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Spatial Configuration and Allocation of Cycling Infrastructure:

The Case of Natal and Campina Grande, Brazil

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ABSTRACT

Despite the approval of a national urban mobility law (Brasil, 2012), the extent and quality of the cycling infrastructure varies from city to city in Brazil. The case studies in this paper are the cycling infrastructure of Natal and Campina Grande, two Brazilian cities with different sizes, forms and local laws concerning active mobility. We aim to ascertain, in a comparative perspective, whether the infrastructures in these two cities respond to the demand for cycling trips, offer adequate conditions for road safety and are allocated in accessible thoroughfares. The investigation of accessibility was based on the space syntax methodology (Hillier and Hanson, 1984) by applying linear representation and quantification to the street grid of Natal and Campina Grande. Segment maps (Turner, 2001) were elaborated in the Space Syntax Toolkit plugin for QGIS (Gil et al., 2015), obtaining syntactic measures (Hillier; Yang; Turner, 2012) for different metric radii to account for diverse travelling distances. The cycling infrastructure of the cities (with their respective categories - cycleway, cycle lane, cycle route, shared lane - considered) was added to the segment maps, as were data on cycling flows and accidents, to gauge compatibility relating type of cycling facility (or its absence), accessibility, potential and real movement. Results indicate that most of the cycling infrastructure in Campina Grande is located on highly accessible roads, while in Natal, many highly accessible roads lack cycling infrastructure. However, in both cities, most of the cycling infrastructure is incompatible with speed limits and car flow intensity, which exposes cyclists to conflicts and great risks. Bike lanes, for being less shielded from the car lanes, are often built in total disregard of guidelines in technical notebooks on cycling infrastructure. By discussing relations between accessibility and road safety in the light of configurational analysis we seek to enhance the debate concerning active mobility and contribute to better practices in urban planning.

KEYWORDS

Cycling Infrastructure, Space Syntax, Spatial Configuration

1 INTRODUCTION

This article compares cycling in two cities in the Northeast of Brazil, Natal and Campina Grande (fig. 1) in the aspect of bikeability - suitability for biking in the urban environment. Considering national and respective local laws concerning active mobility, as well as the difference in size and character of a pervasive car-oriented road system, we investigate whether the allocation of cycling infrastructure in both cities: (1) coincides with the sites where it is most needed, that is, where most cyclists choose to move and there is higher risk of accidents; and (2) is designed appropriately for the accessibility hierarchy and speed limits of the street network.

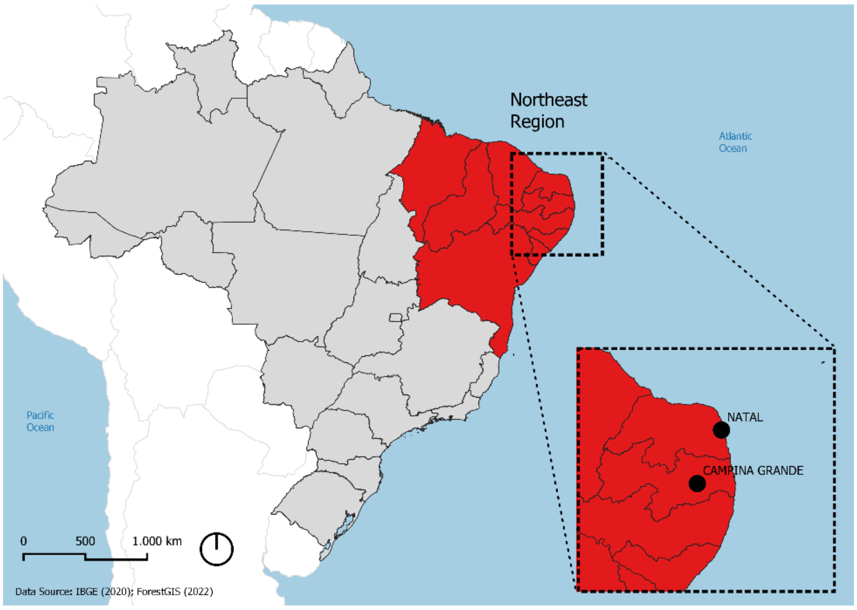

Figure 1: Location of the subject cities in the map of Brazil.

Natal and Campina Grande have, respectively, 890,480 (1,647,414 for the metropolitan region) and 402,912 inhabitants, according to the national statistics office - IBGE (2021). In the last origin-destination surveys conducted in both cities, 4% and 4.4% of Natal and Campina Grande's populations, respectively, used bikes as their main means of transport - high percentages in the context of South American cities, larger than in Rio de Janeiro and São Paulo, and close to Bogota.

The cities have different topographies, as shown in figure 2. Natal is less hilly, its plain areas corresponding to the river and mangrove, whereas the heights are dunes, most of which protected as environmental reserves; Campina Grande has much steeper slopes, especially in the north sector. Considering the data about cycling adequacy to urban terrain, as classified in manuals and technical handbooks (GEIPOT, 2001; TFL, 2016), 10% of terrain slope is considered the maximum declivity a cyclist can ride with some comfort and safety. Natal has a larger urban area below that figure while Campina Grande has a larger area above it.

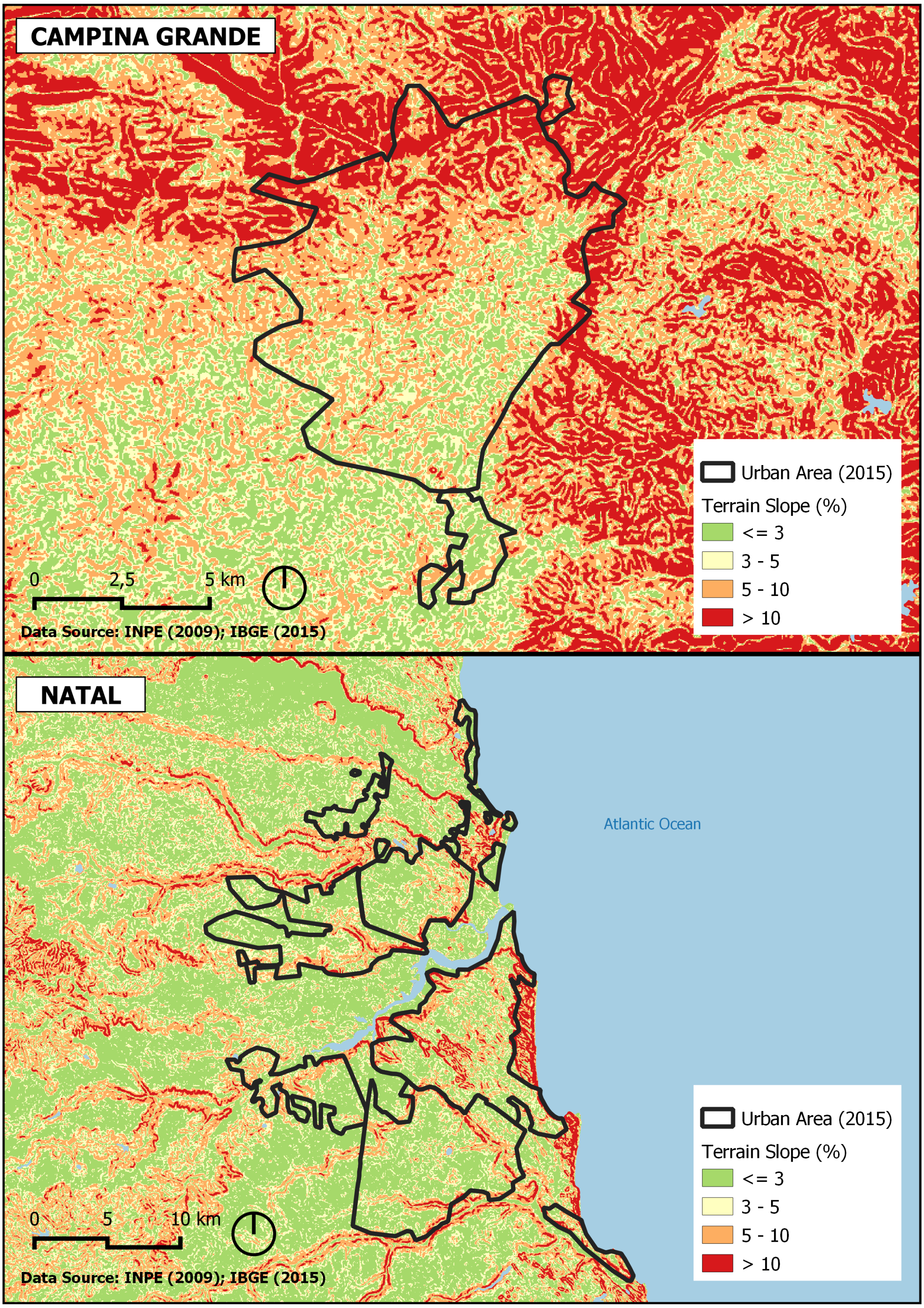

Figure 2: Topographic maps of Campina Grande and Natal.

While in Campina Grande a mobility plan has been passed as a local law by the municipality (Prefeitura Municipal de Campina Grande, 2015) and the new cycling infrastructure has been following its guidelines, Natal has no local law reinforcing the needs of cyclists.

Furthermore, Natal strives with issues common to most state capitals and medium sized metropolitan centres in Brazil, such as a large urban area with a long-established viary system that prioritizes automobiles. Other restrictions hinder betterment of the cycling system: the city is crossed by thoroughfares that are part of the main road system at the scale of the state and of the country, so that the municipality has little or no authority to make changes. These roads largely coincide with the urban accessibility core or mainstreet framework, as will be detailed in section 5.

For evaluating the adequacy of the cycling infrastructure placement in the studied cities, data regarding that infrastructure, multimodal integration, routes and, additionally, in the case of Natal, information about accidents involving cyclists during a five-year period were overlapped with linear representations and accessibility measures for diverse radii of coverage and scales, so that levels of accessibility can be examined in the light of guidelines found in the literature considering the users' safety.

Given the nature of the research pieces presented here that address each of the two cities - a master dissertation and a doctoral thesis - they were studied separately in parallel, so that not only the data available for each case differed, but also the ways in which they were treated. While in Campina Grande, gate counts were made through in loco observations across the city, in Natal route counts were obtained from the app Strava, and records of accidents involving bikers from 2016 to 2020 were obtained from the municipality's urban mobility office.

2 URBAN DESIGN AND PUBLIC POLICIES FOR BIKEABLE CITIES

A good cycling infrastructure besides promoting the use of bicycles in urban mobility and its benefits, such as potential health gains and enhancement in quality of life, reduces pollutant emissions and congestion, and helps to boost the economy and tourism. The improvement of the cycling network has been considered one of the most cost-effective interventions for the well-being of individuals and social groups (Canada Bikes, 2016).

The New Jersey Department of Transportation (2017) states five essential qualities for a good cycling infrastructure. It must be: continuous (with few interruptions at intersections), connected (connections between routes), convenient (crossing public interest equipment), complete (integrated with the rest of the road system and its infrastructure) and comfortable (physical and climatic conditions favourable to use). Based on international consensus regarding aspects considered inherent for best practices in cycling infrastructure planning, the Transport for London (2016) authority, responsible for the urban mobility in London, recommends six goals:

Safety, Direction, Comfort, Coherence, Attractiveness and Adaptability. In both guidelines, continuity, connectivity and direction are aspects related to spatial configuration that may be satisfactorily investigated with the aid of the Space Syntax theory and analytical tools.

The natural movement theory (Hillier and Hanson, 1984; Hillier, 1996; Hillier et al, 2014) establishes that configuration determines movement tendencies through the urban mesh, and that cities are complex asymmetrical artefacts where some spaces are more accessible than others, attracting more movement, and providing locations where commercial and service facilities tend to thrive. These locations will be sought by people using all means of transportation, so that a just and democratic urban mobility plan should contemplate everyone's ability to reach them in safety and equality. This fails to happen, in variable degrees, around the world, according to how centred on the automobile the urban mobility planning is, a situation particularly unfavourable to users of active means of transportation who are far more vulnerable to suffering severe injuries in accidents.

Safety recommendations for types of cycling infrastructure generally agree that the higher the speed and amount of traffic, the more separated should the space dedicated to bikers be from the one dedicated to heavier and faster vehicles (Nacto, 2017; Teramoto, 2008; Transport for London, 2014). As will be detailed in sections 4 and 5, the syntactic measure (choice) that accounts for through-movement across town, which tends to coincide with heavy traffic, also coincided with our data about routes chosen by bikers and places where they suffer accidents. Such acknowledgement has strengthened our view on the adequacy of Space Syntax Analysis (SSA) for estimating high risk roads and hotspots and determining priority for interventions.

Intermodal integration connecting active and public means of transportation is another important issue, more so the larger the urban area. The spreaded configuration of Brazilian cities calls for good integration, since distances are often too long for a comfortable journey using active means of transport. However, 96% of bikers interviewed in Natal declared never having used any intermodal station, often confessing to not knowing at all what the expression means (Perfil do Ciclista, 2021). Bikes are not allowed inside the public transport, and there is very little public equipment for parking them. It is not common for people to keep their bikes in the streets, for fear of thefts (Perfil do Ciclista, 2021).

Urban design strategies must consider active modes of transport as a whole, since, at some point along the way, the cyclist, when dismounting the bicycle, becomes a pedestrian. In this sense, the World Resources Institute (2015) lists five elements of urban form considered essential to improve road safety: block size, road connectivity, road width, access to destinations, and population density.

These principles can contribute to the planning and design of safer cities for pedestrians and cyclists, whose benefits are not limited to the quality of the road space. Urban design, in addition to being important in creating a safe environment for travelling, also contributes to discouraging and reducing the number of trips by motor vehicles by integrating the bicycle with other modes of transport as well as with the walking areas of the city.

According to the recommendations of GEIPOT (2001), the slope of the street, for the purpose of circulation or installation of cycling infrastructure, must be carefully planned, since the cyclist, being the propeller of his own vehicle, is sensitive to this type of difficulty. It is recommended that the slope should be less than 5%, with a maximum inclination of 10%. These values are higher than those recommended in other countries.

Monteiro (2018) considers slopes above 5% unfeasible for bicycle use, both due to excessive physical effort to move and the possibility of high speeds on the descent, which can generate risk of accidents. Such conditions can encourage cyclists to opt for longer and less linear paths, which may reduce the possibility of choosing shorter paths and fewer changes of direction in urban networks with greater spatial accessibility, thus reducing its efficacy. Transport for London (2016) recommends that slopes of up to 5% are recommended for the circulation of cyclists as well as for the implementation of cycling infrastructure.

The preponderance of the automobile is a general reflection of the historical social inequality in Brazil. Municipal authorities in both Campina Grande and Natal, in varying degrees, tend to avoid settling any betterments for bike users unless their placement takes no space or brings no difficulties in any way to the circulation of automobiles - although, as will be detailed in the next sections, Natal's issues are deeper, as the city runs late in policies and planning for active urban mobility.

Even though the lack of appropriate cycling infrastructure (such as cycling tracks and lanes, bike parkings, etc.) is the issue most cited by bikers in Natal and in other South American cities (Perfil do Ciclista 2015, 2018 and 2021), it is necessary to stress the importance and need of parallel policies for traffic education and institutional changes in the privileges given to private automobiles in taxing and fines.

The continuous gathering and sharing of data and information that is expected to be a priority for public administrations, a core attribute of public transparency in governance, and a condition for research funding policies is also scarce. The data which anchor this study diverged for each city, either because the public offices responsible for gathering them did not grant access to researchers, or because they are not gathered at all.

3 CONFIGURATIONAL ASPECTS OF BIKEABILITY

The promotion of bicycle use as a mobility solution takes place within a context of urban planning and in line with urban sustainability thinking. According to Porter et al. (2019), studies on bicycle use have developed indicators and metrics to assess the cycling potential of cities, and such indicators measure the degree of bikeability of public road spaces, considering social, economic, environmental and infrastructure variables, whose criteria vary from country to country. In recent years, several indexes have been developed to measure ease in biking, most of which are indicators and variables related to infrastructure, environment, road and public safety, among other categories.

Important configurational aspects are related to cycling in the urban environment. These aspects present measures similar to those used in Space Syntax Analysis, which allow for relational studies concerning spatial configuration and mobility and for identifying which aspects favour cyclomobility. From the literature review, based on pedalling indexes, the following configurational aspects were identified: road connectivity and intersection density, length of street segments and block dimensions, linearity and continuity, topography and slope.

Length of street segments is the metric quantification of the length of a street between two intersections. Authors, such as Jacobs (2011) and Gehl (2013), highlight the advantages of shorter blocks for encouraging pedestrian movement and urban animation. However, few bikeability indices use this variable, such as Gholamialam and Matisziw (2019). Although the World Resources Institute (2015) considers that block sizes (which, consequently, are lengths of street segments) applied to walking mobility indicators can be applied in studies on bicycles, it is important to verify what dimension parameters would be ideal for cycling, since some criteria for pedestrians cannot be replicated for cyclists.

Linearity and continuity consist of how straight the cyclist's path is and the number of interruptions that occur during the displacement. The smaller the number of turns (changes of direction) and the angle of the turns, the more direct the movement and the easier the cyclist will reach the desired destinations. Linearity and continuity are variables little explored in pedalling indices. This configurational aspect is related to the concept of topology, which in the theory of the Social Logic of Space (Hillier and Hanson, 1984) is understood as changes in direction during the course of a route.

The costs of changing direction, used by Turner (2000), Medeiros (2004), Grigore et al. (2019) and Cooper (2017) are important parameters to analyse the potential of bicycle circulation in the urban environment. The NACH (normalised choice) measure, used in Space Syntax, can assess the degree of linearity and continuity of roads.

Connectivity corresponds to the number of intersections of a given street (or street segment) with other adjacent streets. Increased road connectivity reduces distances between destinations, improving bicycle accessibility, especially where paths provide shortcuts so that pedalling is more direct than travelling by car (Litman and Steele, 2021). It is understood, therefore, that connectivity is a key attribute for pedalling (McNeil, 2011).

In Space Syntax, the Node Count feature (Turner, 2004) calculates the number of axes (or segments), within a certain radius, which may be of a topological, angular or metric character and extent; the distance takes into account the centre of each axis or segment. This measure can complement connectivity analyses, aiming to better understand how the urban fabric is organised, and how this organisation can enhance (or not) mobility by bicycle in cities. The density of nodes (or connections over a given radius) is used by McNeil (2011) and Winters et al. (2013), as a measure of road connectivity.

As well as establishing good practices in cycling infrastructure, the configurational aspects that qualify pedalling need to be calibrated according to the reality of each case study, since the reality of most cities investigated throughout the world is different from that of Brazilian cities, especially in respect to social, economy and cultural ethos, which also lead cyclists to perceive and evaluate pedalling differently.

Considering what has been said, this paper focused on the linearity/continuity aspect in spatial configuration, applying betweenness-based measures (choice and NACH in angular analysis) and radii to understand how the cycle infrastructure is related to bicycle movement in study cases (Turner, 2007).

4 METHODS

This research was made based in the following steps:

I) Space Syntax Modelling and Analysis: linear representation of Natal and Campina Grande were modelled, according to Hillier and Hanson (1984), then converted into segment maps. Normalised Choice measures (Hillier; Yang; Turner, 2012) were calculated in two radii: global (radius N) and metric local radii. The metric radii used were 2,400 metres for Campina Grande and 3,200 metres for Natal, once these measures and radii were best correlated to bicycle flow in the respective cities (Figueira, 2019; Castro, 2021). When comparing the data available for each city to their linear representations in different measures and radii, different scales were observed to work in each city. These findings helped to understand the potential of movement of the urban grid of the studied cities, and allowed for comparisons with other urban aspects;

II) Cyclist Flow, Accidents and Infrastructure Data Compilation: the cycle infrastructure was mapped and imported into segment maps, according to category (bicycle track, lane, shared lane/street). Cyclist flows were also mapped according to available public data (for Campina Grande) and to the Strava application data (for Natal). The 200 routes collected from Strava were filtered through the keyword "Natal" and only the routes that entered the city's urban perimeter were considered.

Official records of accidents that occurred between the years of 2016 and 2020 were obtained and georeferenced in the map of Natal, where their location coincided with high accessibility segments in NACH r3200. In Campina Grande, such data were not available, only the crossings with the greatest number of accidents in general (not only the ones involving cyclists), which largely coincided with the streets with the highest gate counts of cyclists.

III) Spatial and Statistical Analysis: configurational measures as a proxy to movement potential was compared to the location and type of bicycle infrastructure, cyclists flows and traffic accidents.

5 SIMILARITIES AND COMMON WEAKNESSES

The global spatial structures of Campina Grande and Natal have similarities in the maximum values for NACH. Campina Grande is 1.63, while Natal is 1.61. It means, according to Hillier, Yang and Turner (2012) that the foreground networks (or the degree of deformation and interruption the foreground structure of the grid has) in each city is compatible respecting strength as movement indicators. As many Brazilian cities, Campina Grande and Natal have predominant regular grids plus some radial streets and roads that cross the urban area, connecting central regions to perimetral structures or peripheral settlements.

Considering the mean values of NACH, the cities have different patterns: the mean value of NACH for Campina Grande is 0.93, and for Natal is 0.86. According to Hillier, Yang and Turner (2012), mean values of NACH are related to the continuity of the urban grid structure. Campina Grande, as shown in Figure 3, has a more compact and denser urban grid, with a regular tissue connecting the central area to the periphery. Natal has a sparser grid, with fewer connections between the central areas and the periphery, which can result in longer trips for cyclists in the metropolitan area.

Observing the spatial structure with local radius, both cities have similarities. The 2,400m radius is best related to bicycle movement in Campina Grande (Castro, 2021), as shown in Figure 4; the most accessible streets in NACHr2400m are scattered throughout the urban grid. In Natal, bicycle movement correlates better with NACHr3200m (Figueira, 2019), as in this radius there are many highly accessible segments. The most accessible streets coincide with high counts of cyclist flows and accident records, as shown in Figure 4.

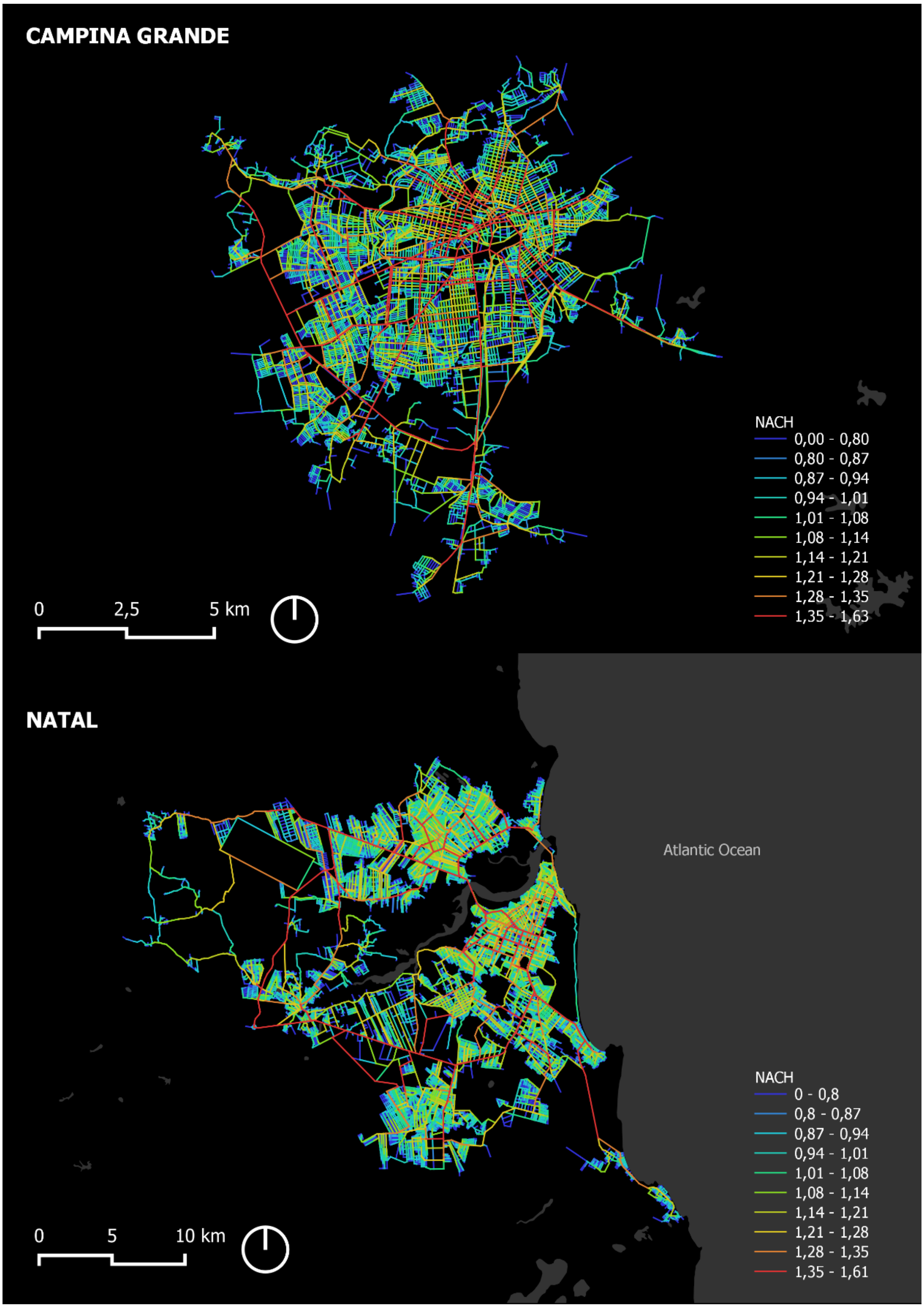

Figure 3: NACH Measure in Campina Grande and Natal.

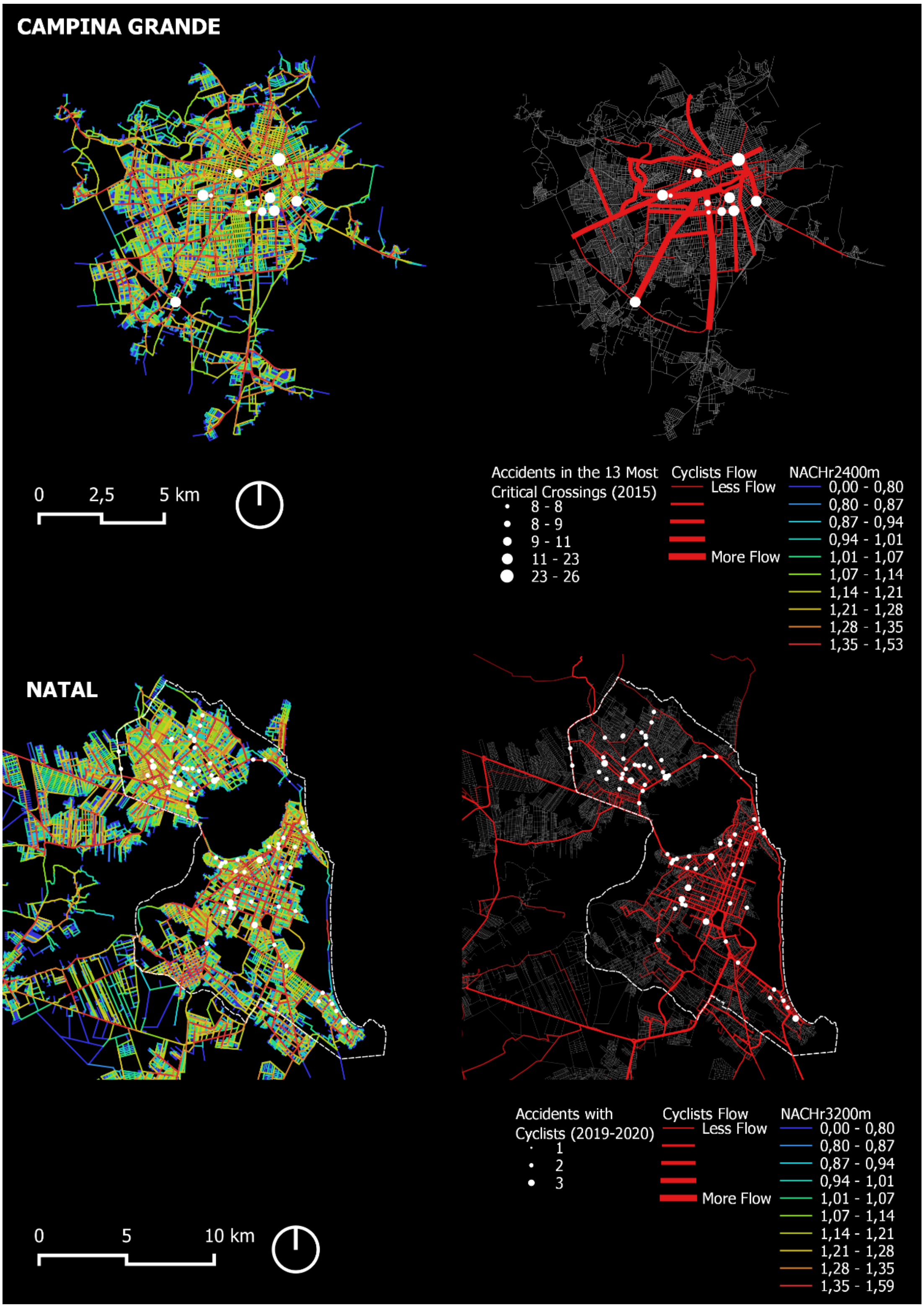

Figure 4: Spatial Structure of Campina Grande and Natal for Local Radii of NACH.

Whereas in Natal the cycling infrastructure was built around the central area and is scarce in regions West and North (the poorer regions in the city, where real estate values are lowest), with 5 different types of cycling ways, in Campina Grande the infrastructure in predominantly peripheric with 2 types of cycling ways , as shown in Figure 5.

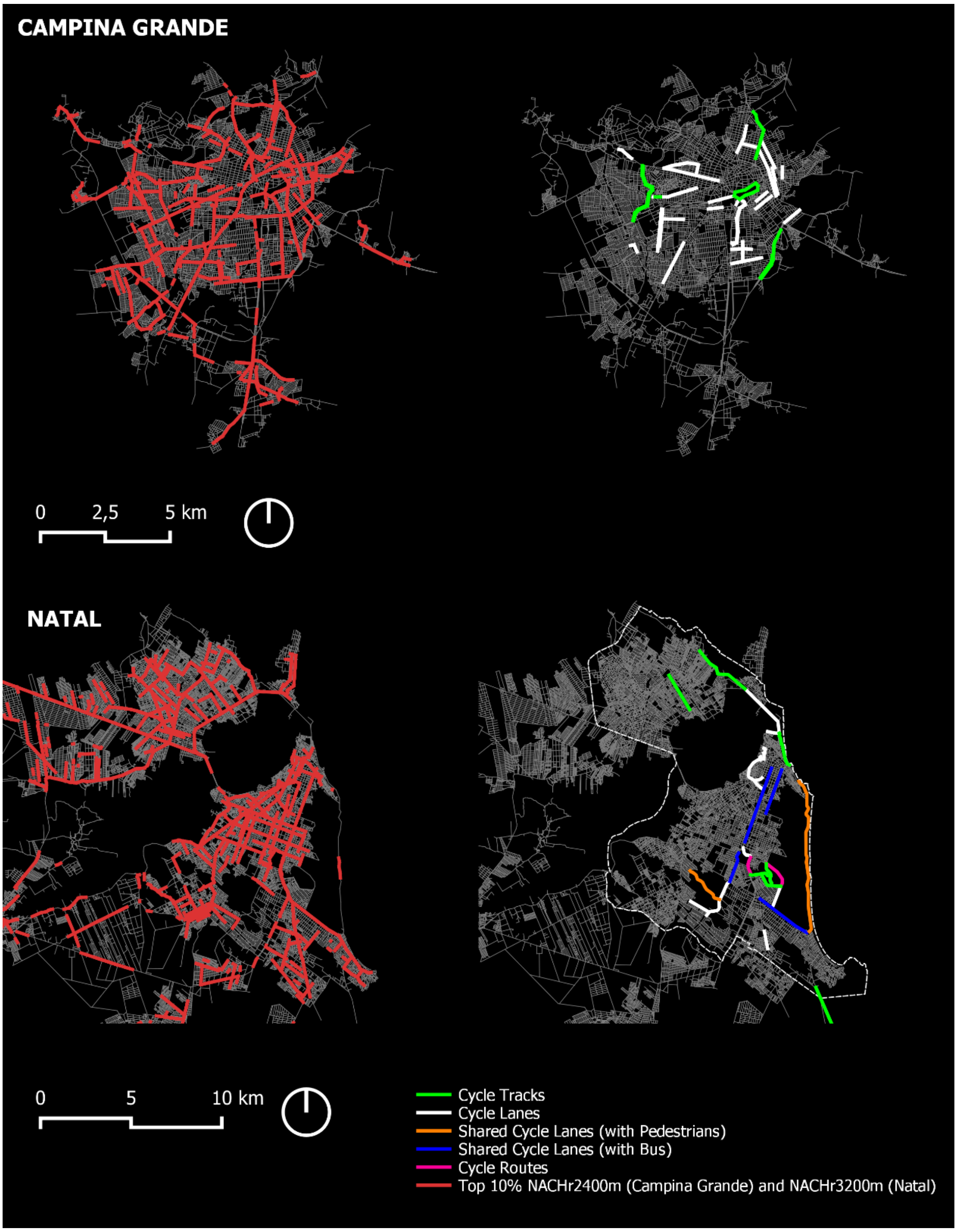

Figure 5: Spatial Structure and Cycle Infrastructure Location in Campina Grande and Natal.

One similarity observed in both cities is that cycle tracks are fewer in comparison to cycle lanes. This can be explained by the fact that cycle lanes are faster and cheaper to build, and require only minor intervention in the street network. Moreover, cycle lanes occupy less road space, thus generating less conflicts related to the circulation area required by drivers of other vehicles.

When the average accessibility value for all segments is compared to that for segments equipped with cycling infrastructure in both cities, slightly higher NACH values are shown for segments with infrastructure, at local and global radii. However, the average connectivity values for both cities, taken as whole systems, are larger than the average of segments with infrastructure, indicating that such infrastructure tends to be placed in streets with less crossings (Figures 6 and 7).

The majority of traffic collisions happen in or close to crossings (Teramoto, 2008), thus indicating that crossings require particularly careful urban design schemes oriented to the safety of all transport users. In spite of that, the numbers indicate avoidance to build infrastructure in such spaces altogether, probably motivated by the direct relationship between complexity of required design and cost.

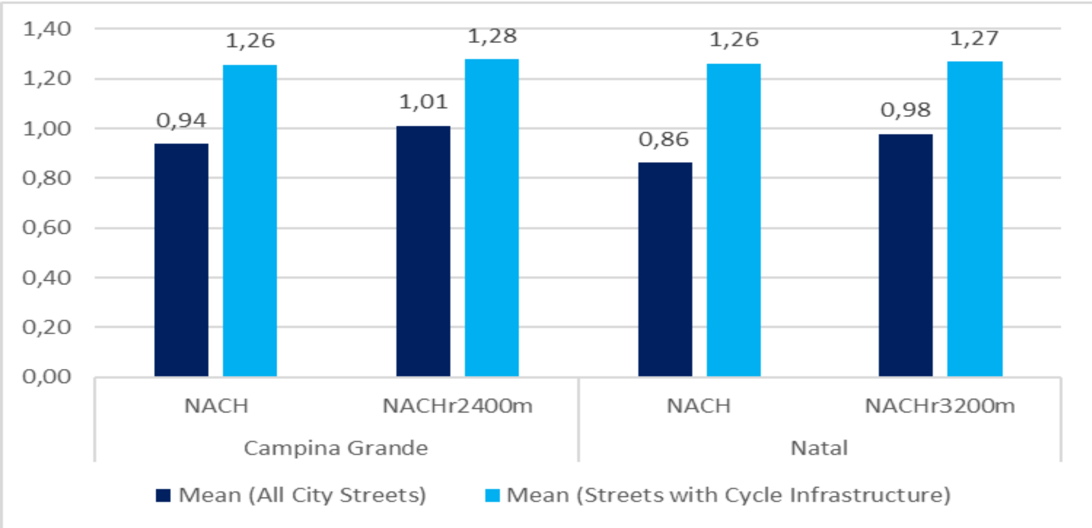

Figure 6: Comparison of accessibility average values in segments with infrastructure and all segments, respectively in Campina Grande and Natal. Source: Authors' elaboration.

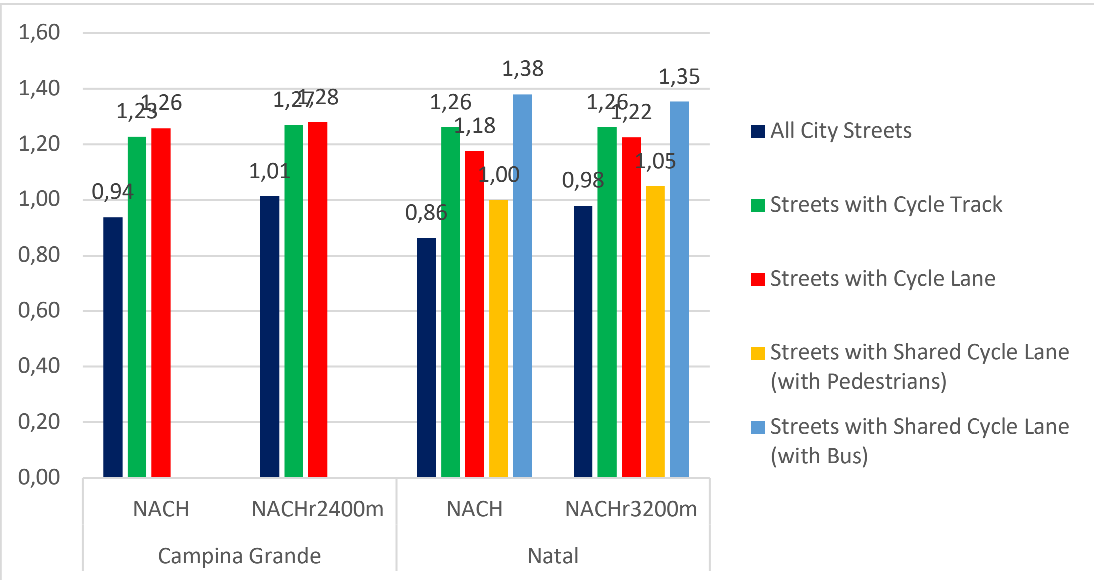

Figure 7: Comparison of accessibility average values in segments with infrastructure (per type) and all segments, respectively in Campina Grande and Natal. Source: Authors' elaboration.

Both cities have been found to be equipped with low percentages of street segments with cicleviary infrastructure in comparison to the total number of segments; although the case in Natal is more extreme - the percentage of segments equipped with cycling infrastructure is less than 1%, while in Campina Grande, they reach about 3%.

Considering that NAIN values form an accessibility core, and NACH values a foreground framework of main streets, and given that data on traffic safety have shown that high accessibility values tend to coincide with the occurrence of accidents (Figueira, 2019), it seemed relevant to verify how many of the 10% most accessible segments are equipped with cycling infrastructure. Both cities showed relatively low percentages of cycling facilities in highly accessible roads, but in Campina Grande results were not as bad as those in Natal. In Campina Grande 26% of the 10% highest valued segments (for NACH 2400) had some sort of cycling infrastructure, whereas in Natal that proportion was only 5% (for NACH 3200).

27% of the segments with infrastructure are among the 90% lowest accessibility values in Natal, 16% in the 80% lowest, 11% in the 70% lowest. These numbers indicate that a chunky part of the investment is being placed in low accessibility routes, where risky traffic situations are less likely to happen, thus revealing that the choice of priorities is sometimes neither based on accessibility nor on safety criteria.

6 DIFFERENCES AND LESSONS.

In Natal, the majority of the cicleviary infrastructure located in the main-street framework formed by the 10% highest accessible segments (NACH r3200) comprises bike lanes shared with buses (as well as with any other vehicle turning right). All of the segments containing one of these shared lanes are in the 10% highest accessible framework. This practice, initiated in the last decade, is uncommon, deemed dangerous and disencouraged by some cicleviary design manuals and studies (Teramoto, 2008; Nacto, 2017; Transport for London, 2014), but used as a low cost, space saving solution by the municipality's mobility planning agency.

Largely criticised by users, who find that their preference status is not being respected, the space sharing amongst vehicles of extremely different speeds and sizes is difficult to say the least. Some of the complaints, for example, state that the weight of the buses deforms the asphalt, and that the vacuum they leave behind can interfere with a biker's balance (Perfil do Ciclista, 2021). The scheme is also known to disencourage bikers with little experience in the urban traffic, and people declared having given up on using their bikes for daily transportation because of dissatisfaction with the infrastructure available (Figueira and Cavalcante, 2021).

Some improvement in traffic safety is, however, pointed out by recent analysis. Accidents have been greatly reduced or even eliminated in segments with traffic-calming and public transport oriented design strategies, such as exclusive bus lanes, speed radars and sensors for trespassing the red lights. The adoption of these palliative solutions is allegedly justified by the difficulty of integrating diverse stances of public policies and authority layers related to the federal, the state and the municipal jurisdiction over the city's main streets. However, it also shows reluctance in taking action that might upset owners of private automobiles in benefit of other means of transportation such as the active mode (Figure 8).

Figure 8: Picture showing (on the right side, signaled with a red stripe) one of the bike lanes shared with buses and other vehicles who will turn right in Natal, at Avenue Hermes da Fonseca. Source: Google street view, 2019.

In Campina Grande, since the 2015 plan of urban mobility, the construction of cycling infrastructures increased significantly despite the fact that the city's sloppy terrain is hardly encouraging. Most of the north sector of the city has over 5% of inclination, which is considered, according to technical handbooks (Transport for London, 2016), inappropriate for cycling (although some Brazilian technical handbooks suggest that a 10% slope is acceptable). Nonetheless, in 4 years, the amount of cyclable structures increased from 6,9 km in 2014 to 28,24 km in 2019. This public policy facilitated the implementation of bike lanes and bike paths in corridors where there was prior knowledge of the flow of cyclists, contributing to a better cycling experience in the city (Figure 9).

Most of the cycle tracks and cycle lanes are located in streets with high accessibility, mainly in 2,400m radius (which is related to a 10 minutes travel by bicycle). Most of them are lanes that are cheaper and easier to build than a cycle track. Also, due to conflicts of use of space, these infrastructures are located in wider streets. They are located around the city centre, but there are no cyclable structures built in the centre itself. The sector has short and narrow streets, which has low linearity / continuity to the main city corridors.

However, there is a conflict between the type of the bike structure and the flow of vehicles in the streets in which they were implanted. The bike lanes were implanted in roads with a high volume of vehicles travelling daily, which can generate safety problems. Cycle lanes make the cyclist more exposed and vulnerable to conflicts with cars, increasing the risk of accidents and run overs.

Figure 9: Cycle lane in Campina Grande, Brazil. Source: Google Street View, 2019.

Despite the positive advances in public policies to promote the use of bicycles as a means of transport in Campina Grande, it is necessary to review the type of infrastructure that is implemented, especially on roads where there is a greater flow of vehicles and greater chances of road conflicts. The city's urban mobility plan provides for the construction of more bike lanes on roads with high accessibility and traffic flow, and these are expected to be less exposed to cars.

7 CONCLUSIONS

This research aimed to understand the relationship between the allocation of cycling infrastructure and the potential movement of the urban network, as well as to assess whether the types of infrastructure are adequate or not in relation to the spatial accessibility of the streets. The findings indicate similarities and differences between Natal and Campina Grande, coming from public management practices in Brazilian cities and their geographical particularities.

The national mobility law (Brasil, 2012) provided incentive to bikeability in Brazilian cities, but the lack of articulation among institutional stances creates different scenarios depending on multiple factors in each city's local reality. Its approval came at a moment of progressive national policies that are currently in a process of institutional dismantlement - the extinction of the ministry of cities being a landmark in this process, which is having catastrophic consequences for Brazilian cities. The late approval of this national law also shows a long term history of social inequality and rodoviaristic urban planning, resulting in over sprawled urban areas and poor conditions for public transport and active transport users.

Both cities have low percentages of segments equipped with cicleviary infrastructure within the 10% most accessible segments in the measures and radii previously specified, especially Natal, a finding that appears worrying, considering that the analysis on movement flow and accidents indicates that those segments are the highest priorities for the implementation of safety measures. The percentage of infrastructure placed in segments of low accessibility showed to be relatively high.

Thus, it looks clear that the placement of infrastructure does not always take safety as a priority factor; and as economically impaired city regions are left unattended, there is a strong indication that part of this infrastructure placement is being used for real estate market speculation.

The case of Campina Grande was seen to be less dramatic than that of Natal for the characteristics related to bikeability, in spite of having a less appropriated topography for the practice of urban cycling. Being a smaller city and not a capital, with less consolidated car-oriented viary infrastructure and users seems to have played an important role in this development, which makes way for a conclusion at the same time hopeful and unsettling. While it points to a high potential of betterments in bikeability in small and medium sized cities, it also shows worrisome tendencies for larger cities and the need for fundamental reforms in their institutions.

The number of coincidences involving the location of cycling infrastructure and of variables relating to bikeability and the foreground network of highly accessible streets, measured for choice in specific radii, is expressive and points to the high potential of Space Syntax Analysis as a tool for understanding urban dynamics, foreseeing accident risks and creating guidelines for a safety-oriented sustainable urban mobility design.

The fact that each of the two cities examined here has its own radii that better coincides with each set of local data concerning bike usage, raises questions about which factors might underlie such relations. Possible conjectures have contemplated differences in the size of the urban area, steepness of topography, specific configuration properties that might favour a scale range in-between that of pedestrian and automobile movement, thus resonating with the investigations by Read and Lopes Gil (2017).

Due to the COVID-19 pandemic and the lack of updated statistical and socioeconomic data from the cities studied, it is recommended, for future studies, that other aspects such as income, land use, routes and flows of other modes of transport can be compared. to the location of cycling infrastructure, in an attempt to idenfy the potentials and limitations of the city's cycling network, contributing to public management and the formulation of improvement of this infrastructure.

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