The influence of socio-spatial segregation on urban mobility indicators: the case of Belém – PA

A influência da segregação sócio-espacial nos indicadores de mobilidade urbana: o caso de Belém - PA

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ABSTRACT
The article discusses how the suburb socio-spatial segregation influences the urban mobility of a population, using Belém-PA, Brazil as a case study. The methodology started from the integration of socioeconomic and transport microdata for areas containing selected household and their spatial location, that were obtained from the 2010 Brazilian Census. In the spatial analysis of these microdata, the variation in the average commute time for each resident was observed, given the geographic location of the central business district (CBD) and other commercial and industrial agglomerations. In the results, the generated maps, compared to the on-site visit, allowed to identify the subareas with major and minor mobility and the priorities for investment in transport infrastructure.

Keywords: Segregation, Mobility, Indicators, Influence.

RESUMO

O artigo discute como a segregação socioespacial da periferia influencia a mobilidade urbana de uma população, tendo como estudo de caso Belém-PA, Brasil. A metodologia partiu da integração de microdados socioeconômicos e de transporte para áreas contendo domicílios selecionados e sua localização espacial, obtidos a partir do Censo Brasileiro de 2010. Na análise espacial desses microdados, observou-se a variação do tempo médio de deslocamento de cada morador, dada a localização geográfica do distrito central de negócios (CBD) e demais aglomerações comerciais e industriais. Nos resultados, os mapas gerados, comparados com a visita in loco, permitiram identificar as subáreas com maior e menor mobilidade e as prioridades de investimento em infraestrutura de transportes.

Palavras-chave: Segregação, Mobilidade, Indicadores, Influência.

1 INTRODUCTION

In the last decades, an intense and disorderly urban expansion has been observed in large Brazilian cities, conditioned by population growth and the low cost of living in places further away from the urban centers of commerce and services. In this way, areas increasingly distant from the urban center began to house countless low-income families, who found better economic housing conditions, but with deficient transport infrastructure, making it difficult to move on foot or by bicycle, making the dependence on motorized transport something inevitable. These families have more difficulties than those in the same condition, who live in more consolidated areas of the city, a fact proven in several studies, such as: health care (Azevedo, 2009), school performance (Cunha *et al.*, 2009; Cunha and Jiménez, 2009; Flores, 2006 and Torres *et al.*, 2005) and the insertion in the labor market (Cunha and Jakob, 2010).

For the low-income population in the distant suburb, with low accessibility, investments by public authorities in public transport were not observed in the same proportion as the population's need, as opposed to automobiles, in which the public authorities, notably, in recent decades, offered facilities for importing and financing vehicles, encouraging the high consumption of this mode of transportation (Paviani, 2013). In this way, in the distant suburb, the population, which mostly uses public transport as means of transportation, needs to overcome the generalized travel cost, notably, influenced by the fare, distance and travel time. The scenario is one of long traffic jams, scarce and precarious bus fleets, in addition to the poor conditions of road infrastructure in most of these suburban areas.

It should be noted that, in the Brazilian urbanization model, the main commercial center of the city is not only the main area of commerce and services, but also of employment, therefore, it attracts not only a big number of those who live in the neighborhoods closer, such as those who live in distant suburbs, who face, daily, various difficulties to reach their destination and return to their homes, to reach the opportunities found in the city center (Deák, 2015). In this context, it is considered that the distant suburban population suffers negative impacts when living far from where the major employment opportunities are found, including time wasted in traffic, which could be used for the qualification of these people, increasing access opportunities in the labor market. It is important to note that there are also commercial and industrial sub-centers in peripheral areas, but with much lower job offers than that in the central business district and surrounding area (Costa *et al*., 2020).

For Domingues (1994), this suburban dependence related to the urban center encourages what he calls commuting inhabitants, that is, people who live in the suburb, but have their daily needs and opportunities in the urban center. This daily movement, increasingly intense between the distant suburb and the urban center, is one of the biggest reasons of the problems that urban mobility has today in big cities. Shortly, the center, occupied by upper-income levels in society, concentrates most of public and private urban services. It is important to understand that the urban mobility crisis has caused a decrease in the life quality of the population living in distant suburbs, due to the difficulties in accessing basic services that the city offers, such as hospitals, schools, police stations, among others. And "there is also a cultural prejudice, with regard to how these people start to see the world and what their objective awareness of their socially and spatially segregated state is" (Negri, 2008: 138).

The suburb, occupied by the lower-income levels of society, is poorly attended by both private and public services and, in most cases, has difficulty in accessing the facilities in the center, through a public transport system, which characterizes a situation of socio-spatial segregation, in which mobility is presumed to be a highly relevant factor within this process (Villaça, 2004). Thus, this article sought to contribute to this discussion, through two existing suburban situations in the city of Belém do Pará, Brazil.

Considering an integrated demographic database of areas containing selected household and their spatial location, that were obtained from the 2010 Brazilian Census, use of ground and urban mobility, adopting a micro-analytical spatial analysis of individuals living in the above-mentioned areas of selected households, the study

reflected the social situation of these individuals with travel time to workplace as a variable. On the other hand, therefore, the central question that guided this study, which focused on a practical situation of travel time in public transport, was the following: How does the socio-spatial segregation of the distant suburb affect urban mobility?

As a hypothesis, there is the fact that the major growth of socio-spatial segregation through distant suburbs is having a negative impact on urban mobility indicators and, thus, the issues of socio-spatial segregation and the people's freedom of movement with quality and the effective reach to all the benefits that the city can provide to them, should be the object of action guidelines and investments in urban infrastructure, to achieve a fairer and more environmentally sustainable city.

The article is structured with the theoretical reference, containing the main categories of analysis: socio-spatial segregation and urban mobility; followed by the methodological approach, with two fundamental steps: the formation of the database and the implementation of the spatial microdata model; ending with the case study.

2 THEORICAL REFERENCE

In general, urbanization in Brazil, and particularly in its metropolitan areas, has assumed a standard defined by social, demographic, economic and environmental segmentation, and differentiation. This pattern is also characterized by the low urban life quality and high physical growth, suburb expansion and all the consequences that this implies deficiencies in urban infrastructure and social facilities; production of infrastructure urban voids; speculative ground retention, among others. Not only the processes of production and ground appreciation for housing purposes, but also those related to the location of economic activities have decisive impacts on the urban form, influencing its expansion, its socio-spatial differentiation, and the mobility of the population (Bourdieu, 2003).

The issue of socio-spatial segregation and urban mobility are inserted in a larger political context in which the quality of life of a significant portion of the population is being compromised by the growing of obstacles to urban motion (Gottdiener, 1993). And, in the case of urban mobility and its intrinsic relationship with urban expansion, several studies have shown the intensification of the processes of socio-spatial segregation of the population (Matos, 1994; Rigotti and Rodrigues, 1994; Lago, 2000 and Rodríguez, 2007).

2.1 URBAN SOCIO-SPATIAL SEGREGATION

Brazilian cities, like many others located in the developing world, are profoundly unequal in spatial terms, which constitutes the manifestation in the territory of profound social inequalities. The study of socio-spatial segregation in cities starts from an analysis of urban evolution up to the present day, as segregation is not a static point that emerged in a single moment, but a process of social fragmentation resulting from the development of cities that occurred in **many ways** in every place in the world. It is important to understand that class-based society historically precedes the origin of urban space itself (Singer, 1973), that is, cities were already born socially segregated. In the case of capitalist cities, in addition to social segregation, it is also spatial, reflecting the complex of class-based structure society. Thus, socio-spatial segregation was accentuated due to population growth within the urban space, which expanded to suburban areas.

The process of socio-spatial segregation did not occur randomly, with standards of residential segregation, for example, which developed over time and can be observed in the models of Kohl, Burgess and Hoyt (Burgess, 1925; Hoyt, 1939 and Maerivoet e de Mor, 2005). Kohl's nineteenth-century model expressed the spatial distribution of social classes in European cities, where the central region (location of important urban and financial institutions and commerce) was dominated by the upper class and the distant suburb region was occupied by the lower class. Burgess' model was based on northern American cities in the 1920s, where the lowest income class is the one located in the downtown area of the city. This is because in this period the evolution of automobile technology allowed more mobility for the upper-income population, which moved away from the lower-income population in search of better housing. Finally, Hoyt's 1939 model suggested a sectoral standard from the center, rather than circles around the center, indicating that the higher status population settled in areas with more amenities, which were located around the main access roads to the urban center, thus, the rich continued to enjoy the benefits provided by the center and remained distant from the poor population (Correa, 1989).

In Brazil, as well as in Latin America, it was Kohl's model that developed within the urban space, which does not mean that there cannot be another model in the same urban space, the very concept of socio-spatial segregation, refers to the different income classes concentrated in different regions of the cities, with the upper class concentrated in the central region and the lower class concentrated in distant suburban areas, but without there being class exclusivity in each space (Kowarick, 2000). As an example, the

southern area, in Rio de Janeiro, despite the existing favelas, in general, is the region with the highest concentration of rich people in the city. Thus, Villaça concludes that what will define the class segregation is the concentration of one of it on the other in a certain space.

It is important to address that, in recent decades, socio-spatial segregation has been accentuated due to the intense urban expansion that has been taking place in large cities, which according to Batty et al. (2003), caused high density in the urban center, which raised land prices in the region, leading the low-income population to seek more and more distant places to settle down. Jargowsky (2001) understood urban expansion as an exclusionary growth, in which the segregation between rich and middle class from the poor is accentuated, contributing to the social exclusion of this last group. Consequently, exclusion concentrates wealth in the best sectors of the city, leaving the low-income population isolated socially and geographically in the undesired sectors of the city.

For Santos and Ferreira (2016), the accentuation of socio-spatial segregation is also caused by relationships between the urban space producing agents and the development of motorized transport modes, with the capitalist system favoring the upper income classes, while the low-income population is forced to isolate themselves in regions of precarious access, in addition to being frequently relocated to increasingly unwanted regions of cities. In this context, socio-spatial segregation is not just about differences related to location, but also about the difference in opportunities, the quality of public services and the infrastructure necessary to have a good quality of life.

2.2 URBAN MOBILITY AND INDICATORS

Law No. 12.587/2012 (Brazil, 2012), which established the guidelines of the National Policy of Urban Mobility, in its Article 4th considers urban mobility as the condition in which the displacement of people and cargo in the urban space takes place. In the current organization of urban life in the capitalist city, composed by center and suburb, people perform their activities in different places. Based on this observation, space and time become determinants of transport demand, permeated by the heterogeneity of the origins and destinations of urban displacements of the population: the work groups determined by the economic space and the population groups determined by the residential social space.

The spatial dimensions of mobility get a social significance when the movement that drives people daily from the suburb to the center is analyzed. Alongside time and cultural practices, work is at the forefront of human behavior, as it represents a time spent

due to transport. Transport has an important, often ignored, influence on socioeconomic issues, which can be seen as the respiratory and circulatory system of the urban economy; because it contributes to the distribution of labor, goods, and services in the industrial and commercial centers of economic space. In consequence, access to public transport, of course, has a great influence on the distances to work in industrial and commercial centers and, therefore, on possibilities of work for people living in suburban areas.

In a sociological analysis, it can be thought that workers displacements are more penalized by time than by the family budget expense. Therefore, the economic development of a country is measured by the speed and density of displacement of people, goods, and services in its organization. This displacement presupposes that an effort and a certain period between the departure and arrival times require a cost, called transfer cost, which must be considered in productivity. The word production, in the economic sense, involves any activity that generates utility and, consequently, creates value. In urban public transport by bus, for example, a series of problems can be seen that lead to the deterioration of service levels offered to users and that negatively influence both the citizens' quality of life and the levels of economic, social, and cultural production.

Given the above, it can be assumed that the economic and social development of a place is measured by the speed and density of displacement of people, goods, and services, that is, by mobility, reflecting on people's quality of life. The question is how to measure mobility, which has been processed through a set of indicators to evaluate interventions in urban space. Studies to define urban mobility indicators are several and diverse (Banister et al., 2000; Costa et al., 2004; Costa, 2008). In general, the proposed indicators are based on three dimensions: physical-environmental, economic and by grouping: population; of activities, or related to groupings by linear extension or area.

3 METHOD

The methodology was developed in two steps. The first stage dealt with the assembly of three maps or thematic cartograms, all of them using the QGIS program (Cavallini, 2007):

a) Spatial distribution of household income by census sectors, to evaluate socio-spatial segregation in the municipal territory;

b) Spatial distribution of basic road infrastructure and main public transport routes; and

c) Spatial distribution of the percentage of people who spend an average of two or more hours commuting, by weighting areas, which represents the indicator that relates

quality of life with urban mobility: the higher this percentage, the worse is the situation.

This last indicator was obtained using microdata from the Demographic Census 2010, performed by the Brazilian Institute of Geography and Statistics (IBGE). The microdata records the individual data contained in the sample questionnaire of all residents in permanent private households who were sampled. For this reason, it represents a very detailed portrait of reality. The microdata is available by the Brazilian Institute of Geography and Statistics – IBGE (*https://www.ibge.gov.br*) in "txt" format. For them to be tabulated and analyzed, the R statistical program was used.

Operationally, the data were grouped into the so-called weighting areas, which are areas that aggregate enough residents for the sample data to be statistically representative. These weighting areas constitute territorial units with some socioeconomic similarity among their residents. Then, the weighting areas were mapped using the QGIS program and, subsequently, the corresponding statistical data was assigned to each one of them. Finally, through the same program, the weighting areas were classified into four categories of the investigated indicator, intending to perform the analysis of the spatial distribution of the results.

Given the results in a GIS environment, they could be compared with on-site records of locational situations of urban infrastructure and transport. Areas with the most critical results of the urban mobility indicator were selected and the conditions of the road infrastructure and public transport were observed, thus validating the results obtained, using the photographic record as the usual tool. The proposed methodology can be implemented in any region to show the evaluation of urban mobility, relating it to socio-spatial segregation. Another possibility is to evaluate future scenarios, given the impact of new investments in terms of better connectivity or service by urban transport systems.

4 CASE STUDY

The case study took place in Belém – Pará, which, as well as other large population concentrations in Brazil, showed a strong expansion of the urban area in recent decades. Part of this expansion has been taking place in a dispersed way, with the emergence of low-density housing areas or isolated from the preexisting urban area, configuring urban fragmentation, where many residents move daily to the CDB and surrounding area.

4.1 SOCIO-SPATIAL SEGREGATION IN BELÉM

The municipality territory of Belém is divided into two parts: a continental and an insular one. It is in the continental area that most of the population and almost all economic establishments are concentrated, and, for this reason, the analysis of this article focuses on the continental and on one of the islands that compose the municipal territory - Caratateua - spaces where the vast majority of daily trips household-to-workplace occurs. In 2010, nearly 1,400,000 people lived in the capital of Pará, corresponding to 18.4% of the state's population.

The first standard of socio-spatial segregation can be observed within the First Property League of Belém (a circle sector shape area with a radius of a league in length in a straight line from the original city core- on the shores of the Guajará Bay - by means of a Sesmarias Donation Letter donated by the Portuguese Crown, in 1627, to the Municipality Council of Belém), between the highest areas where the largest concentration of high-income families in the municipality is located and the poor families living in former floodplain areas, currently urbanized, located in the surroundings, which, as the name implies, are places with lower altitudes, close to sea level, where the infrastructure presents a higher or lower level of precariousness, some of which suffer with flooding during rainy season.

The second standard of socio-spatial segregation is the classic center-suburb, where the distant suburb (areas far from the First League, as shown in Image 1a), despite having a great diversity of residential areas, generally presents lower quality infrastructure than that existing in the high areas of the First League. Most of the population living in the suburb is low-income.

The third standard of socio-spatial segregation occurs inside distant suburb of Belém, which houses of diverse socioeconomic groups, due to the emergence of gated housing developments, where people with higher incomes live and are provided with security and comfort. These housing developments share the space with people with lower incomes, who live in the surroundings. This standard of socio-spatial segregation is presented in Image 1a, that shows the distribution of average household income by census tract, in the analyzed area.

This process of urban decentralization ended up bringing difficulties in the daily trips, because despite people moving to the distant suburb, the urban center still concentrates the greatest opportunities for employment, commerce, and services, bringing

serious mobility problems to the region, such as the long traffic jams on the main access roads to the city center.

4.2 SOCIO-SPATIAL SEGREGATION VERSUS URBAN MOBILITY

Image 1b shows a cartogram with the percentage spatial distribution of people who spend an hour or more to get to work. Almost all the weighting areas belonging to the class with the lowest percentage are located within the First Property League of the municipality of Belém. This can be explained by the fact that it is in this area that are most of the establishments of commerce and services in the city – therefore, the largest spatial agglomeration offering occupations –, which also includes the main commercial center, in consequence constituting the most important urban center.

On the other hand, all weighting areas located in the two classes with the highest percentages – are in the distant suburb, despite the presence of some important economic centralities, such as the subcenters of Icoaraci and Entroncamento and the Industrial District of Icoaraci. It can be seen, then, in a structural context, that it is the center-suburb segregation that influences the context of urban mobility, due to the increase of commuting time, due to the concentration of economic establishments within the First Property League. However, the socio-spatial segregation inside First League, between high and low areas, is little influenced by travel time.

At a more local scope, inside of distant suburb, as on-site validation, there are two selected areas, where critical mobility situations were observed (see Image 2): in Caratateua Island (1) and in an intermediate area of the suburb, on the margins of a large urban transport corridor, called Av. Augusto Montenegro (2). In these areas, the presence of another factor that influences travel times was noticed: the quality of road infrastructure and public transport routes. It can be seen, comparatively, in Images 3a and 3b, the road network and the scarce public transport network. This factor is related to socio-spatial segregation within the suburban space. The rarefied infrastructure and the low range of spatial service of public transport network make the average commuting time higher.

Image 1: a) Average household income by census sector and b) Economic active people who spend more than an hour commuting in weighting areas
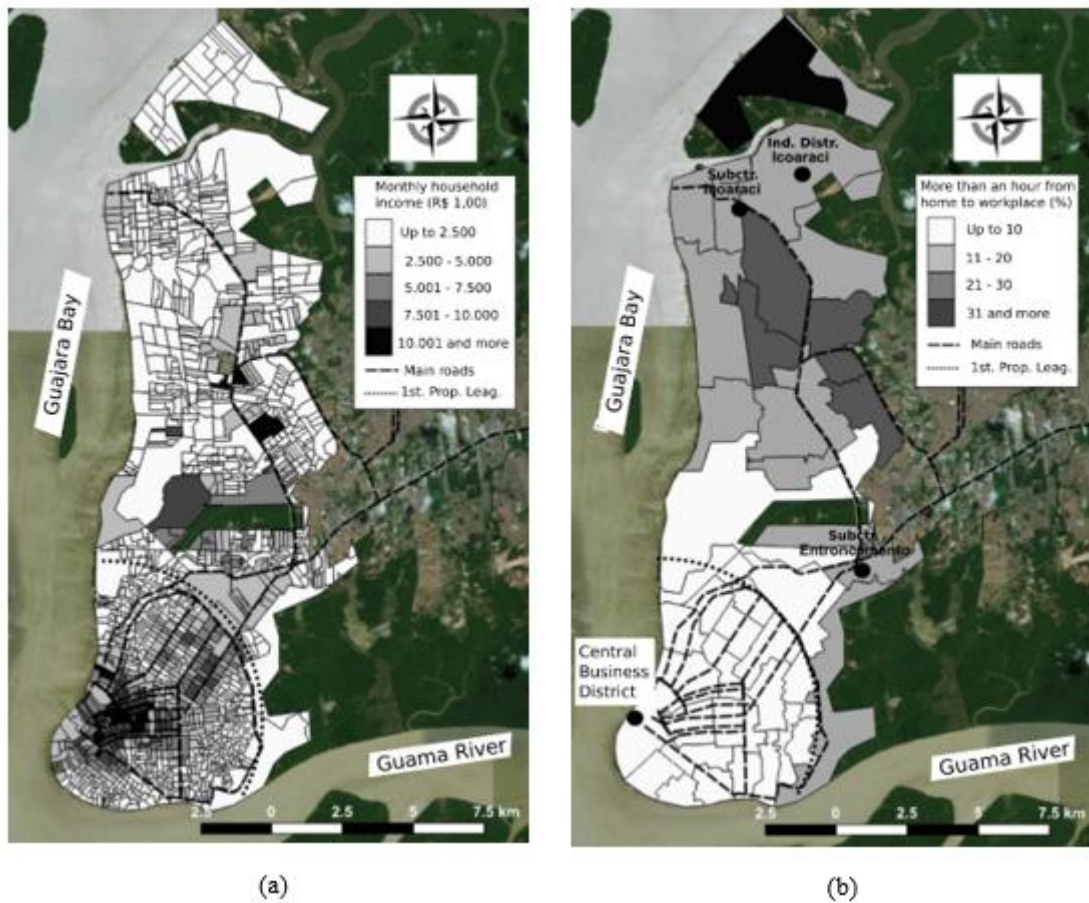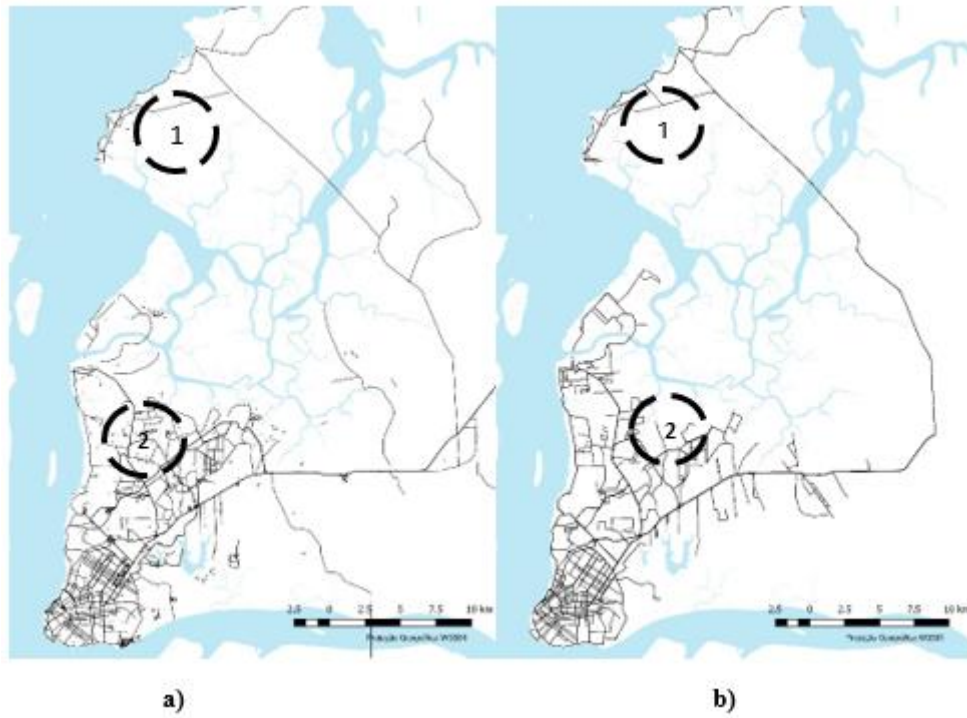

(a)　　　　　　　　　　(b)

Source: Authors, 2018; based on census of IBGE (2010).

Image 2: Selected weighting areas for on-site verification of the conditions of socio-spatial segregation, infrastructure, and public transport service
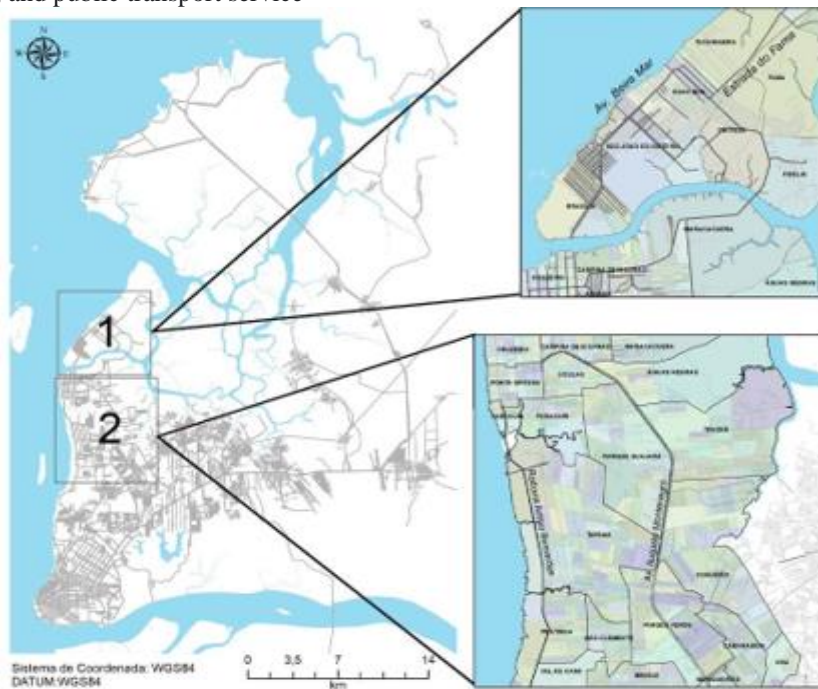
Source: elaborated by Rendeiro, 2018, based on *Google Maps*.

Image 3: a) Road Network and b) Public Transport Network in areas (1) and (2) respectively

a) b)

Source: elaborated by Rendeiro, 2018, based on *Google Maps*.

Image 4: Images of areas (1) and (2), respectively

Source: Authors, 2018. Images of 27/04/2018.

The on-site verification of the conditions of socio-spatial segregation on the areas (1) and (2) selected, allowed the visualization of the conditions of the road network and transport. Image 4 attests to these conditions as compatible with the situations verified in Images 1 and 3, validating the hypothesis that the socio-spatial segregation of the distant suburb influences urban mobility, permeated by precarious road infrastructure and poor conditions of public transport service. It should be noted that the average travel time is also affected by walking to public transport access points, increasing the entirely travel cost.

5 CONCLUSION

The hypothesis that socio-spatial segregation has an influence on urban mobility indicators – in particular, on the average travel time from home to work – proved to be plausible. Center-Suburb segregation is the main factor in this regard, due to the long distances between homes located on the suburb and the large concentration of economic establishments in the center. However, another socio-spatial segregation of a more local context, which occurs in the suburb context, also interferes with the indicator in question: in the results, the maps generated, compared with the on-site visit, allowed to identify in selected areas the mobility being affected by the scarcity of road infrastructure and the lack of public transport services, making the priorities for investment in road infrastructure and transport crucial.

Increased travel times on public transport towards the suburb area, associated with the predominance of low-income population involved and the dependence on the center for its main activities, refers to the urgent need of public authorities, especially in the municipal and state spheres, to initiate an effective economic decentralization policy, with the stimulus for creation of new economic subcenters or the strengthening of the existing ones. It is also of fundamental importance to improve the infrastructure in places where it is most precarious, in addition to the necessary articulation between local transport modes with an integrated trunk transport system, in the case of Belém, a system is under construction: the Bus Rapid Transit - BRT.

In conclusion, the urban development model of Belém must be rethought, expanding spaces for its economic activities, integrating them in a sustainable way, as a form to reducing spatial inequalities, with a positive effect on reducing socio-spatial segregation and improving the indicators of urban mobility.

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