TRAVEL BEHAVIOR AND URBAN MORPHOLOGY IN LOW-INCOME AREAS IN THE URBAN AGGLOMERATION OF FLORIANÓPOLIS, BRAZIL

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ABSTRACT

Difficulties of urban mobility for low-income groups may be partially overcome by active modes of transportation if they are able to live close to the places they need to go. Land use diversity and other aspects of urban form, therefore, could play an essential role in affording the right conditions for this to happen. In this study, we examine two low-income areas located relatively close to each other with comparable land use mix scores, but contrasting shares of trips by foot and individual vehicles, to understand how urban form interacts with these aspects to influence travel behavior. To compare the two areas, we analyzed land use distribution, built form characteristics, syntactic measures, and characteristics of trips to and from the areas, as well as in-loco *traffic counts. The results showed that travel behavior in the two areas are, in general, in line with previous studies, with two main differences: a very low proportion of trips other than for work and school purposes, and a tendency of the proportion of trips by motorcycle (as opposed to cars) to be a substitute for trips by foot when the urban form is not amenable to walking.*
Keywords: land use mix, mobility, urban morphology, low-income, travel behavior.

INTRODUCTION

Urban travel usually takes place with a pre-established destination and a specific purpose in mind: going to work or shopping, meeting friends, visiting new places, etc. Therefore, mobility is a key part of how people carry out their activities and discover new realities. The modes of transportation by which this is done are influenced by factors such as cost, estimated journey time, distance, safety, and expected rewards, among others. Another relevant factor is income, because it limits available alternatives to users, sometimes restricting or even inhibiting mobility. Low-income groups have fewer transport mode options, but this may be partially overcome by active modes of transportation if they are able to live close to the places they need to go. However, in Latin America what frequently happens is the opposite: low-income groups usually live in areas located far from urban centers (Ford, 1996) with poor infrastructure and accessibility, while high-income groups are more often located in areas with easy access to the rest of the city (Schroeder and Saboya, 2015). Villaça (2001) argues that this pattern creates and reproduces social inequalities, forcing an already disadvantaged population to travel long distances to get to work, school, and other urban amenities.

According to Jacobs (1961), successful neighborhoods enable their residents to experience an enriching urban life through, among other things, a diversity of land uses capable of making distances between activities shorter and street life more intense. But how does land use diversity work regarding transport mode choice in low-income areas?

A previous quantitative analysis of the Urban Agglomeration of Florianópolis (UAF) (Bertolino, 2019) showed some intriguing differences in the travel behavior of two low-income areas located relatively close to each other. Although they had similar socioeconomic conditions (both in the lower tercile) and land use mix scores, they showed contrasting shares of trips by foot and

individual vehicles. Since both socioeconomic conditions and land use mix were similar, what could explain these differences in mode share, and what could be the role of urban form in it?

This study examines this difference in more detail through a qualitative analysis that included on-field land use surveys and traffic counts as well as GIS-based descriptions of morphological aspects such as configurational measures (Integration and Choice), street hierarchy, land use distribution and plots and blocks shapes and sizes. Our goal is to contribute to a better understanding of the influences of space in travel mode choices in low-income areas, thus supporting more effective urban policies that can foster urban diversity in these places and reduce inequalities in access to the city's opportunities.

BACKGROUND

There is now a substantial body of literature examining the influence of the built environment on walking, particularly from the transport, health, and space syntax traditions. Cervero and Kockelman (1997) found that density, the mix of land use, and urban design reduced travel rates and increased travel by active modes, such as pedestrians and bicycles. Duncan et al. (2010) found an association between land use mix and walking for transport, which in turn could help improve people's health.

In the space syntax tradition, a seminal work by Hillier et al. (1993) suggests that the configuration of the urban network itself is the main generator of movement patterns and that more diversified land use tends to be located in more integrated areas to feed from that movement, later becoming multipliers of this "natural" pattern of movement.

However, it is important to understand these relationships from a socio-spatial perspective, as it may help explain how socioeconomic conditions interact with the built environment to influence traveling patterns of different social groups. Villaça (2011, p. 53, our translation) argues that the production of urban areas is permeated by practices that use space as an instrument of social limitation and control: "Being unable to act directly on time, people act on space as a means of acting on time". The reduced time wasted on trips by a privileged section of the population, whether due to the opportunity to choose its modes of transport or simply by the locational advantages of where they live, is an example of the social domination through space (Villaça, 2011).

METHODS AND DATA

As previously mentioned, we selected the two areas to include in this study (Aririu and Imaruim, municipality of Palhoça) based on a previous quantitative study aimed at understanding the trip behavior of different income classes and its potential associations with land use mix throughout the UAF. In that previous analysis, we combined and contrasted data from: a) an origin-destination analysis (ODA) carried out by Plamus (2014); b) an index developed to characterize socioeconomic deprivation/inclusion (Kronenberger & Saboya, 2019) based on five dimensions (income, education, housing, infrastructure, and neighborhood quality); and c) evenness and richness measures of LUM calculated from data from the national census (IBGE, 2010).

At the level of the individual zones, the quantitative data from the ODA does not necessarily have statistical significance but served as a point of departure for a more in-depth analysis. It provided preliminary evidence that the two areas, labeled here as high pedestrian zone (HPZ, Imaruim area)

and low pedestrian zone (LPZ, Aririu area), have 34.3% and 19.9% of their trips made by foot, respectively (Figure 1). In contrast, HPZ has 25.71% of its trips made by car, while this number goes up to 52.38% in the LPZ.

To compare the two areas, we divided the analysis into three stages: urban morphology, syntactic, and trip behavior analyses. The first investigated the natural environment on which the neighborhoods were laid out, land use distribution, built form characteristics, plot and block sizes and shapes, as well as how these aspects were related to each other. Next, we carried out a syntactic analysis that described Integration and Choice values for the two areas, both in global and local radii. In a nutshell, Integration measures the closeness of a street segment to all other segments located within an arbitrary radius, while Choice measures how often each segment lies in the shortest paths between all possible pairs of segments in the radius. Our "global" radius included all street segments in the four municipalities of the metropolitan region of Florianópolis (n=48.302), while our local radius was set at 1000m to differentiate the influence of streets located in the same neighborhood.

The analysis of trip behavior included, first, the destinations chosen for trips with origins in the two areas, along with their purposes and other characteristics. Secondly, we examined the inverse, that is, the zones the trips arriving in the two zones were coming from. In both cases, the duration of trips was examined. We also measured traffic flows in the two study areas, differentiating by modes of transport: pedestrians, bicycles, motorcycles, cars, buses, and trucks. Two counts of 15 minutes were carried out in the main street of each area, one in the morning and one in the afternoon. The average values for each location were considered in the subsequent analyses.

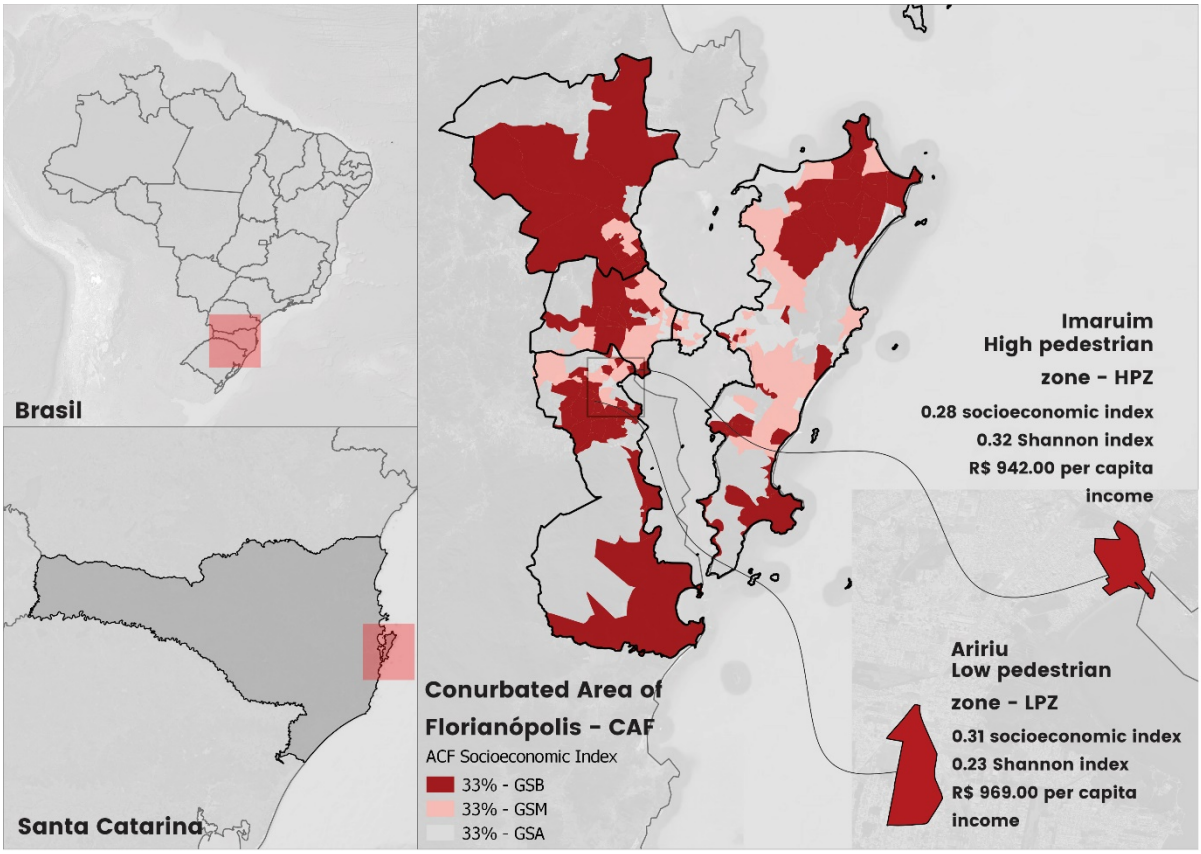


Figure 1. Case study location

The results of each stage were contrasted with each other in a search for possible explanations of the discrepancies in trip behavior regarding mode choice.

URBAN MORPHOLOGY AND TRAVEL BEHAVIOR

Land use distribution is shown in Figures 2a and 2b. While both areas have mainly residential uses, HPZ showed a more diverse combination of land uses, and they were more spread out throughout the urban tissue when compared to the LPZ, where commercial uses were predominantly concentrated along the main route located on one of its borders. This shows one of the limitations of analyzing land use diversity at the zone level: it oversees important internal patterns such as the coverage of non-residential uses and how they may become closer to a larger proportion of the zone when they are more evenly distributed.

We found three different plot patterns in both areas (Figures 2c and 2d). The first (in orange) is characterized by orthogonal shapes and smaller sizes; the second (in green), by irregular shapes and heterogeneity in shapes and sizes that suggests spontaneous development, a common trait in the region; and the third is mostly comprised of bigger plots, many of which have no buildings, and empty and residual areas (in blue).

The shape and size of the plots may facilitate or hinder the interaction of residents and visitors: other things being equal, smaller plots tend to increase the number of dwellers, as well as the flow of people entering and leaving their homes. The location of the area with a higher land use mix coincides with the area with smaller plot sizes, which also suggests that it may be a factor in facilitating the appearance and sustainability of small retails that cater to the neighborhood and which would not be able to afford large pieces of land. On the other hand, it could be argued that more diverse plot sizes would foster diversity in land uses, but this was not the case in the areas studied here.

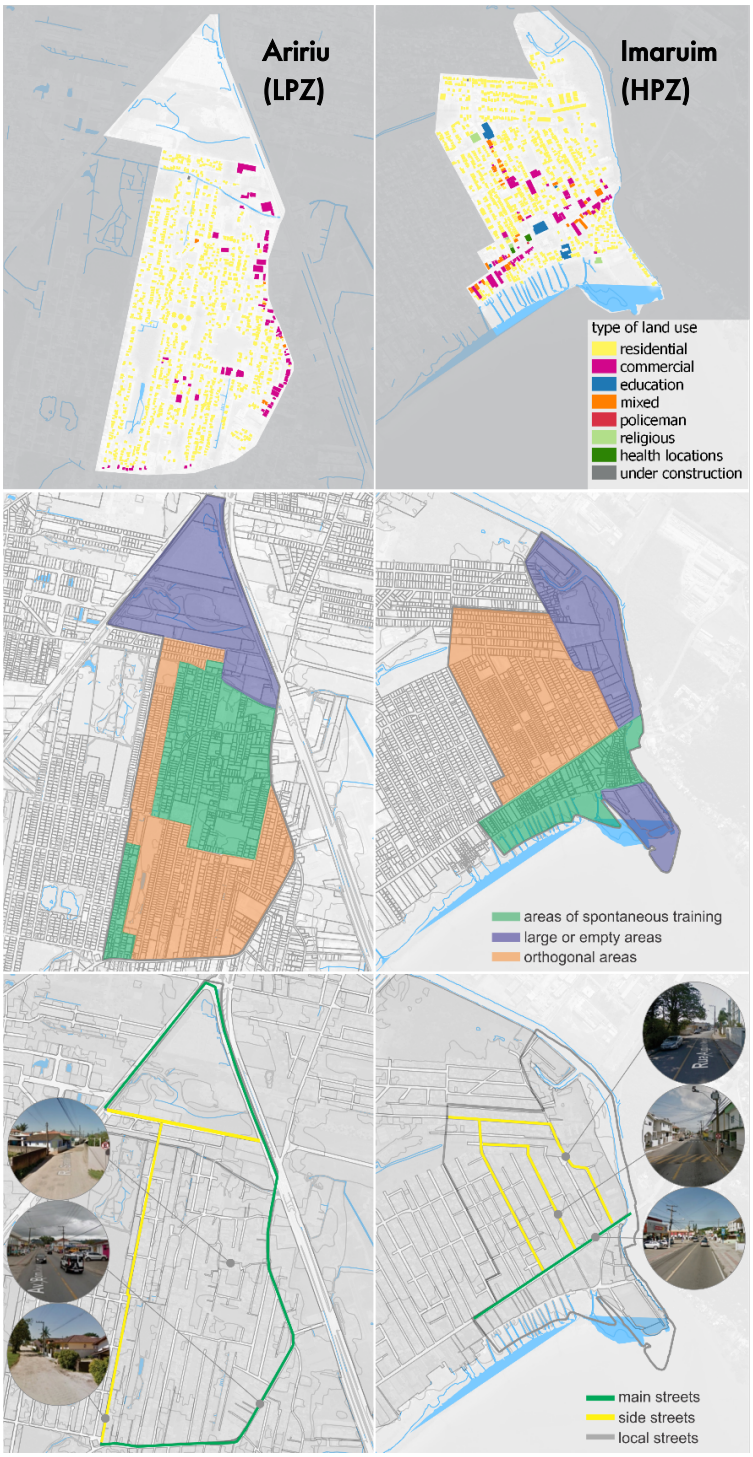


Figure 2. Urban morphology of the study areas

In addition, smaller plots are usually correlated with smaller blocks, which in turn may be another incentive to pedestrian flows; bigger plots, by contrast, are not only usually associated with longer blocks but also with a higher proportion of inactive or blind façades that block the visual and physical connection between the interior of the buildings and the sidewalks, further discouraging pedestrian movement.

The syntactic analyses (Figure 3) may help explain the internal distribution of land uses. In the HPZ, we see that the two main streets have relatively high Integration and Choice when compared both to the other streets in the same area and to LPZ's main street. What is more, the higher values happen both in the global (when all segments in the agglomeration are considered) and local (when taking into account only those located in a radius of 1000m) scale, a condition that Penn et al. (1998) highlight as important for urban centralities to flourish. The "T" formed by the two streets is most clearly captured by the measure of Choice in the 1000m radius, but it can also be noticed in the other maps. What this means is that these two streets are not only close (on average) to other spaces but also in the shortest paths between them, in both the global and local scales. LPZ, on the other hand, shows a much weaker configurational situation: while it has some importance at the global level in Integration terms, it is mainly due to the influence of the adjacent federal highway and concentrated in a small region in the northern section of the area. We can see in the local Choice map that, although there are some relatively high values in north and south, the mid-section of the main street shows lower values.

All trips arriving at or departing from HPZ and LPZ only had work or educational purposes (Figure 4), according to ODA data. In other words, residents of these areas rarely go out for shopping or leisure and do not receive visits with the same purposes (bearing in mind that the sample at this scale is not fully representative, as mentioned before). Being low-income areas, it is unavoidable to recall Villaça's (2011) arguments about how people with high incomes are able to optimize their location, allowing for a greater amount of free time in their daily lives that can be spent in non-mandatory activities.

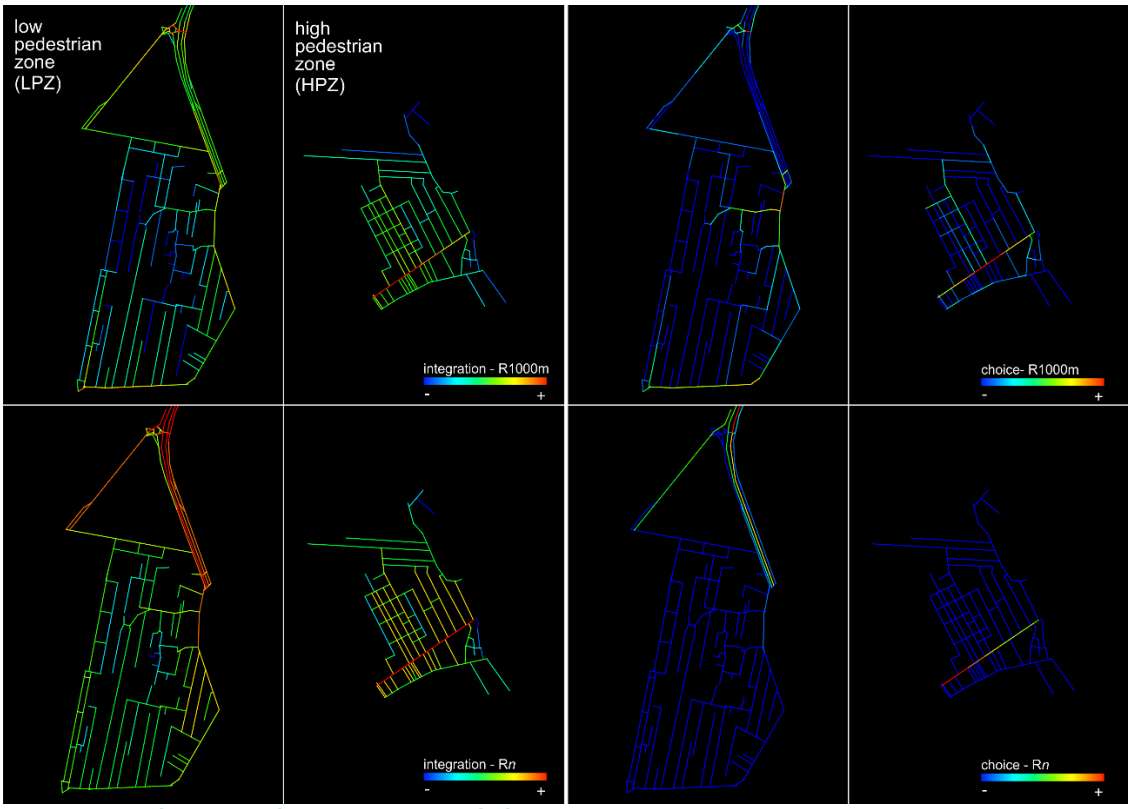


Figure 3. Spatial syntax analysis - Integration and Choice

When compared to the trips that leave the LPZ, trips from the HPZ go to more distant destinations, including the insular section of Florianópolis. This may be the result of HPZ being more syntactically integrated into the UAF global system (Figure 3), with income probably not being a significant factor for the differences since both areas have similar income averages. In contrast, in LPZ there is a greater number of people coming to work from long distances, suggesting that some of its activities require more specialized labor that cannot be supplied by its residents. Interestingly, however, the trip durations to and from the HPZ are considerably lower than those of the LPZ, with only 6% of the total trips taking more than 40 minutes in the former, as opposed to 21% in the latter.

The traffic counts in the main streets of the two areas corroborated the preliminary data from the ODA regarding the higher proportion of trips by foot in the HPZ, with 26.81% as opposed to 11.59% in the LPZ (Figure 5). However, it showed that the difference in the number of car trips between the two areas was not as large as we initially believed, with 57.19% and 59.81% for the high and low pedestrian zones, respectively. Upon further examination, it becomes clear that the biggest discrepancy in the mode share of the two zones, apart from pedestrian flows, is the share of trips carried out by motorcycle, which jumps from 8.89% in the HPZ to 19.17% in the LPZ. All

mode shares absorb some proportion of the "lost" pedestrian trips in the LPZ, but trips by motorcycle are, by far, the highest.

CONCLUSIONS

Travel behavior in the two areas are, in general, in line with previous studies that examined its relation to urban form and the degree of diversity of land uses: higher Integration, Choice and land use diversity, as well as smaller plots and blocks, were associated not only with higher absolute numbers of pedestrians but also higher proportions, as the *in-loco* counts in both main streets confirmed. In this respect, therefore, we can say that urban form influences travel behavior in low-income areas in a similar way as in non-low-income areas.

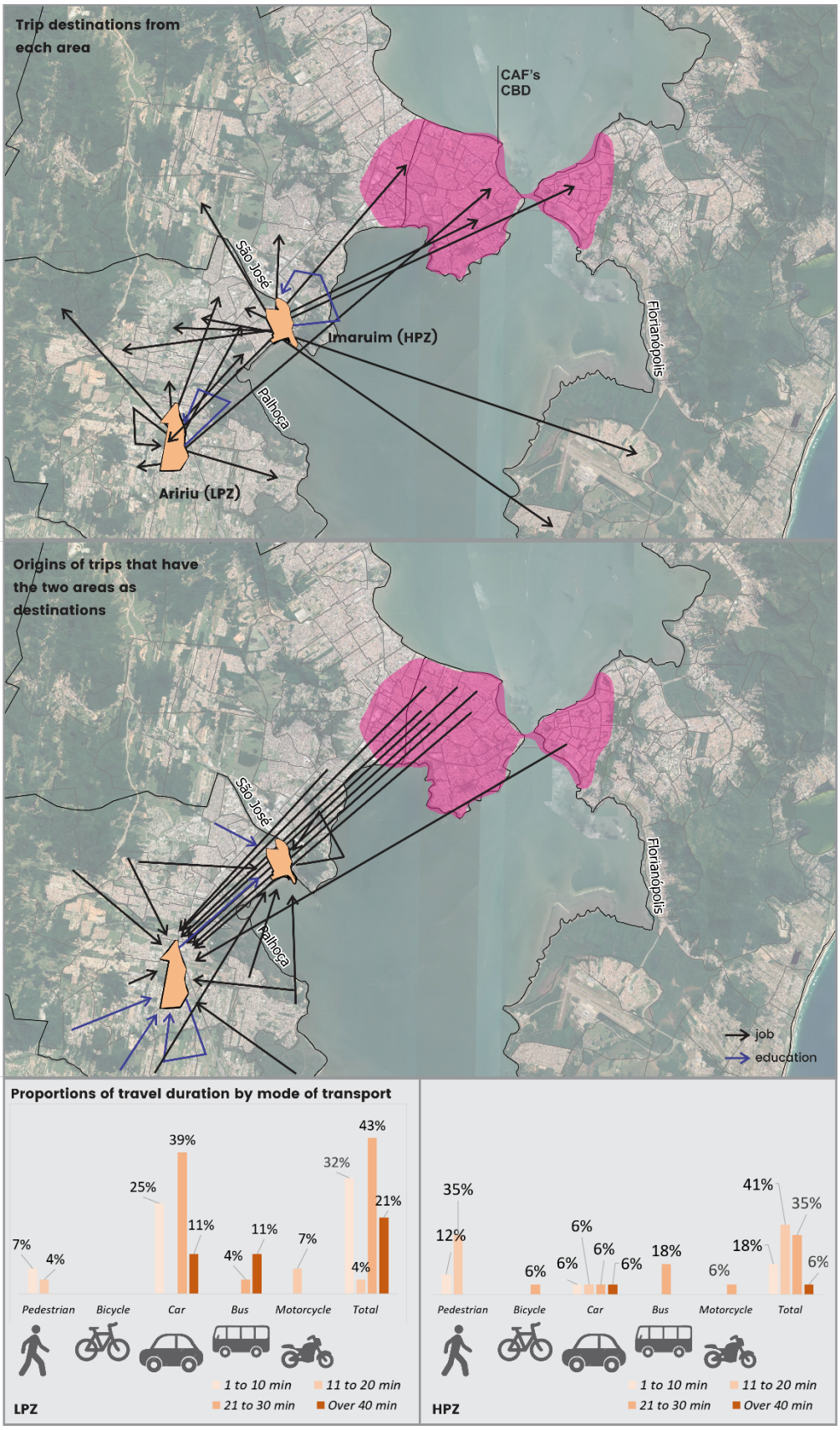
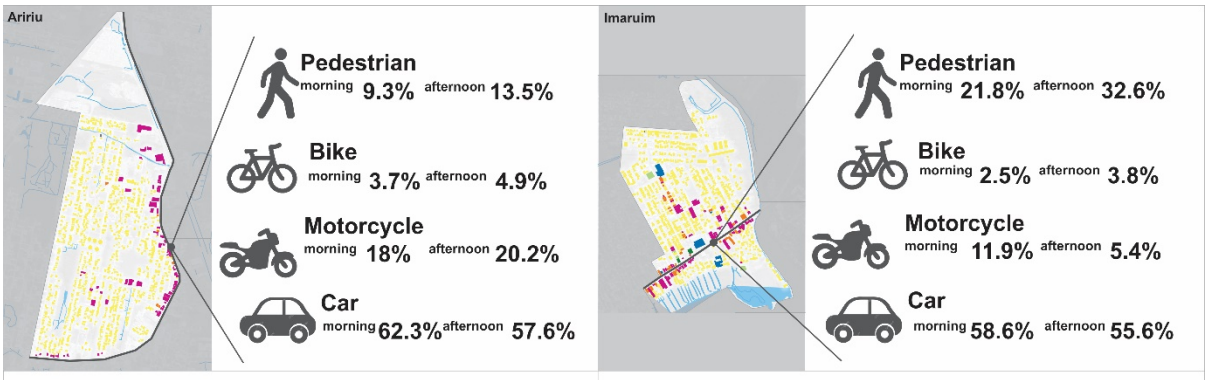


Figure 4. Travel behavior and travel time by mode of transport (Source: made by the authors with data from Plamus, 2014).



Av. Bom Jesus de Nazaré						Av. Aniceto Zacchi					
Time	truck / bus	car	motorcycle	bike	pedestrian	Time	truck / bus	car	motorcycle	bike	pedestrian
8h00-8h15	20	187	54	11	28	8h00-8h15	19	212	43	9	79
12h00-12h15	13	200	70	17	47	12h00-12h15	8	174	17	12	102

Figure 5. Traffic count – Aririu and Imaruim areas.

However, some differences emerged. The absence of leisure-related trips in both areas suggests that residents of these areas have difficulty reconciling these activities with their daily lives. Therefore, land use diversity is probably more crucial for these areas than for high-income neighborhoods whose residents have better conditions to move around to access more diverse and specialized destinations.

Another characteristic of low-income areas revealed by this analysis is that urban form characteristics not amenable to walking and cycling do not result in an increase in trips by car, necessarily, but by motorcycle, a more affordable option. We do not have the ambition to generalize the results of this qualitative study, but it makes sense to suppose that the tradeoffs between modal options are different in high and low-income areas and, therefore, socioeconomic and configurational aspects interact differently in each case. More research should be done to check these assertions.

From a methodological perspective, the study reinforced the importance of more in-depth qualitative analyses to complement and overcome the limitations of large-scale quantitative ones, that often overlook important aspects, especially when we consider them from a policy and design standpoint. More specifically, future studies could benefit from a more disaggregated measure of land use mix that accounts for the actual distances between uses.

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