Analysis of the Quality of Bike Lanes of the Municipality of Balneário Camboriú, SC - Brazil

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1. INTRODUCTION

In the last decades, we have seen a world that was predominantly rural and completely transformed. Migration to cities and the increase in the rate of vegetative growth have transformed the urban landscape.

According to Rogers (2001), between 1950 and 1990, the world population living in cities increased tenfold, from 200 million to over 2 billion. This population is extremely consuming and polluting, consuming three quarters of all energy produced on the planet and producing this same number of pollution.

According to data from 2009 of the Brazilian Association of Manufacturers of Motorcycles, Mopeds, Scooters, Bicycles and Similar (ABRACICLO), Brazil is the third largest producer of bicycles and has a fleet of 60 million bicycles. The bicycle is the most used vehicle in cities with less than 60 thousand inhabitants, where collective transportation is practically non-existent. On the other hand, in medium and large cities, with rare exceptions, the use of bicycle transport is well below its potential, being used most often by the upper middle income class and the very low income classes. The latter in greater number, making use of modal as a mode of transport (Ministry of Cities, 2015).

The lack of preference for cycling as circulation is linked to many reasons, but the main one is the great difficulty to move with safety, comfort and quality.

The city of Balneário Camboriú, where this study is applied, is located on the north-central coast of Santa Catarina and 85km from the state capital, Florianópolis. Its area is 46,238 km² and has an estimated population density of 2,848.89 ha / km², one of the highest in Santa Catarina (IBGE, 2017). According to interviews with a portion of the population for PlanMob (AMFRI, 2015), 11% of the population use the bicycle daily for their displacement.

The Cycle Quality Index (CQI) is the adequacy of the variables of the Walkability Index (CI) of the sidewalks for the cycle paths. The quality of cycle routes, which also includes their safety, is capable of contributing to users' satisfaction and consequently to increasing the use of this type of modal in the daily commutes of the population in general. Therefore, based on the problem addressed, this work consists in evaluating the quality of the bicycle paths in the municipality of Balneário Camboriú through the Cicloviária Quality Index (CQI).

With an innovative character, the Cycle Quality Index (CQI) seeks to discuss and establish criteria that will serve as a guide for future public interventions and private actions, especially the managers of municipal publics, in relation to mobility on cycle paths and the insertion of new routes.

The choice of the theme is justified as a result of the attention that Brazilian public policies for mobility start to look at the bicycle. It begins to be thought of as an efficient resource for urban sustainability and as a transforming agent of society, starting to be used in the modal cycle for displacement, in addition to leisure activity.

1.1 - Urban Sustainability

The concept of sustainability or sustainable development dates back to 1987 through the document prepared by the World Commission on Environment and Development as a result of the 1972 United Nations Conference on the Human Environment held in Stockholm called the Brundtland Report. sustainable development is one that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Following the urban legislative bias, the City Statute itself, in item I of Article 2, establishes as guideline, "the guarantee of the right to sustainable cities, understood as the right to urban land,

housing, environmental sanitation, urban infrastructure , transportation and public services, work and leisure for present and future generations".

For Freitas (2012, p.41) sustainability goes beyond what is established in the CRFB and in the City Statute, because it is the:

> "responsibility of the State and society for the solidary realization of material and immaterial development, socially inclusive, durable and equitable, environmentally clean, innovative, ethical and efficient, in order to ensure, preferably in a preventive and to well-being".

For Rogers (2001), the sustainable city must meet social, environmental, political, cultural, economic and physical objectives. It also states that a sustainable city is a fair city - equal in access to essential goods and services and with democratic management; beautiful; creative; ecological - where its impacts on the environment are minimized, where the buildings are balanced with the landscape and are safe and efficient; easy city - with accessible communication, both personally and electronically, and where public power encourages pedestrian mobility; compact and polycentric - that protects its rural area, concentrates and integrates the community in the neighborhoods, reducing distances; and finally, a diverse city with a wide range of activities that generate vitality and public life in the urban environment.

Gehl (2016, p.04) adds that "the sustainable city is the one that recovers the human scale as a development objective, which implies, among other challenges, to promote a more equitable and sustainable mobility, cycling and public transport".

In the last decades of the twentieth century, three isolated urban movements end up together providing philosophical and practical foundations for the creation of sustainable urbanism. These are: Intelligent Urban Growth, New Urbanism and the U.S. Green Building Council - USGBC (FARR, 2013).

Sustainable Urbanism is defined as having a good public transport system, with the possibility of walking, with buildings and high-performance infrastructure, compact and mixed-use neighborhoods, densification of areas already equipped with infrastructure and human access to nature (FARR, 2013).

Smart urban growth adopted principles such as the creation of neighborhoods where pedestrian locomotion was possible; where transport had a variety of choices; mixed soil use; promotion of interesting places with a strong sense of place; urbanization of areas where infrastructure and neighboring communities already existed; among others. The New Urbanism adopted principles very similar to the one of the Intelligent Urban Growth, however, its greater contribution was the proposal of the Intelligent Code, that came to replace the existing Zoning Codes, creating an open structure that established criteria to be adopted locally. The USGBC initially proposed the construction of sustainable, self-sustaining, energy-saving buildings and that most of them from LEED (Leadership in Energy and Environmental Design) certified renewable sources; ten years later the vision passes from the autonomous unit to a more comprehensive vision, also worrying about land use and transportation (FARR, 2013).

According to the Urban Strategy for Urban and Local Sustainability (EESUL), in order to promote sustainable development in cities, it is necessary to review current construction models and to elaborate, in a participatory way, a project for cities based on new economic, social and environmental practices. (BRAVO, 2012).

Thus,

> “urban sustainability can therefore be understood as a process to be followed, prioritizing social and human development, in its diversity, with the capacity of environmental support. This means cities with resource savings in matter and energy, strengthening cultural identities, reducing social inequalities and urban spatial segregation "(ACSELRAD apud Ministry of Environment, 2011).”

1.2 - Sustainable Mobility

As we saw earlier, urban sustainability can be achieved through a variety of practices, including urban mobility. Sustainable mobility is achieved when it promotes equality in the possibilities of displacement, when it facilitates access to the activities of a region, when fossil fuel consumption is reduced, and when CO2 generation from means of transport is reduced (CAMPOS et al, 2005).

Today, in Brazil, individual motorized transportation is still prioritized. This fact leads, in addition to environmental problems, to public health problems. The emission of CO2 into the

atmosphere, produced by cars, is one of the responsible for the greenhouse effect, as well as the environmental degradation resulting from it. On the other hand, the issue of public health ranges from the index of obese people due to sedentary lifestyle, pulmonary problems caused by poor air quality, stress caused by congestion, and accidents that leave countless injured (Instituto de Energia e Meio Ambiente 2010).

In most of the time, in search of answers to urban mobility, new roads are created for automobile traffic, further reducing green and leisure areas, public spaces, commercial areas and leisure centers (Institute of Energy and Environment Environment, 2010).

For Gehl (2015), transport is a relevant factor in urban sustainability, since it is a massive consumer of energy, responsible for the large carbon emissions in the atmosphere and pollution. According to the same author, the transportation system in the United States is responsible for 28% of carbon emissions. This number in Brazil is 18.2% (OC apud Ministry of Cities, 2015).

According to Costa (2008, p.08) "the worsening of transport problems and the need for a new approach to mobility planning have motivated the adoption of sustainability concepts."

Transport issues have been included in several international treaties, conventions and declarations, with environmental prerogatives, and have highlighted the need to change the sector's behavior patterns, charging for investments in less polluting technologies and circulation systems that reduce environmental impacts associated with urban mobility, ie sustainable mobility (Ministry of Cities, 2015).

Sustainable mobility can then be defined as one that contributes to economic and social well-being without harming human health and the environment. (COSTA, 2008).

Costa (2008) complements that for transport to be sustainable, it must meet the basic needs of access and mobility throughout society in a healthy and ecologically balanced way, and promote equality within and between generations; is financially accessible, efficient, offers user options and supports a dynamic economy and regional development; and limits the emission of gases into the atmosphere, uses renewable energy sources; minimizes the use of the ground and the emission of noises.

The TRANSLAND project offers some ways to encourage the use of more sustainable modes and reduce the use of the private car: increasing the quality and accessibility of public transport services; make walking and cycling more attractive; reduce travel demand by using the soil in a diversified way, reducing distances; remove psychological barriers to the use of transportation alternatives and obtain public support through policies that encourage greater use of these alternatives; make transport an essential component for the development of spatial planning strategies (Erl & Feber apud CAMPOS et al 2005).

Thus, from the environmental perspective, it is necessary to adopt a set of measures that, at the same time as enabling the best environmental performance of public transport, also promote the modal transfer of individual motorized transport to non-motorized and collective modes (Ministry of Cities, 2015).

1.3 - The Bicycle as a Modal Sustainable

Bicycles are inserted into society with the precursor of the current model, in the year 1885. In the early twentieth century, it divided the streets with the other modalities of the time, such as the tram, carriage and pedestrians. As cities grew and expanded their territories and distances, as well as increasing the speed of movement, bicycle transport became unsafe, giving rise to motorized transportation, and consequently reducing its use. Since the 1960s, with the advancement of the automobile industry, the change of streetcars by buses, and the ever-increasing speed, the bicycle has been used almost exclusively for leisure (SILVA, 2014).

According to the Ministry of Cities (2015), cycling is one of the most efficient and appropriate means of transportation for short distances, in addition to its low operating costs. As sustainable modal, the bicycle does not emit pollutants; reduces congestion on the streets; reduces the noise level in the road system; provides greater equity in the appropriation of the urban space destined for circulation; decreases the use of the ground, allowing more free areas for leisure; enables the composition of more pleasant, healthy and clean environments; contributes to the reduction of urban costs due to the reduction of road systems for motor vehicles; and increases the quality of life of the inhabitants, reducing sedentariness and accidents, as it generates a quieter traffic pattern.

IDB and Gehl (2016) further notes that, on individual benefits, cycling helps prevent disease and contributes to improved physical and mental health. In relation to cities, the use of the bicycle makes them safer and more attractive, allowing a new way of seeing the landscapes of the place, at a slower speed.

However, in order for the population to be encouraged to use the modal cycle, a series of changes, starting with the cultural one - where the individual automobile is status - is necessary, going through the infrastructure of the bicycle lanes and educating all the traffic for that purpose. For Gehl (2015), the comfort and convenience of the bicycle networks are part of their infrastructure, and are fundamental to generate a pleasant and comfortable or tedious and difficult pedaling.

Many of the criteria used to evaluate the quality of sidewalks can be used in cycling networks. The Cicloviária Quality Index (CQI) was adapted to the modal cycle from the Walkability Index (CI) by Width (2009), developed by Siebert and Lorenzini (1998) and Santos (2003), and is based on the developed Canadian methodology by Bradshaw (1993) to analyze the quality of sidewalks. The ten criteria adopted to compose the CQI are: leveling, environment, safety in the course, safety in the crossing, comfort, paving, lighting, signaling, physical continuity and width of bicycle paths.

3 METHODOLOGY

The present study was an exploratory and descriptive study in which the index evaluated the quality of the bicycle paths through indicators.

The first step consisted in identifying and mapping in the ArcGIS 10.1 software the existing bicycle paths in the municipality of Balneário Camboriú and the stretches that were analyzed. For this, a search was made in secondary databases in the city and in loco.

The quality analysis was applied to all the city's bicycle lanes, selecting three 250m sections of each, through in situ observation and Google Street View of the 10 descriptors used by CQI.

Each descriptor received a score of one, a half or zero (Table 1), referring respectively to a situation of satisfactory quality until a situation of unsatisfactory for the displacements.

Table 1- Descriptors used for the elaboration of the Cycle Quality Index (CQI)

DESCRIPTORS - CYCLEWORK QUALITY INDEX (CQI)	**PUNCTUATION**
Bike Lane Width	
Bike Lane with free width equal to or great than 2.5m	1,0
Bike Lane with free width of 1.5m or less	Zero
Physical Continuity	
There is no difference, for a stretch of bike lane greater than 200m and with no gradient at the ends or with a ramp	1,0
It has a slope, for a stretch of bike lane less than 200m and with a slope at the ends or without a ramp	Zero
Leveling	
Track level, for bike lane with a transverse slope equal to or less than 2%	1,0
Elevated track level, for bike path or cycle path with transverse slope between 2% and 6%;	Zero
Paving Conditions	
Bike Lane with paving in good condition	1,0
Bicycle path or cycle path with poorly maintained paving (slippery, uneven, with holes)	0,5
Bike Lane with paving that does not exist	Zero
Safety on the Way	
Separate bike-lane or independent cycle lane	1,0
Separate cycle path of motorized lane through paint	Zero

Security at the Crossing	
Safe crossing (crossing lane, signposting, traffic light, crossing in unevenness, etc.)	1,0
Crossing with reasonable security (presence of at least one item)	0,5
Unsafe conditions	Zero
Signaling	
Presence of signage along the whole stretch of the bike lane	1,0
Bike Lane without signaling	Zero
Comfort	
Bike Lane presenting urban furniture and afforestation	1,0
Bike Lane without urban furniture and without afforestation	Zero
Lighting	
Bake Lane well illuminated	1,0
Bike Lane partially illuminated	0,5
Bike Lane without lighting	Zero
Surroundings	
Bike Lane with pleasant surroundings	1,0
Bike Lane with neutral environment	0,5
Bike Lane with neutral environment	Zero

Source: The Author

Data crossing was performed in the ArcGIS software through a simple mean of the score assigned to each of the variables. The final result was separated into four class intervals (Table 2), indicating the quality of the bicycle path through the qualitative descriptor.

Table 2: Class Intervals of the Cycle Quality Index referring to its quality analysis and intervention priority.

CYCLEWORK QUALITY INDEX	PRIORITY OF INTERVENTION
0 a 1,9	Critical situation
2,0 a 3,9	Immediate intervention
4,0 a 5,9	Short-term intervention
6,0 a 10,0	Improvements and improvement

Source: Santos, 2003

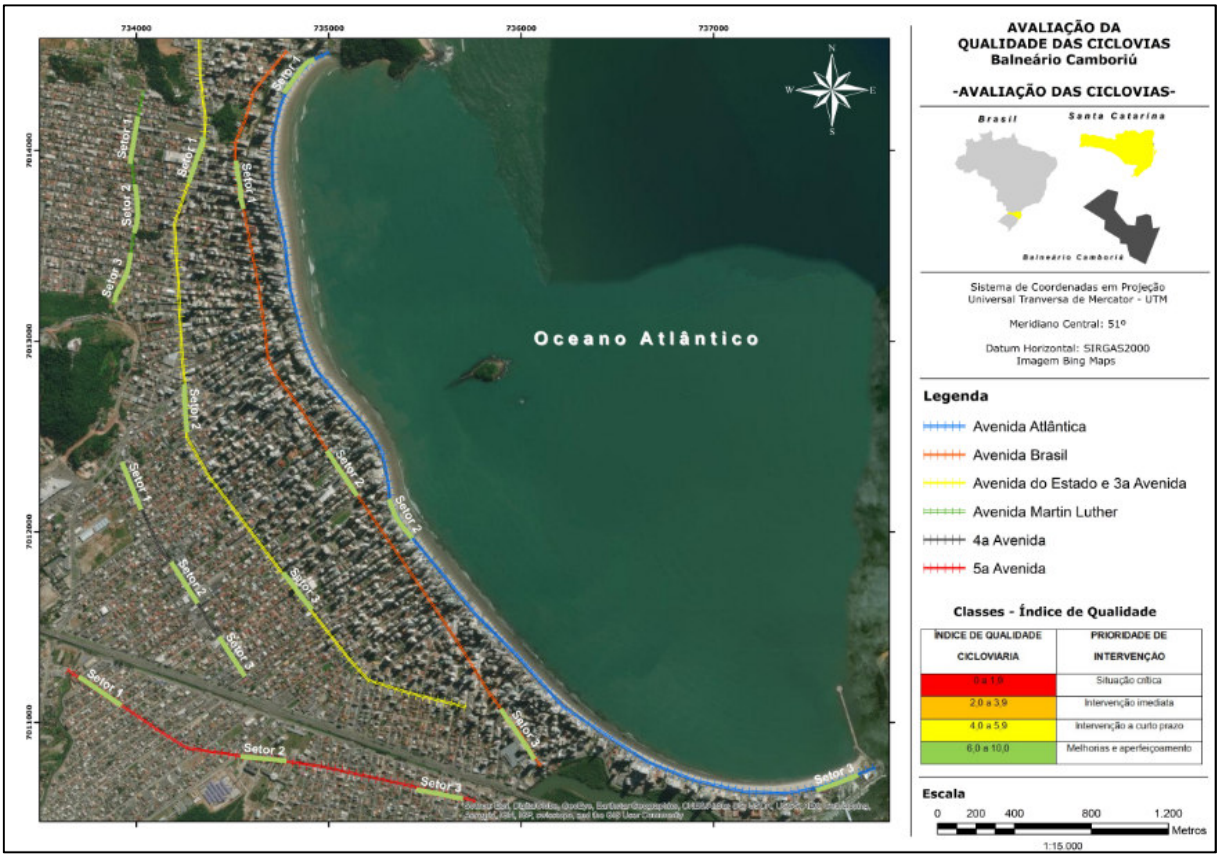
In the third stage, the data were transformed into a thematic chart, where the quality of the cycle paths was compared with the results obtained by the CQI for each section of the avenues analyzed.

4 MAIN RESULTS AND DISCUSSIONS

With the application of the simple average of the grades obtained through each of the ten evaluation criteria, a classification was obtained for each section of the avenues analyzed. For this, only the avenues of the municipality of Balneário Camboriú were chosen, which had bike paths: Atlantic Avenue, Brasil Avenue, State Avenue / 3rd Avenue, Martin Luther Avenue, 4th Avenue and 5th Avenue.

In general, all avenues analyzed reached the same class of cycleway quality (Figure 1), presenting averages between 6.0 and 10 and needing improvement and improvement in the stretches. However, the places that reached the highest and lowest averages were Martin Luther Avenue and State Avenue / 3rd Avenue, respectively.

Figure 1: Classification map of the analyzed sections of the Balneário Camboriú cycle routes according to the Cycle Quality Index.



Source: The Author

4.1 - Atlantic Avenue

The analysis performed at Atlântica Avenue showed that the sections reached an average of 9.5, except for 4800th Street until the end of the avenue, where the criteria for leveling and safety on the way were 0.5, mainly due to painting failures, which resulted in a final average of 9. However, this was the third avenue analyzed with the highest scores (Table 3), second only to Martin Luther Avenue and Brasil Avenue.

The high scores portray how location is a factor that influences the quality of infrastructure by the Municipal Public Administration. This is due to the fact that it is a seafront avenue, presenting itself as the most important in the municipality and receiving more flow of people daily when compared to the others.

Table 3 - Score of the stretches of Atlântica Avenue in relation to the quality classes of the analyzed cycle routes

Atlântica Avenue			
	Beginning of the Avenue	Street 2300 - Street 2500	Street 4800 - End of the Avenue
Width	1	1	1
Continuity	1	1	1
Leveling	0,5	0,5	0,5
Paving	1	1	1
Safety on the course	1	1	0,5
Safety on board	1	1	1
Signaling	1	1	1
Comfort	1	1	1
Lighting	1	1	1
Surroundings	1	1	1
Total	**9,5**	**9,5**	**9**

Source: The Author

4.2 - Brasil Avenue

The Brasil Avenue was the place that presented one of the best averages for the three sections analyzed, being behind only Martin Luther Avenue. This is due to the fact that it is an important commercial route of the municipality, happy shopping of the most diverse sectors, restaurants, shopping, and all the infrastructure that the locals and tourists need, besides its proximity to the sea.

The only evaluation criterion that presented a score lower than one point was the leveling for the three sections analyzed (Table 4), showing that slope is a problem that can disrupt the quality of the bicycle path and present a risk to cyclists mainly due to the mouths of wolf, designated place for the water flow.

Table 4 - Punctuation of the stretches of Brasil

Brasil Avenue			
	Street 1901 - Street 1301	Street 1500 – Street 2050	Street 3604 – Street 3700
Width	1	1	1
Continuity	1	1	1
Leveling	0,5	0,5	0,5
Paving	1	1	1
Safety on the course	1	1	1
Safety on board	1	1	1
Signaling	1	1	1
Comfort	1	1	1
Lighting	1	1	1
Surroundings	1	1	1
Total	**9,5**	**9,5**	**9,5**

Source: The Author

4.3 - State Avenue / 3rd Avenue

The stretches belonging to State Avenue / 3rd Avenue were the ones that presented the lowest averages in general, as much for the width of the bicycle paths as for the safety in the crossing, lighting and environment.

The low means, when compared to the other avenues, are due to the fact that it is a site of intense flow of vehicles, giving access to several areas of the city and also to nearby cities. In addition, it is a more distant avenue, with less flow of people and tourists who do not receive as much attention from municipalities as the places with the largest population.Table 5 presents the scores of each section in relation to the quality indexes of the bicycle lanes.

Table 5 - Punctuation of the stretches of State Avenue / 3rd Avenue

State Avenue /3rd Avenue			
	Street Tailândia - Street Paraguai	Central Avenue - Alvin Bauer Avenue	Street 2300 - Street 2500
Width	0	0	0
Continuity	1	1	1
Leveling	1	1	1
Paving	1	1	1
Safety on the course	1	1	1
Safety on board	0,5	0,5	0,5
Signaling	1	1	1
Comfort	0	0	0
Lighting	0,5	0,5	0,5
Surroundings	0,5	0,5	0,5
Total	**6,5**	**6,5**	**6,5**

Source: The Author

4.4 - Martin Luther Avenue

Martin Luther Avenue presented the best scores for all the excerpts and criteria analyzed, which obtained one point each, being the place with the highest CQI average found.

As a new construction, inaugurated in 2011, its entire structure was designed and designed to the standards required to maintain its quality. Thus, the width of the bicycle paths, pavement, lighting and other descriptors guaranteed an average of 10 in the three stretches of the avenue (Table 6).

Tabela 6 - Score of the Martin Luther Avenue stretches in relation to the quality classes of the analyzed bicycle paths

Martin Luther Avenue			
	Beginning of the Avenue - Street Peru	Street Panamá - Street Líbia	Street Jordânia - Street Iraque
Width	1	1	1
Continuity	1	1	1
Leveling	1	1	1
Paving	1	1	1
Safety on the course	1	1	1
Safety on board	1	1	1
Signaling	1	1	1
Comfort	1	1	1
Lighting	1	1	1
Surroundings	1	1	1
Total	**10**	**10**	**10**

Source: The Author

4.5 - 4th Avenue

The 4th Avenue was classified as the second lowest average among the analyzed avenues, being ahead only of the State Avenue / 3rd Avenue (Tabela 7).

This site contemplates the stretch that obtained the lowest score among all the other sections analyzed of the municipality, which is located between 2400th Street and extends to the end of the avenue, reaching an average of 6 due to the comfort that obtained zero points.

The main criteria that presented scores lower than one point for the three sections analyzed were width, zero points, and pavement, safety in crossing, lighting and surroundings with half a point each.

Tabela 7 - Pontuação dos trechos da 4rd Avenue em relação às classes de qualidade das ciclovias analisadas

4rd Avenue			
	Street 200 - Street 600	Street 1500 - Street 2000	Street 2400 - End of the Avenue
Width	0	0	0
Continuity	1	1	1
Leveling	1	1	1
Paving	0,5	0,5	0,5
Safety on the course	1	1	1
Safety on board	0,5	0,5	0,5
Signaling	1	1	1
Comfort	1	1	0
Lighting	0,5	0,5	0,5
Surroundings	0,5	0,5	0,5
Total	**7**	**7**	**6**

Source: The Author

4.6 - 5th Avenue

Fifth Avenue presented the average 8 (Table 8) for the three sections analyzed, the main criteria being responsible for this result comfort, which obtained zero points, and the width and surroundings that reached half a point each.

This result was obtained due also to the location, since it is the most distant avenue of the urban center more condensed, having a narrow cycle-band, lack of urban furniture, without arborization and with neutral surroundings.

Table 8 - Scores of the 5th Avenue sections in relation to the quality classes of the analyzed cycle routes

5rd Avenue			
	Street Camboriú - Street Curitibanos	Street Alfredo Wagner	Street Dom Sebastião - Street Dom Gregório
Width	0,5	0,5	0,5
Continuity	1	1	1
Leveling	1	1	1
Paving	1	1	1
Safety on the course	1	1	1
Safety on board	1	1	1
Signaling	1	1	1
Comfort	0	0	0
Lighting	1	1	1
Surroundings	0,5	0,5	0,5
Total	**8**	**8**	**8**

Source: The Author

5 CONCLUSION

The present article aimed to analyze the quality of the six main avenues of the city of Balneário Camboriú, through the CQI, in order to arouse the interest of urban public policies to improve the mobility of these cycle routes and also to insert new routes.

In this sense, the methodology used was effective since it classified the analyzed sections into quality classes. These define the main measure to be adopted according to the average reached through the notes of the descriptors used and presented in the methodology.

In the city of Balneário Camboriú, all the avenues analyzed, as well as all the sections, presented CQI between 6 and 10, only needing improvement and improvement.

It was verified that width, safety in the crossing and surroundings are the main problems faced in the cycle routes of the city, being indispensable to the comfort and safety of the cyclist, and therefore, to receive special attention of the Municipal Public Administration.

With the information obtained through the application of the CQI, public bodies have subsidies to develop a more sustainable urban mobility in the municipality, improving cycle routes, thus encouraging pedestrian mobility and promoting the quality of life of the inhabitants of the municipality.

Because it is a short / medium validity analysis, due to the intense transformations we are constantly experiencing, it is suggested that this analysis be performed again, after a certain period of time, to update the information. Thus, it will be possible to have a real panorama of the strengths and points to be improved of the cycle routes, which contributes to the improvement and constant development of this urban infrastructure.

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