pollution.

An intense interdependence of the municipalities with Campinas was verified, due to the concentration of activities such as work, education, health and commerce. This dependence generates large pendular movements, carried out mostly by the low-income population.

Finally, the main weaknesses related to mobility, raised in the diagnosis, are directly linked to land use and occupation policies. Demanding, then, interventions of the governmental spheres in the search of solutions.

2. OBJECTIVE

This study is derived from the initial phase of a master's dissertation carried out by the Graduate Program in Architecture, Technology and the City of the State University of Campinas. And it aims to present and relate the urbanization processes of the Metropolitan Region of Campinas with indicators that identify current mobility patterns.

3 METHODOLOGY

To achieve the objectives of this study, a consultation was carried out on local legislation, integrated urban development plans, master plans, metropolis statute and bibliographic review of scientific works on the themes "mobility indicators" and "Formation of the Metropolitan Region of Campinas".

Data from the 2011 Origin Destination Survey, coordinated by the Metropolitan Transport Department (STM), the São Paulo Metropolitan Company (METRO) and the Metropolitan Urban Transport Company (EMTU) were used. After tabulating the data, spatial analysis techniques and geotechnologies (GIS) were used.

3.1 SELECTED INDICATORS

Based on a review of methods that use mobility indicators and on the data obtained by the Origin Destination Survey of 2011, four indicators were defined and calculated that illustrate the existing mobility patterns in the Metropolitan Region of Campinas, these are:

- Motorization Index (number of cars per inhabitant);
- Average Monthly Income (in reais);
- Number of trips carried out by individual modes per inhabitant;

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ISSN eletrônico 2318-8472, volume 10, número 80, 2022

• Number of trips made by collective modes per inhabitant.

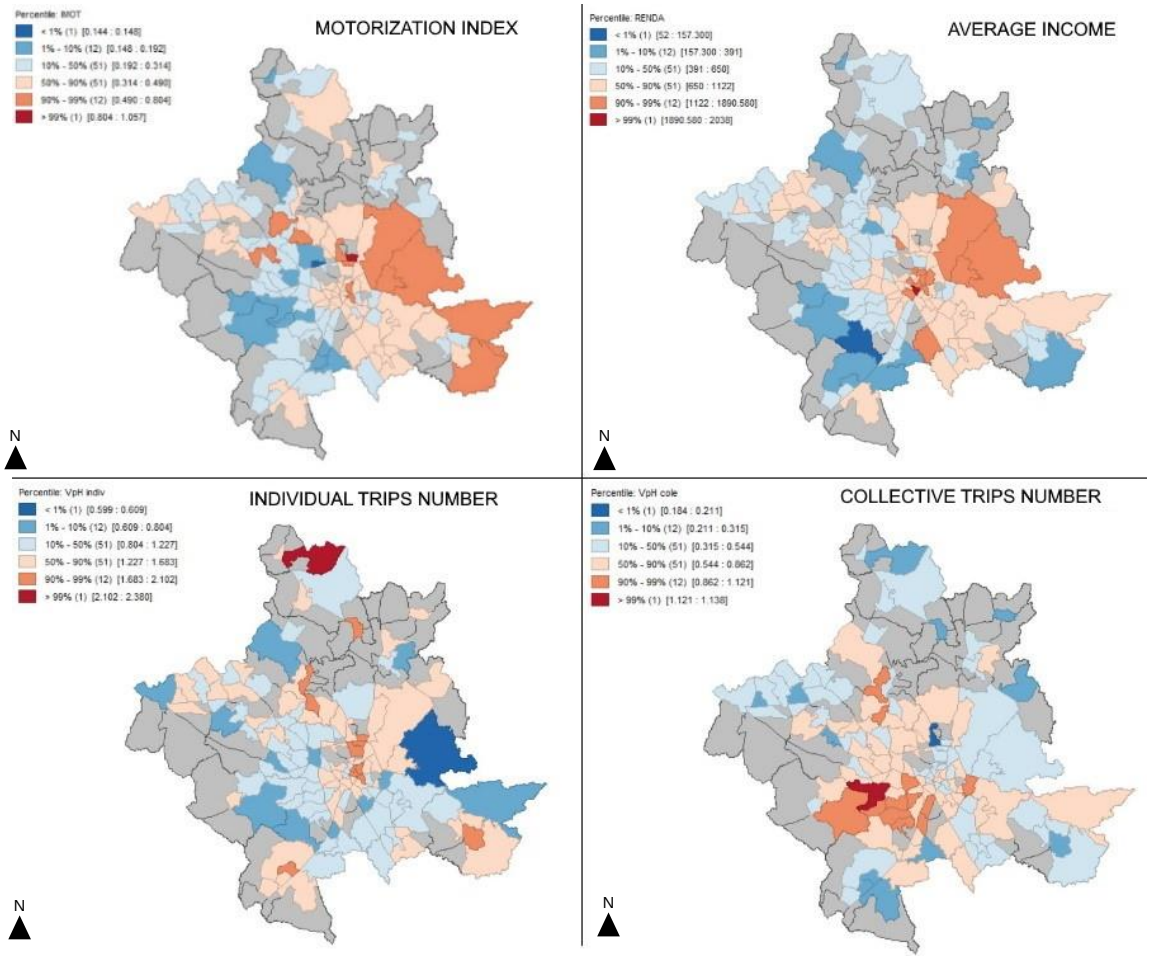
3.2 SPATIAL ANALYSIS

After calculating the indicators, geoprocessing (GIS) and spatial analysis (GeoDa) software were used for spatial distribution of the results obtained. The results were divided into percentiles and presented in diagrams.

4. RESULTS

Once the results of the calculations of the selected indicators were obtained, the following data presented in the percentile diagrams were obtained:

Figure 5 – Percentile diagrams of calculated indicators



Source: Developed by the authors, 2022.

From the observation of the data spatially allocated in the respective traffic zones, it is noted that the spatial polarization identified in the bibliography, initiated from the urbanization process of the region, continues to exist. And it divides the MRC into a pole with a high concentration of income, located to the east, and a pole with low income, located to the west of the MRC.

Income ends up becoming a factor that influences the rate of motorization (number of cars per inhabitant) and also the patterns of displacement. It is noted that the region that concentrates greater purchasing power also has a higher rate of motorization and presents greater numbers of individual trips.

On the other hand, there is also a high number of individual trips in the most extreme areas of the region, which reflects the low coverage and efficiency of metropolitan public transport.

The results also show that most of the trips carried out by collective mode are made by the poorest population that originates from the areas located in the southwest of the region. It was expected by the authors that the denser central areas of the city of Campinas would present higher rates in the use of public transport, but the indicators showed opposite results to what was expected.

From these preliminary results, it is clear the need to deepen the studies so that new discussions can be raised and debated.

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