

URBAN RESILIENCE CONCERNING MOBILITY IN DOWNTOWN RIO DE JANEIRO - BRAZIL

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ABSTRACT

Urban Resilience is a city's ability to resist and regenerate in the face of chronic problems and stress. The objective of this paper is to analyze the current situation of aspects of resilience linked to mobility and transport infrastructure and, finally, to propose improvements for the city of Rio de Janeiro. Projects carried out in Rio de Janeiro and other cities will be evaluated based on the comparison of aspects of the urban mobility culture of each city, seeking to highlight the critical points and potential for improvement in Rio, considering applicability and feasibility in the current context of the country and the city.

Keywords: Urban resilience, Transportation systems, Urban mobility.

1 INTRODUCTION

In the urban context, resilience is directly associated with the challenges of the growing urbanization of cities across the planet, with the total urban area having increased from 10% in the 1990s to over 50% just two decades later (Meerow et al., 2016). Associating the fact that today most of the population lives in cities with projections that point to population growth occurring almost entirely in urban areas, it is concluded that the impacts caused by global phenomena such as climate change, or even problems related to inefficient management of services and resources, economic

crises and conflicts are more serious in these places than in non-urbanized areas (Sharifi & Yamagata, 2014).

The city of Rio de Janeiro – the second most populous in the country, with more than 6.7 million inhabitants – is subject to the most diverse problems caused by the accelerated saturation of the urban environment, in part due to representing a migratory focus since its foundation. Cities like Rio de Janeiro are characterized by constant expansion and are recurrently faced with larger-scale challenges compared to the vast majority of cities. Regarding governance issues, it faces increasing environmental and humanitarian crises, associated with the wide social and economic diversity intrinsic to the city (RIO RESILIENTE, 2016; WEF, 2016).

In recent years, the municipal government has shown a strong presence on the world stage of urban resilience and sustainable development, with relevant participation in large-scale projects such as the Rockefeller Foundation's 100 Resilient Cities (RC) and the C40 Cities Climate Leadership Group. The focus of work and investment in the city was to host the 2016 Olympics, in addition to considering the development that would take place in the years prior to the event (RIO RESILIENTE, 2016). A considerable amount of the developed projects were linked to mobility and also to infrastructure improvements in different regions of the city. One of the most relevant was the harbor area revitalization project. A region that played a fundamental role in the development of the city since the colonial period, when it represented the economic center of the city. Historically rich, the port area – comprising the neighborhoods of Saúde, Gamboa, and Santo Cristo – suffered neglect from the public authorities throughout the 20th century. In this context, the Porto Maravilha project provided for the recovery of the area and the reassessment of this abandoned space with precarious infrastructure (AZEVEDO, 2016).

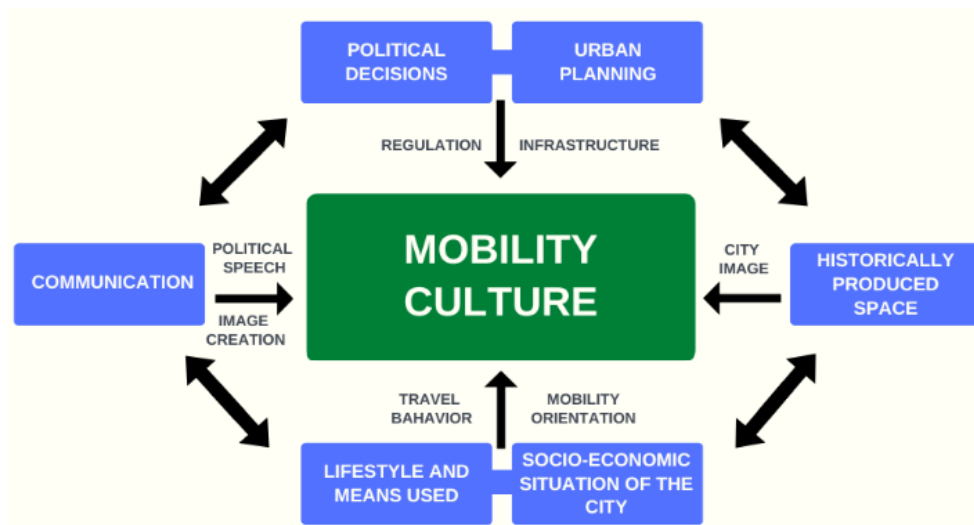
In addition to the harbor zone, the entire downtown area was also part of the municipal government's revitalization plans. Far from being a unique problem of the central region, the precariousness of transport services directly affects citizens' quality of life. Thus, mobility is a worrying factor in the city of Rio de Janeiro in terms of resilience (RIO RESILIENTE, 2016). The population finds itself hostage to low-quality public transport and high prices, which mainly affect the lower-income citizen, who is largely dependent on public services. This and many other trouble spots place the city in a vulnerable position in the face of recurring adversities that affect modern metropolises around the world. The fragility of the urban system explains the dimension of the challenge that Rio de Janeiro will face to become more resilient.

Therefore, the objective of this research is to analyze the current situation of resilience aspects related to mobility and transport infrastructure, and, to propose improvements for the city of Rio de Janeiro.

2 MATERIALS AND METHODS

Klinger et al. (2013) attribute the basic characteristics that can help define a city's mobility culture to 23 indicators that are summarized in the Mobility Culture Diagram (Figure 1). In this paper, an adaptation will be made of the German study "Dimensions of Cultures of Urban Mobility – A comparison of German cities" Klinger et al. (2016), applied in 44 cities. The 22 indicators present in the original research could not be used directly, as cities from different countries will be used for the evaluation carried out in this study.

Figure 1 - Mobility Culture Diagram



Source: Adapted from Klinger et al. (2013).

The cities choice for evaluation was based on the list of 100 RCs, as they already have the potential for resilience as a common feature. The difficulty in obtaining data was also a limiting factor in the analysis process, especially for data from qualitative surveys and public opinion, which depend on the existence of similar surveys for the cities studied. Another twelve cities participating in the 100 RCs were selected due to their relatively similar characteristics to those of Rio de Janeiro. Data were also obtained from five other cities that are not part of this German study, but which, as they appear in most of the mobility studies used as a basis for the proposed analysis, were included for comparative purposes.

The cities of São Paulo, Paris, London, Boston, New York, Santiago, Barcelona, Lisbon, Rome, Singapore, Chicago, and Toronto were evaluated, and Rio de Janeiro, which constitutes the group of thirteen cities of the 100 evaluated RCs that will be categorized. The five cities used for comparison are Hong Kong, Moscow, Berlin, Munich, and Madrid.

The combination of indicators makes it possible to comparatively evaluate the most important items in each city, based on their greatest weaknesses and strengths, as well as the topics to be improved for the development

of a greater degree of resilience. The indicators are divided into five categories: Public Assessment; Urban morphology; Socioeconomic data; Infrastructure; Demand and number of trips.

As the data come from different sources, with different measurement units, they will be standardized individually in a comparative way across cities.

The concepts of Resilience and Sustainability in Mobility were used to define the parameters for calculating the indicators. The relationship between the raw data and its impact on the city's mobility culture will indicate whether it adds value to the aforementioned resilience concepts. Numbers can vary between 0 (zero) - worst case - and 1 (one) - representing the value that would have a more positive impact on the cities' mobility.

For example, the Ticket/Average Wage ratio is inversely proportional to the quality in the mobility culture, as it represents a limiting factor for access to public transport. Considering "I" as the normalized value of the indicator and "V" as the raw data value (Eq. 1):

$$I_i = 1 - \frac{V_i - V_{min}}{V_{max} - V_{min}} \quad (1)$$

Satisfaction Index and per capita GDP indicators represent factors that positively influence the assessment of a city's Mobility Culture. Still considering "I" as the normalized value of the indicator and "V" as the raw data value (Eq. 2):

$$I_i = \frac{V_i - V_{min}}{V_{max} - V_{min}} \quad (2)$$

In some indicators that represent spatial and demographic characteristics, such as urban morphology, the relationship of influence on the Culture of Mobility is not easily analyzed based on raw data. For this reason, these indicators were initially defined as being proportional to the Culture of Mobility (the higher the value, the higher the indicator), so that they can be analyzed together with other indicators where this relationship is more evident, and finally associate them together. To assist in the consistency of the calculated indicators, three new indicators will be used. They will work as an external reference for evaluating the results of each category. Due to the complexity of the topic and the lack of in-depth studies on the categories individually, we will use the three sub-indices of the study developed by Arcadis in 2017 in the calculation of the Sustainable Cities Mobility Index, to highlight discrepancies and guide the results obtained from the raw data:

- People: It relates the social and human implications in urban mobility;
- Planet: Focused on environmental impacts and cities' future goals for mobility and sustainability;
- Profit: Related to the system's efficiency and reliability to facilitate growth and support local businesses.

Table 1 - Urban Mobility Culture Indicators

Category	Concepts in the Mobility Culture Scheme	Indicators
Urban Morphology	Historically produced space Urban planning	Population
		Urban density
Socioeconomic Data	Socioeconomic status of the city	per capita GDP
		Ticket/Average wage
Infrastructure	Infrastructure	Average travel time per day (min)
		% Long trips (+2h/day)
		Average waiting time (min)
		Average travel distance (km)
		% Long trips (+12km)
		% of people who make at least one connection on a route
		% of people who make at two or more connections on a route
		Average distance in 1 route (km)
		% Walking more than 1 km on a route
Extra congestion time		
Demand and Travel	Travel behavior	Motorized transport
		Modal division - On foot
		Modal division - Bicycle
		Modal division – Public Transport
		Modal division – Car
Public Opinion	Mobility orientation	Satisfaction in Public Transport

3 RESULTS AND DISCUSSION

Normalization will consider the raw data values, taking the maximum as benchmark 1 (one) and the minimum as benchmark 0 (zero). For indicators where the highest raw value represents a negative impact on mobility, the value will be inversely normalized, where the minimum value will represent 1 (one), and the maximum value will represent 0 (zero) in the indicator.

From the calculated indicators, the points in which each city stands out positively or negatively can be easily related.

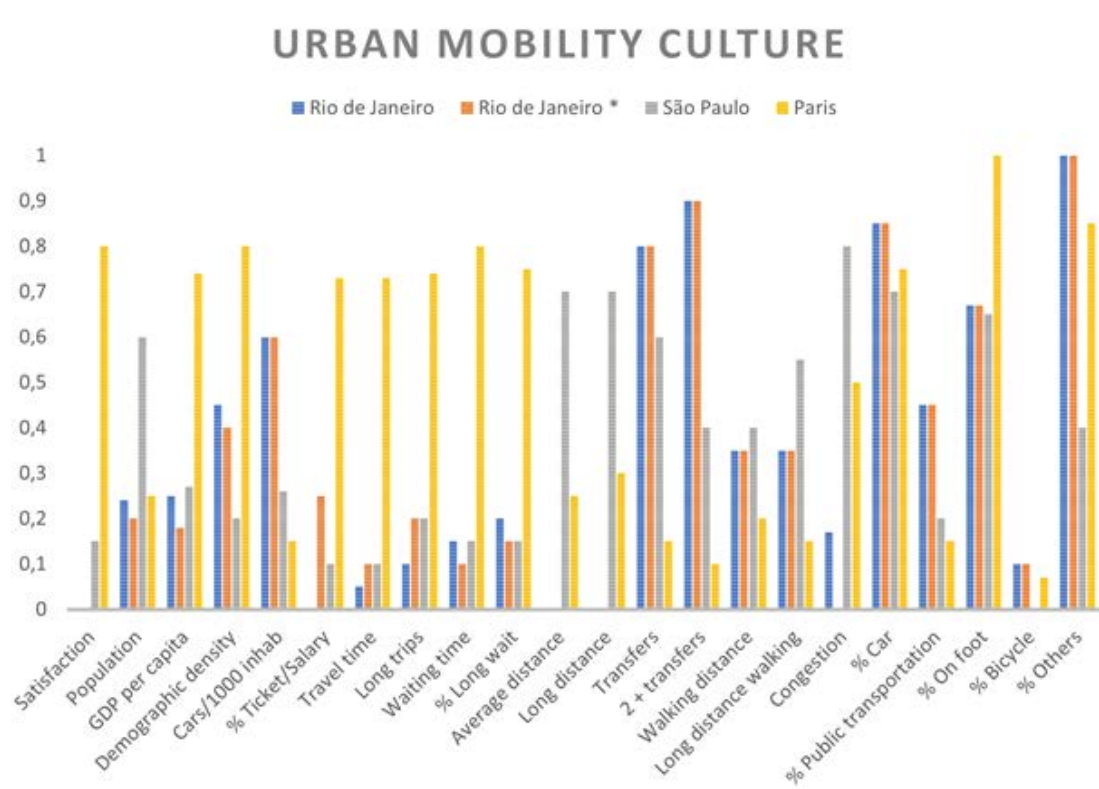
3.1 Strengths

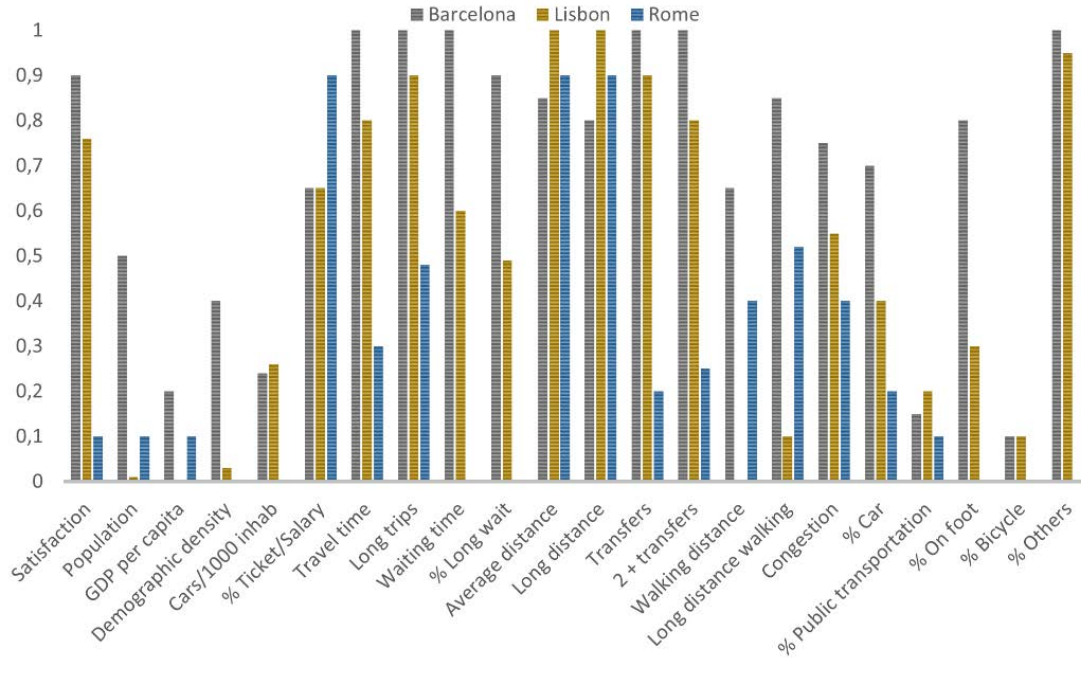
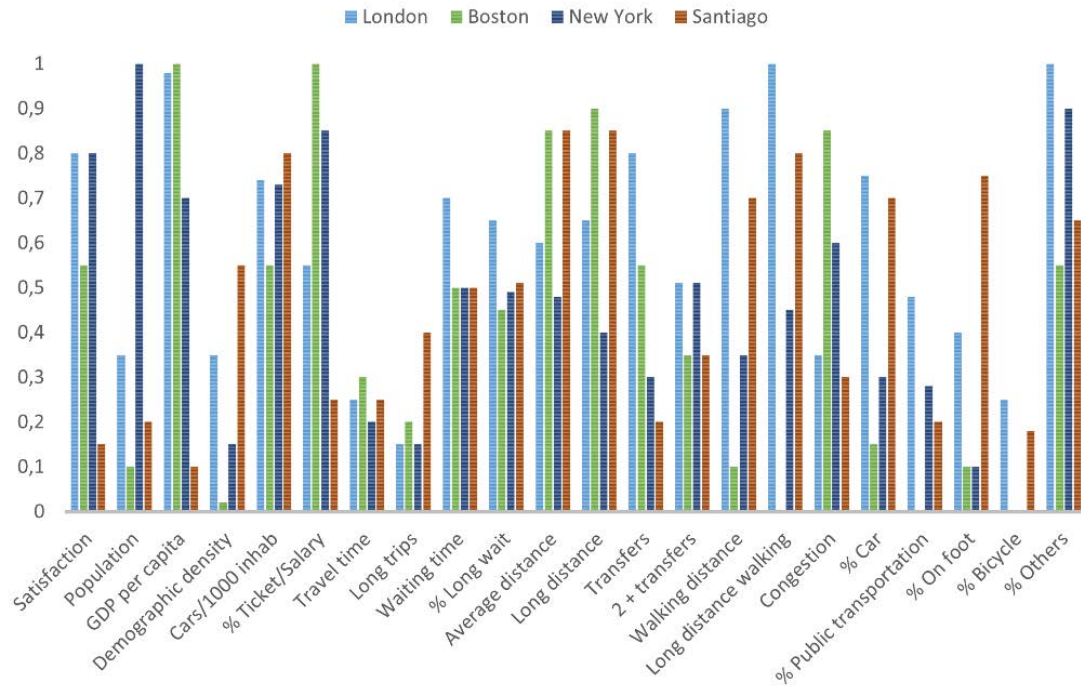
Despite being one of the main tourist centers in the country and having the second-largest GDP, inequality causes the city of Rio de Janeiro to lag behind in socioeconomic issues. The city has a wide variety of transportation modals, positioning itself at the top of the classification of these indicators. Investments related to major events tend to further improve these indicators for the next few years since many of the surveys refer to previous periods, or that occurred at the time of the events.

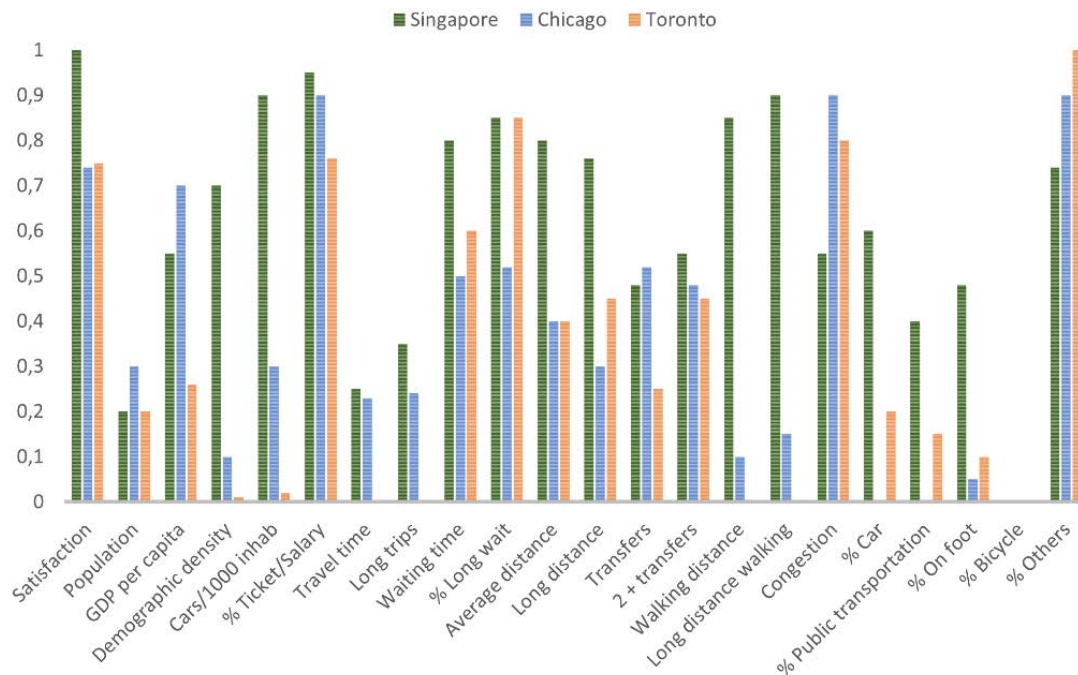
3.2 Challenges

As can be seen, the city of Rio de Janeiro stands out negatively in comparison with other cities in the 100 RCs, with a negative reference in four indicators (Figure 2): Satisfaction; Ticket/Average Wage; Average Travel Distance; Long Distance Travel. In addition, it is below average in the vast majority of indicators, being among the three worst positions in the other four indicators: Average Daily Commute Time; Long Trips; Average Waiting Time; and Long Waits. The satisfaction index is aligned with the result of the calculated indicators, mainly those that are directly related to the quality of the service offered and, consequently, affect the citizens' quality of life. Rio de Janeiro will be evaluated both in the period before and after the major events of the World Cup and the Olympics, seeking to show how the impacts were caused on the city's mobility. In the absence of data, the growth projection observed in previous years was used.

Figure 2 – Urban Mobility Culture







The estimated value of monthly expenses with public transport in the city of Rio de Janeiro is below most of the analyzed cities. However, on the other hand, the lowest salary among all cities makes the Ticket/Average Wage rate also the lowest. The inequality present in the city can be evidenced by placing the two socioeconomic indicators side by side, where Rio de Janeiro can be seen ahead of some cities in the per capita GDP. The population is spread throughout the city. With employment centers located mostly in the central region and few housing options nearby that are really accessible to the vast majority of the population, the average commute distance in Rio is the highest among all cities, exceeding 12 km in 37% of total trips. The average is above even what is considered a long-distance trip.

The indicators of Average travel time and Long trips, where Rio de Janeiro is just ahead of Toronto, are also explained by the above-mentioned reasons. The city's decentralization makes travel long and the population spends a good part of the day on the "home-work" route. The Extra Congestion Time indicator also highlights the mobility challenges in the city of Rio de Janeiro. The city is also in last place in this indicator, although there has been a considerable improvement between 2014 and 2016, reducing four percentage points. The city leads the modal share of public transport and cars, but unlike Toronto, congestion time remains high due to the poor quality of infrastructure, exposed by the recurrence of accidents and palliative maintenance works.

In addition to the difficulty of getting around the city and the long periods of trips that last longer than would be necessary for normal traffic, the population has to face long waiting periods for public transport. The city's congestion and the low quality of services result in transport that lacks punctuality and regularity of lines, increasing daily journeys by up to 40 minutes (Table 2). The decrease in extra congestion time is offset by the

increase in the monthly Ticket/Average Wage. Ticket price readjustments have occurred frequently in recent years, causing great dissatisfaction among the population.

Table 2 – Indicators – Best Placed and Rio de Janeiro’s Position

Indicator	Best Placed	Value	Rio de Janeiro’s Position	Rio de Janeiro’s Value
% Satisfaction	Singapore	83.00%	13	30.00%
Population (millions of citizens)	New York	18.90	6	6.69
Per capita GDP (USD)	Boston	96.05	9	45.60
Urban density (1000 inh./km ²)	Paris	9.19	4	5.57
Cars / 1000 inh.	Singapore	101.00	7	305.00
% Ticket / Average Wage	Boston	2.00%	14	9.50%
Average travel time per day (min)	Barcelona	50.00	13	95
% Long trips (+2h/day)	Barcelona	8.00%	13	32.00%
Average waiting time (min)	Barcelona	10.00	11	19.00
% Long wait (+20 min)	Barcelona	9.00%	11	35.00%
Average travel distance (km)	Lisboa	6.30	13	12.30
% Long trips (+12km)	Lisboa	10.00%	13	37.00%
% of people who make at least one connection on a route	Barcelona	58.00%	4	62.00%
% of people who make at two or more connections on a route	Barcelona	13.00%	2	16.00%
Average distance in a single walking (km)	London	0.53	8	0.70
% Walking more than 1 km on a route	London	11.00%	8	21.00%
% Extra congestion time	Chicago	26.00%	13	47.00%
% private car	Rio de Janeiro	20.00%	1	20.00%
% public transport	Rio de Janeiro	49.00%	1	49.00%
% on foot	Paris	46.00%	5	29.00%
% bicycle	London	5.00%	3	2.00%
%others	Rio de Janeiro*	0.00%	1	0.00%

3.3 Proposals and Recommendations for Potential Improvements

Among the related items, some topics of potential development stand out, ordered by level of complexity:

- Expansion of metro and light rail vehicle (LRV) lines to areas of interest (airport, bus station, etc.): Still far from ideal, the city’s economic limitations prevent investment in expanding existing systems.
- Construction of elevated urban roads/viaducts: Because they are visually less pleasant, the possibility of implementing these structures is usually rejected, even though they may represent a cheaper and faster solution to the problem of traffic retention, as is already the case in several cities around the world.
- Encouraging decentralization through the creation of new economic micro-poles in different regions of the city: This is a

medium to a long-term solution, as it depends on the stabilization of these locations. Since its foundation, the city has revolved around the port area and central region, and most of the opportunities and investments are located in these places. The city still presents some resistance to this decentralization trend, which is strongly recommended in the development of urban resilience due to social, environmental, and economic factors, among others.

- An incentive for the occupation of the Port Area: The focus of most investments is linked to major events, the region has evolved in terms of infrastructure, but is still unoccupied. The insecurity of the population and investors in the State economy as a whole means that confidence does not grow and investments are held back. The economic crisis faced by the city affect the continuity of investments that started long before 2014. Actually, much of what was placed in the port region was not used or is being underutilized. The region has great potential due to its privileged location. With the increase in the presence of companies and residents, the trend is to attract investment again.
- Creation of Special Transport Tickets for Residents: The city has several modals that work in isolation. Intermodality is precarious, which affects the resident's budget and limits access to mobility. Some systems offer a certain interface between them, but nothing effective that significantly improves the population's quality of life. The creation of transport tickets for residents, valid from one month to one year, following European standards, could present an accessibility solution. With a limited number of daily accesses and the payment of a fee that would represent a lower value for each trip, it would influence the population to use public transport, which could reduce congestion levels. In this context, the growing home office movement can also help to significantly reduce the number of passengers, if adopted on a massive basis.

4 CONCLUSIONS

The concept of resilience has gained notoriety around the world for the importance that has been given to the development and preparation of the entire urban environment so that it is not vulnerable to the most varied problems and challenges that cities currently face. The diagnoses carried out together with the 100 RCs demonstrate the seriousness of the situation in the city. From problems related to climate catastrophes to problems intrinsic to the structure (or lack of it) for the most diverse basic services, such as sanitation, security, and transport.

The evaluation carried out in this work, concerning the aspects that define the city's mobility culture, can reinforce the idea that the transport quality and access to mobility in Rio de Janeiro are extremely precarious. Therefore, globally, it presents the worst situation concerning these aspects within the cities used for comparison. Indeed, the city showed an

evolution between the years that comprised the holding of the World Cup in Brazil and the Olympics in Rio de Janeiro, but the population's satisfaction is still not at an acceptable level. But it is important to emphasize that Rio de Janeiro has the potential to change these parameters and, therefore, proved to be suitable for international institutions that were able to host large-scale events that took place in the city.

There are projects that, if executed and implemented correctly, in the way they were planned, can bring to Rio the legacy that was promised when the city accepted to host these major events. However, the ills of governance that is often questionable, make the confidence of the population and foreign investors tend to decrease more and more. For the city of Rio de Janeiro to be truly resilient, the spheres responsible for the feasibility and execution of projects must act with efficiency and transparency. This is the only way to make the city grow economically and improve the citizens' quality of life.

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