

# Induction Factors of the Built Environment to Sustainable Mobility — The Case of the Nova Marquês do Paraná Project in the Downtown Area of Niterói/RJ, Brazil

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**Abstract:** This paper aims to analyze how the induction factors of the built environment from the revitalization works of *Marquês do Paraná Avenue*, in the central area of the municipality of Niterói/RJ- Brazil. Moreover, their relations with the advances brought by the Sustainable Urban Mobility Plan (PMUS) released in 2019, which influenced the transformations of the mobility paradigm along the avenue and in its nearby neighborhoods, were also objects of evaluation. It was applied an analytical and exploratory methodology of the attributes executed in the *Nova Marquês do Paraná Project*, evaluating the improvements of mobility noticed on the street when compared to the urban planning of this avenue in the past. It was possible to contrast the current induction factors of the built environment to sustainable mobility with the mobility attributes historically prevalent in the avenue that characterized it as a street axis of passage, inviting only motorized traffic. It was observed that these induction factors acquired the potential to transform local dynamics of displacement and permanence, induced the choice of active modes of travel integrated to public transport and enhance social, economic and leisure activities at the adjacent public spaces of the avenue. This research concluded that the new induction factors are means that can incorporate the human scale on the avenue, promote integrated management of public transport and land use and become reference practices for future masterplans and urban projects in Niterói and similar cities.

**Key words:** induction factors, built environment, PMUS, active mobility, Marquês do Paraná Avenue

## 1. Introduction

The structuring of mobility is one of the key elements for the planning and effective functioning of sustainable urban areas [1]. This organizational portion of the territory has been focused more and more on infrastructure to the active modes of travel linked to the formation of new centralities, the attractiveness of new land uses and the urban treatment of the built environment inserted in the networks of movement of people in cities worldwide.

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The emphasis given to the provision of hierarchical and integrated accessibility between modes of transport meets the demand to make urban spaces more attractive and safer to pedestrians and cyclists. A dynamic and attractive urban environment to this target audience must integrate sustainable ways of transport with different types of public space [2]. It is necessary to continuously review the conditions of juxtaposition between the spaces-design of encounter and experience of people (streets, avenues, squares and parks), the displacement spaces (stations, stops and means of transport) and the spaces generated (buildings, equipment and urban systems) to value the pedestrian and the cyclist. This integration between the three types of spaces is relevant for the induction of a better

readability of landmarks, arches and nodes along the routes, providing guidance and satisfaction to people and maximizing their feeling of belonging to the place [3].

Gehl and Hook (2010) [4] point out the need to harmoniously distribute urban furniture in the environment to provide pleasant breaks during commuting and build and conserve sidewalks and public spaces with quality paving materials. Germani (2004) [5] exhibits urban afforestation initiatives and landscape solutions to ensure climatic, acoustic, and aesthetic comfort on the streets. Rosito (2009) [6], in turn, shows urban lighting solutions with the objective of highlighting the importance of inserting remarkable luminance points in the paths to make the streets safe at night.

The principles that guide Transit Oriented Development (TOD) and the concept of Complete Streets advocate the balanced and safe integration between the public spaces for longer permanence of the pedestrian and cyclists and the routes of rapid flows of motorized traffic in central areas requalified. For such principles, Cervero et al. (2009) [7] and Grieco et al. (2015) [8] point out that a built environment of high density built, diversified and accessible in its activities and integrated with public transport directly influences the adoption of walks and cycling as first options for short trips, the known “first mile” and “last mile”.

The objective of this research is to analyze the recent transport planning paradigm shift towards sustainable mobility to the central area of Niterói, a municipality located in the metropolitan region of Rio de Janeiro, Brazil. Through the study of the Nova Marquês do Paraná Project, it is proposed to verify the hypothesis that the avenue presents improvements in patterns of active mobility and increase in social coexistence and vivacity on its public spaces. An analytical and exploratory methodology is chosen about the main induction factors already executed in the works of the Nova Marquês do Paraná Project, evaluating the positive points brought from the interventions and the

ones that still need to be improved. Besides, the search compares the actual local scenario with the urban planning of the avenue occurred in the past through urban and transport plans predecessors to the Sustainable Urban Mobility Plan released in 2019, such as the Jaime Lerner Plan dated to 2012.

It is expected that this study of the Nova Marquês do Paraná Project might help guide public policies and future urban projects in Niterói and other large and medium-sized Brazilian cities, which have urban contexts and morphologies like the Marquês do Paraná Avenue corridor. At the end, suggestions are formulated for future researches, aiming to fill the specific gaps on sustainable and active mobility themes, as well as to identify additional opportunities for Avenida Marquês do Paraná.

## **2. History and Urban Characteristics of the Downtown Area of Niterói and Its Reflections on Marquês do Paraná Avenue**

The Niterói city center and the neighborhood of *Icaraí*, more traditional places of the city, are connected by the corridor of Marquês do Paraná Avenue, main object of this search. These areas have urban singularities and planning references related to the embryonic process of development of the municipality dating from the nineteenth century.

Marcolini (2011) [9] observes two opposing models used in the history of urban planning in Niterói. The first, which has occurred until the early 1920s, was guided by the establishment of “neighbourhood centres” connected by junction points of the transport system, in particular, the tram lines services that were integrated with the ferryboat known as *Barcas*. At the same time, there was a dynamic local trade and an atmosphere of vibrant social life, as well as a small fleet of cars. Thus, *Icaraí* and the city center were pleasant neighborhoods to walking trips and had characteristics of urban development oriented to sustainable mobility.

However, this local scenario changed speedily under the influence of the European modernist highway

model developed in the twentieth century, through the growth of the motorization of the middle class, the decay of public management of trams, the urban expansion to neighborhoods far from the city center and Icaraí and the reduction of demand for metropolitan waterway transport.

In this scenario, the Marquês do Paraná Avenue acquired an essential role for the individual motorized transport network, as it became naturally the main circulation corridor of the city. Thus, the other transport modals, especially the active ones, had been devalued by the municipal administrations for years, being only rescued in recent decades. For this reason, it is observed that the actions and decisions for active mobility on the avenue did not reach the expected positive achievements, such as inducing walking and cycling trips, taking advantage of short distances between the neighbourhoods of downtown, *Icaraí*, *Santa Rosa* and *Fátima* (local average routes are around 1.5 km)

Fig. 1 presents a current satellite figure of the study's region, highlighting the network aspect of convergence of Marquês do Paraná Avenue (marked with the green square) in relation to the adjacent neighbourhoods (downtown in the upper left corner, *Fátima* in the upper right corner and *Icaraí* in the lower right corner).

Fig. 1 also shows the scale of proximity between the neighborhoods cited, emphasizing the potential for accessibility origin and destinations peers through walking trips and bicycles, the influence of the rugged topography that reinforces the compaction of the environment built, the lack of pleasant public spaces and alternative public transport routes, and the distribution of bus stops/shelters.

The mobility paradigm, once focused on motor vehicles, has been changing slowly in recent years, especially from 2019 to now through Niterói's recent urban and mobility policies, for instance the newest Master Plan and the Sustainable Urban Mobility Plan (PMUS). Therewith, these two instruments have been used more and more firmly by local managers in order



**Fig. 1 Aerial view of Avenida Marquês do Paraná and neighboring neighborhoods [11, 14].**

to reorient the urban development of the city center through the combination of active mobility improvements, diversification of land use and efficacy of public transport networks.

Within these transformative initiatives, Marquês do Paraná Avenue has gained prominence as from the realization, since 2018, of the *Nova Marquês do Paraná* Project. In June 2020, the first stage of this urban intervention was ready, being the first delivery of the PMUS project booklet.

In due course, it is perceived that, although the greatest advances made in the last two years, there are good heritages of the projects and plans prior to the PMUS for Marquês do Paraná Avenue. It can be cited as an example the inauguration of the work of Tunnel Angela Fernandes in 2013 provided by the Jaime

Lerner Plan, which was elaborated between 2009 and 2011. This plan could improve the safety of pedestrians and cyclists locally, by having diverted the flow of vehicles from the surface of the street. This allowed the availability of a walkable stretch with good conditions to the population and a greater fluidity of traffic from the descent of the Rio-Niterói Bridge to the neighborhood of *Icaraí*, separating it from the traffic directed to the city center [10].

Therefore, it can be seen through the last implemented projects that Marquês do Paraná Avenue has been undergoing a gradual change of paradigm of mobility towards walkability, cycling and an integrated public transport system. In addition, the potential of the built environment with efficient urban infrastructure, the population densification and the concentration of opportunities and activities make the referred project an alibi for the intensification of socioeconomic exchanges and local development.

For this reason, the following chapter proposes to present the attributes of sustainable mobility that were implemented in the *Nova Marquês do Paraná* Project.

### **3. Impacts and Expectations Related to *Nova Marquês do Paraná* Project**

The *Nova Marquês do Paraná* Project can be considered as a catalyst vector for the increase of walking and bicycles trips percentages in the modal matrix of Niterói for the coming years. It should be emphasized that the city has already an expressive 29.37% of walking trips and 4.04% in bicycles [11], but needs to advance even further in these active mobility types to reach the Brazilian average of 40.2%, considering both, observed in municipalities with a population of more than 60,000 inhabitants [12].

For this reason, the PMUS emphasizes the relevance of favorable topographic and dimensional conditions presented on Marquês do Paraná Avenue, such as the average distance of the displacements being equal to or less than 1.5 km. Beyond that, according to the literature, the savings of space consumed by

pedestrians and bicycles, in the order of 95% and 90%, respectively, when compared to the cars, are important to be argued as well for this scenario [11].

Regarding walkability, the requalification of the local sidewalks was guided by the Accessible Sidewalks Program [13]. In this program, the expansion, reform and standardization of sidewalks, the guarantee of universal ramps aligned with the pedestrian lanes on each corner, the regulation of horizontal and vertical signage, the spatialization of landscaping and afforestation and lightning elements were proposed to attract and give comfort to the users of this mobility infrastructure. All these induction factors were applied with the objective of transforming the Marquês do Paraná Avenue and others corridors into attractive poles of sociability, full of activities, making them urban boulevards [11, 14].

For bicycle enthusiasts, a two-way bike path was implemented and segregated from the vehicle lanes [11]. It is noteworthy that the cycling infrastructure is still restricted to the main roads connected to the Marquês do Paraná Avenue (as shown in Fig. 2), needing to spread it in the internal streets of the neighbourhoods.

Other points that can hinder the dynamics of active mobility on the avenue are the fact that the *Nova Marquês do Paraná* Project has considered the traditional “Predict and Provide” model by providing the construction of an additional traffic lane. It is seen as a weakening factor to encourage locally walking and cycling cultures as opposed to the ones related to cars and motorcycles. Another regional concern lies in the effectiveness of maintaining new pedestrian and cycling infrastructures in the coming years by future municipal management, as an offshoot of the *Nova Marquês do Paraná* Project.

Fig. 3 illustrates the planned changes for the *Nova Marquês do Paraná* project, highlighting the quality public sidewalks, the segregated bidirectional bike path, and the synergies of these elements with the revitalized environment of the avenue.



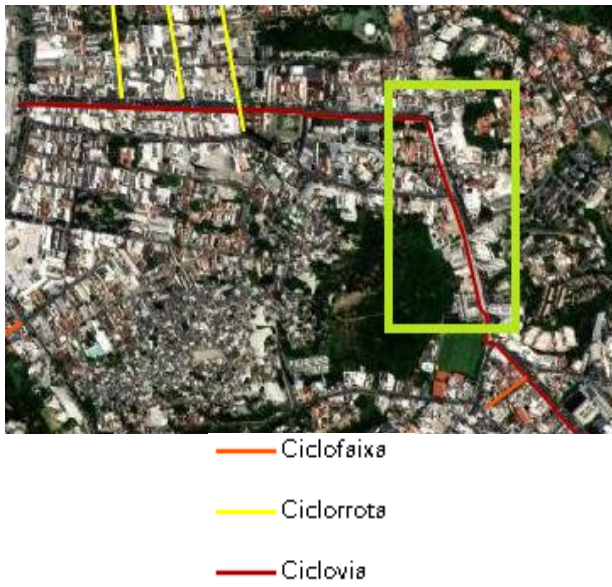


Fig. 2 Cycle Infrastructure and Av. Marquês do Paraná (green rectangle) [11, 14].



Fig. 3 Requalification project of Marquês do Paraná Avenue [11, 14].

Despite the limiting aspects previously presented, the renovation of sidewalks and the implementation of the bike path on *Marquês do Paraná* Avenue have great potential to positively modify socio-spatial relationships, provide more pleasant experiences of displacement, reduce the time lost in traffic jams and generate greater flexibility of movement and pauses during trips.

The landscape treatment of the avenue, including afforestation, new lighting and renovated urban

furniture are also seen as important urban induction factors to achieve aesthetic attractions and public safety for the displacements of the population.

Figs. 4 and 5 show the aspect of boulevard created on Marquês do Paraná Avenue, near the Tunnel Angela Fernandes, once a location of frequent road conflicts between pedestrians and drivers and degraded built environment.

The implementation of a new bay and bus stop above the Tunnel Angela Fernandes, previously located on the opposite side of Marquês do Paraná Avenue, in front of the Antonio Pedro University Hospital (HUAP-UFF), is also one of the aspects to stand out from the urban requalification. It has been representing an effective solution to the old road conflict between buses and automobiles occurred there, an important improvement for modal integration between bus lines and active modes and a local urban gain through the better use of the tunnel's upper slab that was previously poorly used as a place of displacement.

However, there is still a lack of integration between the new bus station and cyclists since there are not



Fig. 4 Boulevard Marquês do Paraná Avenue - Direction Centre.



**Fig. 5** Boulevard Marques do Paraná Avenue – Direction Icaraí.

enough shared bike racks or bicycles on site to perform the modal change. Figs. 6 and 7 present the before and after the situation shown of the bus stop on Marquês do Parana Avenue.

For the next few years, it is planned the continuity of the reurbanization works of Marquês do Paraná Avenue, adopting the same principles and guidelines of the first phase of the project. To ensure territorial development and mixed and attractive land use for active mobility on the avenue, the construction of a shopping center is on the list of priorities of municipal managers, as well as the use of urban voids and underused commercial lots adjacent to the avenue axis.

Another project predicted for the region in order to develop increasingly an integrated public transport system for Marquês do Paraná Avenue and its surroundings is the implementation plan of a Light Rail Vehicle line, including 1 (one) stop station in the vicinity of the future shopping center [15]. In this way, the urban integration and synergy between bus lines, VLT system, bike paths, great sidewalks and attractive buildings would be greatly enhanced and accessibility



**Fig. 6** Old bus stop in Marquês do Paraná Avenue near the tunnel Angela Fernandes (Source: Google Street View).



**Fig. 7** New bus stop in Marquês do Paraná Avenue and its integration with the bicycle lane.

to opportunities on the avenue, leveraged.

The proposal of the new mall has been dividing opinions between local urban managers and society to the extent that the impacts of the commercial enterprise on traffic and active mobility indicators on the avenue are not known for sure yet. Is it an extra incentive



factor for walking and cycling trips? What will be the impact of motorized traffic flow due to this attractive new travel hub? How to mitigate the impacts of the large supply of spaces planned for cars and motorcycles in the design of the mall's parking lot? Will walkability be the predominant behavior of mobility for those who live in the central area of Niterói and want to access this commercial enterprise? How will the shopping center modify the characteristics of the built environment of the avenue? What measures should be taken to improve public transport service for this new travel demand, including the future perspective of the Light Rail Vehicle line? Answers to these questions and other queries should arise to settle down a fruitful field of debates about the future of mobility and urban management in this important structuring axis of Niterói.

#### 4. Final Considerations

Active mobility proposes to be an alternative solution regarding the way in which public spaces are occupied and used, mitigating or even reversing, depending on the scale of a given urban intervention, the lack of accessibility on foot and by bicycle to places of coexistence and equity, full of social activities, commerce and leisure options. Thus, combining active mobility with new innovated models of built environment planning has the power of contributing greatly to the execution of urban projects that value above all the human scale. Else, this association can promote safe, inclusive and sustainable circulation strategies, and integrated management between transport systems and land use.

This article investigated the spatial dynamics of mobility and accessibility of Marquês do Paraná Avenue with repercussions in its border neighbourhoods (*Icaraí, Centro, Santa Rosa and Fátima*). It was observed that this avenue is affected by until now, despite the improvements made, the saturation of road capacity, significant traffic jams, and the imbalance between the spaces of walkability,

cycling and vehicle lanes.

The *Nova Marquês do Paraná* Project has brought encouraging perspectives for the diffusion of active mobility on the avenue, as well as the revitalization and appropriation of the adjacent deteriorated urban public space. Following the premises of the Niterói Master Plan of 2019 in line with PMUS, this intervention also seeks to induce the diversification of activities and new circulation ordering, making the avenue an attractive boulevard of walkability, cycling and sociability.

Due to this project, important modifications can already be noticed in the reinvigorated scenario of Marquês do Paraná Avenue, satisfying the hypothesis raised in the introduction. The remodeling of sidewalks and the implanting of bike paths showed positive results in this intervention's beginning, noticing good quality of the materials appointed and more pleasant experiences of displacement.

The landscape treatment, including afforestation, efficient lighting and renovated urban furniture, has enabled people to enjoy a region with more aesthetic attractions, and public and road safeties. The implementation of a bus stop reached through a segregated bay in the upper slab of the Angela Fernandes Tunnel, in turn, represents an important improvement to foster modal integration between bus lines and active modes, and a local urban gain through the better use of the built environment.

Despite the gains already achieved in the project, there is still a lack of shared bike racks, cycling routes and bicycle sheds supplied on site in order to intensify transport exchanges, and new attractive enterprises to promote walking trips in place of the exaggerated amount of particular motorized vehicles.

Finally, two local urban projects planned for the coming years were shown. The future implementation of a municipal line of Light Rail Vehicle, passing through the Marquês do Paraná Avenue with one stop stations predicted, can serve to reinforce the association of public transport, bike paths, sidewalks and accessibility to urban opportunities in the region.

The lease planning of a new mall at the avenue has been motivating a series of discussions about the positive and negative impacts of this enterprise in terms of road capacity, active mobility and built environment attributes such as density, diversity and urban design.

Both projects are seen as potential themes for future researches that aim to keep evaluating Marquês do Paraná Avenue post-requalification. This way, complementary studies about new travel generating centers in the region, such as the mall, and demand management evolution of active and motorized transport are suggested. For sure, these issues are lines to be searched deeply in an attempt to understand the actions already included in PMUS and in Niterói Master Plan, or possibly added in its developments, for the Marquês do Paraná Avenue scenario and, in extent, the entire central area of Niterói.

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