The concept of sustainability, when associated with the urban space, goes beyond the limits of the environmental discourse and also includes economic and social factors related to human activities. In this context, different forms of public transport may play a relevant role.

The model of urban development that promotes the use of private automobiles has caused problems to the quality of life of city dwellers. However, there are ways that can help reducing the impact of motor vehicles used by individual drivers. One of them is the promotion of the bicycle as a mean of urban transport. The use of bicycles in an urban centre can be an addition to the existing public transport system by increasing its capacity and limitations and by replacing other existing means of transport for short distances.

In order to promote the use of bicycles as a mean of urban transport, it is important to adopt a series of well integrated public policies that would discourage the individual use of motor vehicles. These policies should offer some essential conditions for the comfort and safety of bicycle users making it more appealing to people. One of the initiatives that could be adopted to promote and expand the use of bicycles is the bike-sharing system already in use in many parts of the world, especially in the last 10 years, with an increasing appeal.

A bike-sharing system can validate the use of bicycles in urban centres by making the need of individuals to travel and reach a certain destination easier and without having to purchase and repair a bicycle. It was in the Netherlands, in the 60’s, that the first attempts to adopt such systems were implemented without much success in the beginning. Recently, new technologies have been developed to improve the control of the use of public bikes thus making the program more financially efficient, in a larger scale.
Also, it allowed the expansion of the BSS (bike-sharing system) in other countries. However, it is still a recent system of urban transport and, therefore, there is not much research or information available to analyse the real benefits for public transport and urban sustainability. These urban transport systems are usually associated with the question of sustainability mainly because they help to reduce the pollution from gas emissions released by public transport vehicles. However, some researchers claim that the benefits obtained from these systems are over-rated.

The purpose of this research was to evaluate the contribution of the bicycle sharing system – Bike Rio - to the environmental sustainability in the city of Rio de Janeiro, as well as its contribution to urban public transport taking into consideration the objectives associated with its implementation.

These objectives were based on three factors: (1) A program named “Rio, the bike capital” created by the Rio de Janeiro Municipal Administration in order to increase the use of bicycles as a form of public transport, (2) A bidding offer to “provide public space for the implementation, maintenance and operation of a bicycle transport system” foreseeing an increase in the number of bicycles, bicycle parking stations and city boroughs wishing to adopt the Bike Rio system, and (3) all the information found in the Bike Rio website where several objectives of the program are listed. Consequently, 6 (six) objectives of the Bike Rio program were established:

- The use of bicycles as a mean of transport
- Reduce transit congestion
- Reduce air pollution
- Promote citizen social responsibility
- Promote the “humanization” of the urban environment
- Promote more physical activity and healthy habits among the population.

The objectives of this research were divided in 3 categories: (1) mobility, (2) the environment, and (3) the society. The objectives related with mobility are the use of bicycles as a mean of transport and the reduction of the
number of car parking lots. The objectives related with the environment are those aimed at reducing air pollution. The objectives related to society are the well-being and the health of individuals as well as the quality of the urban space.

The information and data used to evaluate the Bike Rio program in this research were the following:

- Transport Plan for the City of Rio de Janeiro
- Data obtained from City Administration and from the Bike Rio website
- Inventory report on gas emissions and the greenhouse effect in the City of Rio de Janeiro
- Research in the internet
- Theoretical references

The research on bike users was done with interviews asking several questions to establish the following objectives: (1) establish the profile of bike users; (2) verify the usual ways that people travel within the city and the capacity of Bike Rio to replace other means of transport; (3) verify how Bike Rio is already integrated with the other means of transport, and (4) research how bike users rate the BSS and the transport in the city with bicycles.

Research in the internet was done in order to further investigate the available data on non-bicycle users. A question form was sent to people registered on several social media and we received 115 replies. Although research through social media was limited to a smaller social-economic group of people, it allowed us, nevertheless, to reach a larger geographic distribution of people. The replies received from bike users and the research done in the internet also provided a general view of the main obstacles that could jeopardize the further development of a bicycle transport system in the city.

Although the implementation of the Bike Rio program is related to a series of objectives, there is still no set of clear objectives for its operation. Regarding objectives 1, 2, 3 and 6, the methodology used was the one used by Fernández (2011) to evaluate the factors that can determine the success of
bicycle sharing programs. It is based on its impact and efficiency and makes comparison with the BSS of Paris (Velib), Barcelona (Bicing) and Viena (Citybike). The research of objectives 4 and 5 was done through an evaluation based on the theoretical references of the research itself.

Verification of the existing Urban Transport Plan showed us that there was an increase of 18.20% in the average number of people that moved in the city, daily, between 2003 and 2012. However, this movement of people did not occur in a homogenous manner. There was an increase of 21.39% in the average daily displacement of people using public transport and there was an increase of 41.93% in the average daily movement of people using private automobiles. However, there was a reduction of 1.29% in the average daily movement of people not using motorized vehicles. This reduction can be explained due to changes in the social-economic conditions of society, considering that job availability and personal income are important factors in the choice of type of transport. Essential movement of people, especially those going to work or to school is taken into consideration when they choose their means of transport in the City of Rio de Janeiro. We noticed that there is a usual concentration of people movement during 3 (three) periods of the day: early morning, noon and late afternoon. Data obtained from the Urban Transport Plan also allowed us to establish that the average number of daily trips made by people using bicycles was 274,788. That corresponds to 2% of the total of people displacements in the city.

The BSS system in Rio de Janeiro was initially created in 2008 but services were interrupted in 2010 due to problems such as bicycle theft, problems with the fare-control system and the scale of the implementation of the program. Services were restored in 2011 with a new sponsor, with changes in the business model and with more advanced technology. The system operated properly until 2013, with 60 pick-up stations and 600 bicycles available in several boroughs of the south region of Rio de Janeiro and downtown, reaching an average of 3,000 to 4,000 bike trips a day.

The Municipal Administration of Rio de Janeiro published a bidding offer in September 2013 to extend the Bike Rio program, foreseeing a total of 260 bike parking stations and 2600 bicycles available for the public. Other
boroughs in the north and west regions of the city would benefit from the program as well. The expansion of the program began during the first quarter of 2014. Our research verified only the average daily displacements, every month in 2012 and 2013, because the program expansion plan is still an ongoing process. We did not notice any special seasonal average data on bike displacements, as well as no significant relation between the number of trips and the weather conditions (Ex.: rainfall). We believe that a verification of longer periods should be carried out in order to establish whether there is indeed a seasonal influence in the use of the Bike Rio system.

The research done with Bike Rio users indicated that the majority of them live in the boroughs already served with the system (78%), that they are young adults between the ages of 21 and 40 years old (89%), and that they are mostly males (67%). Regarding the frequency of their use of the system, 31% of users informed us that they use the Bike Rio system 1 to 3 times a week. 25% of users ride a bicycle daily, 24% of users ride a bike 4 or 5 five times a day and 10% of users ride a bike less than once a day. The majority of people interviewed (51%) informed us that they ride their bicycles for useful purposes, especially to go to work, and 20% of users ride their bikes to go to school. 16% of the people interviewed informed us that they use their bikes for pleasure and 6% for physical exercise. 39% of bike users own a car and 41% have their own bicycles. We also learned that 56% of the users who own a bicycle prefer to use the Bike Rio system because they find it more practical. 20% of bike riders use the system for safety reasons, 16% informed us that it is difficult to find a place to park their own bicycles and 8% told us it is because of the maintenance costs.

In order to evaluate the connection between Bike Rio and the urban transport systems, we asked the people we interviewed if they would consider another type of transport to complete their daily displacements. The majority of people (62%) informed us that they travel exclusively by bicycle. Those who would consider using another type of transport to complement their bike rides informed us that they would use the subway system (75%) and the bus system (22%). The reason for the high number of people opting for the
subway is probably due to the fact that the interviews were conducted near subway stations.

A majority of people (52%) informed us that they would use the bus public system if there were no BSS in operation. Some people (24%) said they would walk to their final destination and some people (15%) informed us that they would take the subway. Only 2% of the people interviewed told us that they would use their own cars. The main reason presented for using the BBS was the speed to go from place to place, thus avoiding transit congestion or simply because riding a bicycle is faster than walking.

People interviewed were also asked about the locations of their initial and final destination during their daily moving routine. This would allow us to determine and analyze the average distances of their trips. The majority of trips were made within a distance of 3.5km and corresponded to displacements made by people within their own boroughs or between neighbouring boroughs.

The last part of our question form tried to identify the way bicycle users evaluate Bike Rio and the general bicycle system in the city. The main problems cited by users of the BSS system were related to its operation: operational failures (59%), problems with equipment maintenance (21%), and failure in the proper distribution of bikes (21%). The number of bikes available and bike stations in the BSS system was also considered a negative factor by 24% of people interviewed. As for the positive factors cited in the interviews, the majority of replies were related to the concept of the BSS itself. 44% of people interviewed told us that the greatest quality was that it is practical, 19% of users think the BSS is an option for transport and 19% informed us that they like the idea of a bicycle sharing system.

As a whole, Bike Rio was well evaluated by the users. On a scale of 0 to 5 where 0 is “not-satisfied at all”, and 5 is “very satisfied”, the average resulting grading was 3.35. However, only 55% of the users rated the system 4 or 5 and only 5% of the people rated the system 0 or 1. This evaluation of the bicycle transport system by users of Bike Rio indicated that their main concern is safety. Lack of safety in the transit was cited in 48% of the replies, and the same percentage mentioned the small number of bike-paths and the poor quality of the infrastructure.
In our internet research, 60% of the people informed us that they do not use a bicycle as a mean of transport. The reason for not using bikes was the question of safety. 42% of people informed us they fear to be robbed, 34% cited the lack of sufficient bike paths and 24% told us they fear a transit accident. In the group of bike users (40%), almost half (51%) told us they never used Bike Rio system, and 49% use the system or had used the system before. The reason offered by those who never used the BSS system was because they prefer to use their own bicycles. Among those who abandoned the Bike Rio system, 36.4% of them told us that they prefer to use their own bikes and 27.3% told us they think there are many failures in the system.

The analysis of all the data collected allowed us to evaluate the degree of efficiency of the Bike Rio system in the reduction of the number of motor vehicles in the city, the increase of the number of bicycle users, the reduction of CO₂ and, finally, the incentive to promote more physical exercise and healthy habits among the population. We compared the results obtained with those from Paris, Barcelona and Vienna. The choice of those cities in our research was due to their population numbers (over 1 million inhabitants) and for the availability of data and information.

Promotion of social responsibility was also evaluated based on the reasons offered by BSS users. We also evaluated the promotion of human socialization within the environment taking into consideration the human scale in the urban areas, the desire to improve the quality of public spaces and to reduce the size of areas used by motor vehicles.

Bike Rio represents 0.25% of the total daily movement of people in the city and 1.28% of displacements made on bicycles. This reduced participation in the bike system is related to its own scale: 60 bike stations and 600 available bicycles (data from 2013). Bike Rio is 10 times smaller than Bicing in Barcelona, and 40 times smaller than Velib in Paris (cities with smaller urban areas and population than Rio de Janeiro).

Considering the fact that the majority of Bike Rio users are young adults, mostly males, this indicates that transport on bicycles in the city needs to be safer so that more people can also benefit from it. The low level of participation of women and people of different ages indicates that there is a
need to adopt new wider public policies to improve comfort, safety and the practical use of bicycles. The result of our research with bike users, as well as our research in the internet showed us that the principal negative aspects of the use of bicycles in Rio de Janeiro are related to public safety and the dangers of sharing the public space with motor vehicles. But the construction of new bicycle paths, alone, did not prove be a determining factor to promote more use of bicycles. A reduction of bike users occurred even during a time when new bike paths were being constructed, doubling the extension of paths in the city.

The results of our research indicated that the contribution of Bike Rio for the question of mobility and urban sustainability was very small. The reason was its scale and the low rate and number of people who chose to ride a bike instead of a car. Bike Rio was not successful to attract people who owned cars, unlike their similar programs in Paris, Barcelona and Vienna. Although 39% of Rio’s BSS users owned a car, only 2% of them told us that they were giving their cars up for the Bike Rio system. Trips made using the BSS represent only 0.002% of the total movement of people who own a car. The analysis of the bike contribution to the reduction of polluting gases, especially CO$_2$ emissions, indicated that Bike Rio helped reducing only 0.00035% of the total CO$_2$ emissions a year, caused by the existing Public Transport System in Rio de Janeiro. Such a small contribution to the improvement of air quality and the reduction of problems caused by transit congestion occurs in all the cities served by a BBS system that we investigated. Even in Barcelona, where there were signs of some improvement, the impact in the reduction of motor vehicles displacements in the city was slightly above 0.15%. Those results indicate the need to be more careful when establishing the real advantages of the BSS system for the reduction of gas emissions and transit congestion.

As for the capacity of Bike Rio to attract new users, the results of our research were very encouraging. The majority of people interviewed (59%) told us they do not own a bicycle. The ones who own bicycles informed us that they do not plan to use their bikes as a mean of regular transport. This indicates that Bike Rio is capable of encouraging the use of bicycles as an alternative mean of urban transport by attracting bicycle owners who usually would not use their bikes to travel within the city.
As for the question of “promoting the practice of healthy habits and more physical activities among the population”, it seems that the expansion of the Bike Rio system could benefit a great segment of the population. The results of our research indicated that 31% of users who traded their cars for bicycles, use the BSS system 4 or more times a week. In addition, 26% of people interviewed told us that they use the Bike Rio system for exercising.

Our research did not find any direct evidence linking the Bike Rio program to the promotion of “social responsibility among the population”. Although it is a fact that BBS systems are usually linked to the question of sustainability and more benefits to the quality of life in the cities, the results of our interviews with bike users indicated that they use their bikes mostly for personal reasons, at least in Rio de Janeiro. Also, it was not possible to establish a direct influence of Bike Rio in the “humanizing process in urban areas”. The experience of BSS systems in cities such as Paris and New York - where the implementation of an infrastructure for the system was done before the implementation of the system itself – let us suppose that BSS systems are the beneficiaries of the process rather than being active agents in the promotion of “humanization”.

The greatest contribution of Bike Rio to the mobility and urban sustainability found in this research was the integration with the rest of the city’s transit system. We noticed that a large number of car owners do not use their motor vehicles for daily displacements in the city. Therefore, the BSS could contribute to this situation by making the use of the public transport system more attractive and, indirectly, playing an important role in the reduction of the use of private cars.

The results obtained in this research indicate that BSS systems can be considered a valuable tool to promote more use of bicycles as means of transport, but not necessarily a determining factor for this activity. In Vienna, the BSS presented the worst performance results although Vienna is the city with the largest number of bicycle daily displacements compared with Paris Rio and Barcelona.

The scale of things is the main factor responsible for the impact of Bike Rio considering all the information obtained in our research. When we
evaluated its structure, that is the number of bicycles available, we realized that Bike Rio is very efficient and that is an encouraging incentive for its expansion. However, the positive result regarding its efficiency may be linked to the reduced number of bicycles available, a factor that explains the high volume of usage of the system. The reduced number of bicycles available in the system may explain the large use of bikes in a constant rotation. Therefore, we guess that by increasing the number of bicycles available, notwithstanding the real demand, there will be fewer problems related to the efficiency of the system.

The process of expansion of the Bike Rio system started in the first quarter of 2014 but the relationship between the number of bikes available and the size of the urban population, the relationship between the number of bike stations and the extension of the intended riding area will certainly keep the Bike Rio system inferior to the Velib’ (Paris), Bicing (Barcelona) and even CityBike (Vienna) systems. Furthermore, the intended expansion of the riding area creates a major logistic challenge for the operation of the system, the main complaint from users. Among the operational problems, the most important one to users is the frequent failure to unlock the bikes from their station bars, as well as the problem to check the availability of bikes at a specific station. This is a very important factor for the operation of the system because the many complaints from users and the frequent failures in the system were the reasons why so many users give up using Bike Rio after a while. Another problem cited was the poor distribution of bicycles throughout the system. As a consequence, any future plans to expand the area served by the Bike Rio program must take into consideration the necessary number of employees and resources to face the increasing demand for maintenance services and the distribution of bicycles.

We recommend that a careful supervision and much attention should be given to the process of extending the Bike Rio system to verify if the increase in the number of bike stations, the number of bicycles and the larger area of the system network will not affect the efficiency of the BSS in Rio de Janeiro. We also recommend that more and wider research be done on the main factors that discourage people from using bicycles as an alternative mean of transport in the city. Thus, it will be possible to determine more precisely the real demand
for the use of bicycles and the best ways to deal with the main problems to adopt the BSS system as a viable alternative transport mode in Rio de Janeiro. We hope that all the data and information collected in this research may contribute and subsidise other research projects aimed at furthering and complementing this study, raising new questions related to the role of BSS systems, especially in Brazilian cities.

**Keywords**

Transportation; urban sustainability; mobility; bicycle; Bicycle Sharing System; Rio de Janeiro.