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URBAN MOBILITY IN SMART CITIES: A CASE STUDY IN THE CITY OF CURITIBA

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ABSTRACT

This study addresses the urban mobility in the city of Curitiba, whoseissue is of vital importance for large cities, directly impacting the quality of life of citizens. Curitiba has been recognized worldwide for the quality of its public transportation, especially with the introduction of the Bus Rapid Transit and its exclusive lanes, but in recent years the city has suffered a negative impact due to the growth of the automobile fleet and the lack of investment in public transportation in new modes to meet the needs of users. The city has been living with serious problems such as crowded public transportation and traffic jams. This article aims to make a case study of urban mobility in the city of Curitiba. The systematic literature review methodology called Methodi Ordinatio was used to select the most relevant articles on the subject. As a result, it was possible to verify that, even having a public transportation infrastructure with exclusive lanes for BRT, the city is suffering the impacts of the growth of the automobile fleet and it is necessary to apply public policies to avoid the exhaustion of the public transportation system, with investments in new modalities, flexibilization of working hours, and the creation of new bike lanes.

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INTRODUCTION

The difficulties faced by cities and their managers are old, especially with regard to the resources used so that the city can provide its inhabitants with an adequate infrastructure. Urban mobility is a current issue and it is important for the managers of large cities to make their inhabitants able to move from one point to another with ease, but this has become a challenge in recent years. In a survey conducted by Ritchie &Roser (2018), it can be seen that there are currently about 7.6 billion people in the world, and the distribution of this population is 4.2 billion people living in urban areas and 3.4 billion living in rural areas. The authors of the study indicate that the world population in the year 2050 will be 9.8 billion, of which 6.7 billion will live in urban areas and 3.1 billion in rural areas. This projection takes into account projected population growth based on the UN's average fertility scenario. The migration of people from rural to urban areas is causing a number of problems, since most cities were not planned to accommodate this rapid population growth. At the beginning of the 20th century Brazil had a population of 17,438,434 inhabitants, while at the beginning of the 21st century the number was 166,112,500 (IBGEd, 2021) and in 2020 Brazil registered 211,755,692 inhabitants (IBGEe, 2021). City managers must seek to find solutions to this population growth in the urban area, because this has caused many problems in various sectors, with significant impact on mobility, such as overcrowding in public transport and congestion on traffic routes, causing the lives of the inhabitants to be impaired. The traffic infrastructure in many urban areas is unable to accommodate the large number of vehicles, and the consequence of this is an increase in traffic congestion, average travel time, fuel consumption and carbon dioxide emissions (Tripathy et al., 2020). As cities grow, the population's needs regarding urban mobility increase, which becomes an increasingly current demand compatible with the principles of sustainability (PINHEIRO et al., 2018).

THEORETICAL FRAMEWORK

Smart Cities: As a way to provide a better quality of life to its inhabitants, the concept of smart cities was created, which are part of the constant technological advances that have occurred in recent years (Tekouabou et al., 2020). This concept emerged in 1994 indicating that there should be interactions between its inhabitants, the economic system, and institutions, prioritizing changes in the social dimensions

(Dameri&Cocchia, 2013). Large cities are living with continuous population growth and urbanization that occurs in some cases in an uncontrolled way (Garau et al., 2016). New technologies and concepts are needed to improve efficiency and increase productivity (Moraci et al., 2020). This definition has been widely discussed in various parts of the world, however, there is still no single definition, and current urbanization trends need to find possible solutions to allow its inhabitants to be able to live comfortably, even if cities have growth in population density (Cesarz, 2020). A smart city should privilege technological products and solutions as well as be concerned with the adherence of citizens in its proposal (Cerutti et al., 2019). Smart cities are part of the constant technological advances to provide a better quality of life (Tekouabou, et al., 2020), and their implementation can sometimes encounter scarce resources and volatile environments, becoming a challenge for their managers. Moreover, a fundamental point is the citizens that must integrate a city in such a way that they are part of a whole. There is no use in investing in infrastructure if people do not assume their roles as protagonists. A smart city fundamentally has smart people.

Urban Mobility: It is one of the most important components of a smart city. Everyday millions of people use the public roads of large cities to get around and carry out their professional and personal activities. In recent years this process has been a challenge, because of problems such as congestion and poor public transportation. City managers are working to ensure that mobility is efficient, and that users can use the modes of transport quickly and safely. The solutions are not always simple or cheap, such as building an underground subway system, which is expensive and takes many years to complete. On the other hand, there are simpler solutions that can completely change traffic logistics and improve urban mobility. It is important that there are sustainable urban mobility policies, and these policies should be concerned with promoting the use of different types of modals, such as the bicycle, which enables the reduction of car traffic in smart cities (Arsenio et al., 2018). On the other hand, cities must provide users with adequate infrastructure for the use of services, such as an exclusive bike lane network. Bicycle use is strongly dependent on the urban environment: bicycle paths can significantly increase the number of bicycles by causing a sharing between different modes in traffic in an area (PASE, et al., 2020). The connectivity of a bicycle network is important because it prevents cyclists from using public roads, thus decreasing the risk of accidents with other modes.

Urban mobility currently relies on the assistance of computer systems, thus developing a new generation of transportation systems, based on intelligent mobility systems, strongly supported by information and communication technologies. They allow a connection between the users of the systems and the administrators (Carresea et al., 2019). These systems are very important in smart cities because they allow users to use a computer system to check traffic information, public transport, or even to make modal reservations. Thus, a person who is in his car moving along public roads can use software connected to a GPS satellite to check the path that must be traveled, indicating less congested routes. He can also rent a shared car, a bicycle, or a scooter using a computer system. With this, one of the ways big city managers can improve urban mobility is to integrate the transportation system with computer software. It is vitally important to have access to the opportunities that are afforded by everyday urban life, and mobility is a fundamental point within a society built around the assumption of high mobility. It is essential for citizens to be able to move around cities in search of resources and contributes to the pursuit of personal life goals and to the fulfillment of individuals (Vecchio, 2017). High quality in public transport services is an essential key element to improve urban mobility in large cities (Brizon et al., 2018).

Bus Rapid Transit (BRT): The BRT is a high-capacity bus system that aims to provide a fast, efficient and comfortable service to its users, using exclusive corridors on public roads (Tobias & Oliveira, 2014). One of the strategies to promote improvements in urban mobility in large cities is the implementation of BRT, which is being used to relieve traffic on public roads, where congestion is a major problem. This modal has lower operating costs compared to other types of public transportation, offering a better quality of service in terms of service frequency, reliability, and travel speed, with the increase in the number of passengers served (Hassan et al., 2021). BRT is expected to improve urban mobility conditions bringing economic benefits and opportunities for the development of cities (Zhanga&Yenb, 2020). This system was idealized by architect and urban planner Jaime Lerner in 1974 in the city of Curitiba, implementing a transportation system in conjunction with tube stations that imitated the operation of the subway, where the user could pay the fare before boarding the bus (Jenkins, 2012), thus enabling greater mobility of users when entering and exiting the BRT. A trinary system was built around two central lanes that were left dedicated, supported by auxiliary lanes: the central lane dedicated to the BRT was flanked by two auxiliary lanes, which provide access to buildings constructed alongside this system (Jenkins, 2012). This model has been deployed in several cities in Brazil and around the world and has advantages in solving urban mobility problems. Table 1 shows the advantages and disadvantages of using BRT as a means of public transport in the view of the Institute for Research and Urban Planning of Curitiba (IPPUCa, 2009).

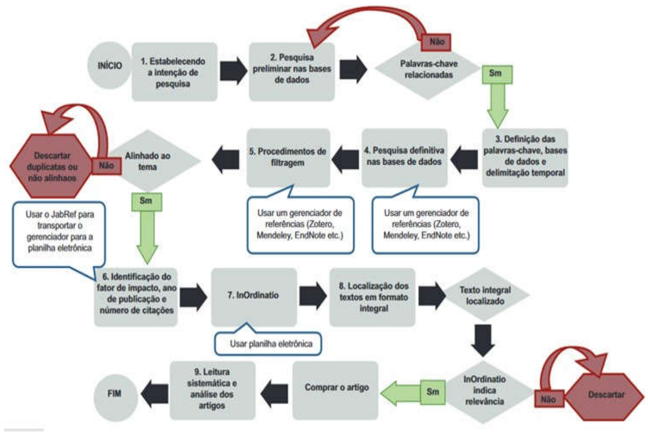
Table 1. Advantages and disadvantages of BRT

Advantages	Disadvantages
At peak times, the system can carry more than 18,000 passengers per hour per direction.	Environmental impact: diesel engine buses emit particulates and organic compounds.
It is an intermediate solution between the current system and a high-capacity modal.	It tends to degrade the surroundings and affect thecommerce along the corridor.
Low implementation cost.	Little assurance of passenger safety.
Maximum commercial speed of 25km/h.	Level operation, reducing speed.
Short time intervals between vehicles.	Interdependency with other systems.
Higher capacity vehicles, reducing the emission of pollutants.	It is affected by adverse weather conditions (rain).

Source: IPPUCa (2009)

METHODS

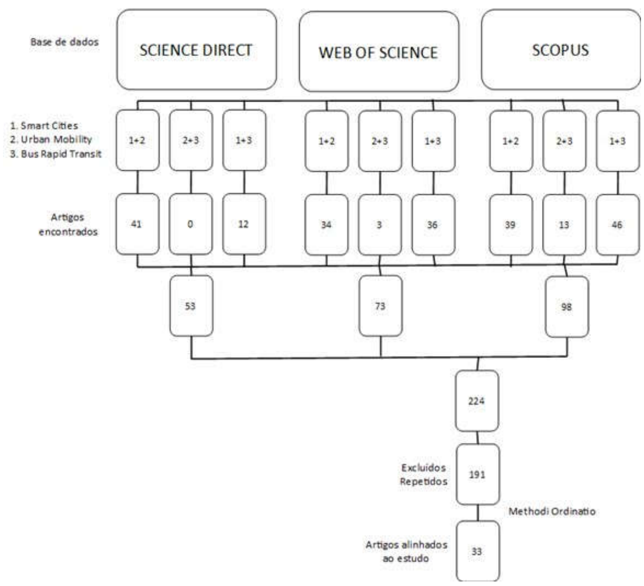
Systematic literature review: Exploratory study with a predominantly qualitative approach to the problem and documentary technical procedure. The systematic literature review methodology called Methodi Ordinatio was used to select the most relevant articles on the theme addressed. A structured literature review was carried out with the themes: "Smart Cities", "Urban Mobility" and "Bus Rapid Transit". According to Pagani, Resende and Kovaleski, (2015) the Methodi Ordinatio methodology consists of nine steps as follows:



Source: Pagani et al. (2018).

Figure 1. Stages of Methodi Ordinatio

After the search conducted in the Science Direct, Web of Science and Scopus databases, together with the defined keywords, the files were exported to be opened in the reference manager software. First, the reference manager Mendeley was used, where it was possible to check and delete the articles that were duplicates. Once organized, an export was made to the file compatible with the JabRef reference manager software, which was used as a bridge for exporting the article list to Microsoft Excel software (spreadsheet). With the data exported to Microsoft Excel, it was possible to organize the spreadsheet, inserting columns for the inclusion of the Impact Factor (IF), Citations (CI) and year of publication. Once this was done, the next step was to seek the information of impact factors and citations in the sources indicated for the research and insert it in a spreadsheet. With this data, it was possible to apply the InOrdinatio equation that ranked the most important articles. The next step was to search for the complete publications in the databases so that they could be read and the alignment with the central research theme could be identified. Through this last step, it was possible to discard the articles that were not aligned, thus being possible to conclude the steps in the application of Methodi Ordinatio (PAGANI et al., 2015). In the initial search, 224 articles were found in the databases used and 191 articles were discarded for being duplicates (Mendeley) or for not being aligned with the central research theme. This left 33 publications to compose the final portfolio, which were analyzed and classified according to the central theme of the research.



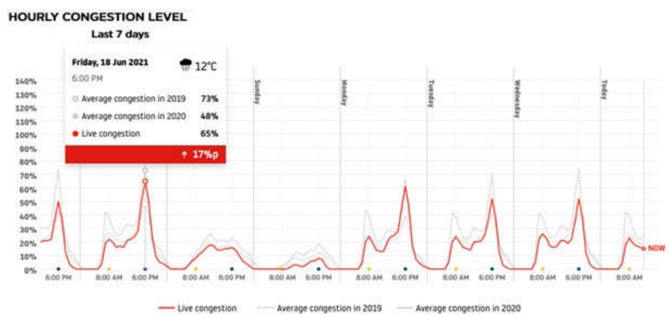
Source: own authorship

Figure 2. Overview of the selection process of the articles studied

With the core portfolio of publications defined, aligned with the research theme, the information compiled was: list of authors, publication title, year of publication, Journal where it was published, Impact Factor (IF), Citations (CI) and the Inordinatio, which was calculated in relation to IF, CI and year of publication. In addition to the articles that were part of the core portfolio, we used documents collected from the websites of the Brazilian Institute of Geography and Statistics (IBGE), the Curitiba Urbanization and Sanitation Company (URBS), the Institute of Research and Urban Planning of Curitiba (IPPUC), of Curitiba Bus Companies (SETRANSP), Denatran-PR, Brazilian Association of Manufacturers of Motorcycles, Mopeds, Scooters, Bicycles and Similar (Abraciclo), Paraná Transit Department (DETRAN) and the City Hall of Curitiba (PMC). To analyze the research corpus, the content analysis technique was adopted. The parameters proposed by Badin (1977) were observed.

CASE STUDY: URBAN MOBILITY IN CURITIBA: The city of Curitiba was a pioneer in the implementation of the BRT, with its exclusive lanes that made the city's public transport fast and safe, meeting the demands at the time of its implementation.

For many years the city was considered a model of urban mobility. Just as other large cities in Brazil and the world had high population growth, Curitiba also suffered from this problem. In the year 2020, the city registered a population of 1,948,626 people (IBGE, 2020a) only in the capital, not counting the Metropolitan Region of Curitiba (RMC). Regarding the vehicle fleet, it is the fifth Brazilian city with the largest car fleet in Brazil, with a total of 1,062,056 cars, behind only São Paulo, Rio de Janeiro, Belo Horizonte and Brasília (IBGE, 2018b). In the ratio of resident population versus circulating fleet, the city ranks first in Brazil, with an index of 1.83, while Brazil has a ratio of 3.85. This indicates that if the entire population of Curitiba uses this mode of transportation, the average would be around two passengers per vehicle. The automobile is definitely the biggest problem related to urban mobility in large cities, because it is a selfish means of transportation, despite having the capacity to carry five to seven passengers, it is usually used in a solitary way. It is the biggest cause of congestion on public roads, besides generating high levels of pollution, contributing to the degradation of the environment and the quality of life. On the other hand, it offers comfort and convenience to the user, allowing him/her to move around privately. There is a preference of people to use private vehicles instead of public transportation due to some reasons such as safety, punctuality, reliability, comfort, convenience, time and quality (Hassan et al. 2021). The car fleet in the whole state of Paraná in 1977 was 397,269 (IBGEc, 1980) and so the system implemented at that time was efficient, because, with a low number of cars on the streets, the city still had no congestion problems. Another relevant point in this system implementation is the population of Curitiba and RMC, which at the time was 600,000 inhabitants. With fewer cars on the streets and fewer people using public transportation, the BRTs had the possibility to complete their routes with a minimum of congestion, thus enabling the system to flow quickly, so that users could be served with higher quality. Curitiba and the RMC had an intense population growth, going from 600,000 inhabitants in 1974 to 3,572,326 inhabitants in 2021 (PMC, 2021). Consequently, there was also an increase in the number of automobiles in the city. As there was no planning for this growth, the city began to suffer the causes of these transformations, with overcrowding and delay in the use of means of transportation and increased time to travel the bus lines' itinerary.



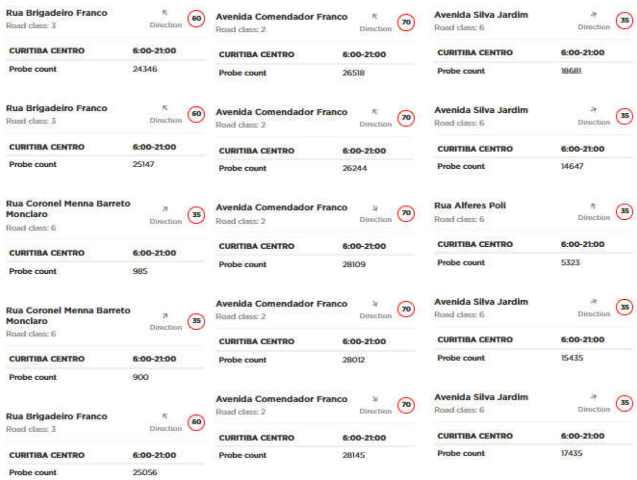
Source: (TOMTOMa, 2021)

Figure 3. Graph of the level of congestion in Curitiba

Figure 3 shows a graph with information on the level of congestion during the period between 6/17/2021 and 6/24/2021 in the city of Curitiba, showing some peak times, especially in the late afternoon (6pm). At peak hours, the congestion level reached 70%. The graph was obtained by the company TOMTOM NV, which specializes in devices for urban mobility and monitors traffic in the city. This information indicates the behavior of the inhabitants, showing that at certain times in the city there is a larger number of vehicles on public roads. The BRTs have their exclusive lanes, but this does not mean that congestion of cars and other modes does not affect their operation. With a very large number of vehicles, it is necessary to control traffic, especially with the use of traffic lights, impacting the path that the BRT must follow on its route since other modes cross the expressway. In some more central regions of the city of Curitiba, there are traffic lights on every corner to control the flow of vehicles, and this ends up impacting the BRT route.

Source: (TOMTOMb, 2021)

In figure 4 you can see a traffic analysis done by the software TOMTOM Move Traffic Stats, from the company TOMTOM NV, which was performed based on the public roads of the city of Curitiba, in the period from January 20, 2020, to January 26, 2020, in the period between 6:00 am and 9:00 pm. The analysis was done in the central region of Curitiba.



Source: (TOMTOMb, 2021)

Figure 5. Traffic on Curitiba's roads

In Figure 5 we can see some data obtained from the traffic analysis of Figure 4, from sections of the central streets and avenues of the city of Curitiba, along with data on maximum speed and the number of vehicles that passed during the period indicated. The roads indicated in figure 5 have an intense traffic of vehicles, and it can be seen that in a certain period there was a flow of 28,109 vehicles on Avenida Comendador Franco, which is the avenue that connects São José dos Pinhais to Curitiba, in the period from 06:00 AM to 09:00 PM. This flow is larger than the number of vehicles in many cities in Paraná and with this amount of vehicles on public roads, traffic accidents are constant. Figure 6 shows the data from the Traffic Department of Paraná (DETRAN) regarding accidents in the period from 2014 to 2019 in the city of Curitiba. These accidents end up becoming a negative point in relation to congested public roads, including people being run over, cyclists, or involving other modes.

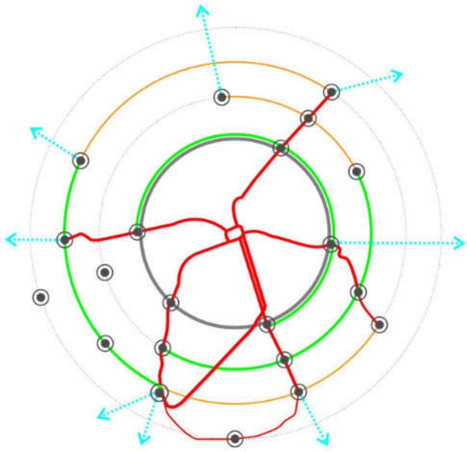
DADOS	ANOS					
	2014	2015	2016	2017	2018	2019
População / Projetada	1.864.416	1.879.355	1.893.997	1.908.359	1.917.185	1.948.626
Frota	1.406.049	1.415.987	1.405.123	1.401.153	1.416.388	1.450.110
Acidentes com vítimas	5.598	4.786	4.341	4.631	5.079	4.628
Vítimas Fatais (1)	79	56	56	68	96	66
Vítimas não fatais	6.656	5.657	5.166	5.401	6.051	5.259
Total de vítimas	6.735	5.713	5.222	5.469	6.147	5.325

Source: Detran, 2019.

Figure 6. Traffic on Curitiba's roads

Each accident that occurs on the roads generates a disturbance to the normal traffic flow, which can form a traffic jam of many kilometers until the situation is brought under control. This disrupts the normal conditions of urban mobility, delaying the movement of people in the city.

In the first four months of 2021, a study by the Traffic Police Battalion (BPTran) showed 1,426 traffic accidents in the capital of Paraná (Santos, 2021). The study also indicated a worrisome fact: the increase in the number of deaths (13) in accidents compared to previous years. Besides the 13 deaths, 629 people were injured. As BRTs need to maintain an average speed to meet the schedules set for the route, sometimes these speeds can be dangerous for pedestrians crossing the street, since the BRTs circulate in places with large concentrations of people. As many of the inhabitants of the RMC work in Curitiba, it is necessary to take into account this public who will use public transportation between the RMC and the capital. For the user of public transportation, one of the points that most impact its use is the high fare, which ends up weighing on the budget. Many people spend up to 30% of their salary on fares, and one of the causes of the high price is the lack of integration between the lines. Sometimes users need to use two or more modes to get to work, because of the distance they must travel. Curitiba has an integrated bus system through the terminals installed in the neighborhoods and downtown. These terminals allow the user to use several lines paying a single fare, thus reducing the cost. Curitiba has the Integrated Network of Collective Transportation (RIT), which allows users to use several bus lines paying a single fare (URBS, 2021). For the RIT to function properly there are integration terminals that allow users to disembark and board any other line served within the terminal space, without having to pay the fare again. The RIT transportation infrastructure in the Metropolitan Collective Transportation System maintains 13 municipalities in the Curitiba Metropolitan Region.



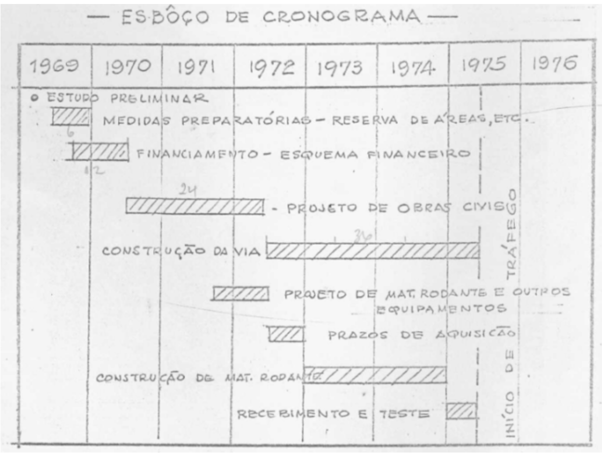
Source: (URBS, 2021)

Figure 7. Map of Curitiba's Integrated Mass Transportation Network

SOLUTIONS FOR URBAN MOBILITY IN CURITIBA: Many Brazilian cities, including Curitiba, have faced daily difficulties due to traffic congestion, accumulating significant losses in quality of life for its inhabitants (Brizon et al., 2018). The increase in population and the private car fleet in the city have contributed to urban mobility problems. The city was for years a world model, but it currently needs new solutions to prevent the public transportation system from collapsing in the coming years. Some solutions adopted in other cities in the world and that can be used in Curitiba are: underground metro, suspended monorail, investments and prioritization in the bicycle path network, use of computer systems and more flexible working hours.

One of the most discussed points in recent years regarding Curitiba's urban mobility is the construction of the underground subway. The topic has been discussed for many years by different mayors, and many projects have been elaborated, but until today there are no practical solutions for the construction of the infrastructure for this mode. The underground subway is ideal for public transportation, not congesting public roads or occupying the space of other modes, while the bus system offers a poorer service, with low-speed vehicles and the stigma that overloads traffic (Bassett &Marpillero-Colomina, 2013).

Brizon et al., (2018) conducted a socioeconomic analysis to verify the gains from the reduction of congestion in the city of Curitiba, the impact of reduced pollution, travel times, accidents and also fuel consumption from the implementation of a subway metro system in the city. The results show that there are socioeconomic gains and that these can finance a large part of the subway project, presenting with these gains in quality of life, such as the reduction of air pollutant levels, traffic accidents, and commuting times of Curitiba's inhabitants (Brizon et al., 2018). The Preliminary Plan of Urbanism of the city of Curitiba was created in 1964 through a public contest, in which there were two winners: SereteEngenharia S.A. and Jorge WilheimArquitetosAssociados (IPPUCb, 2021). A preliminary study for the construction of the subway of Curitiba was conducted in 1969, which already indicated at that time a concern with the congestion of public roads in the city and the impossibility of the public transport system continued to serve the inhabitants with speed, regularity and comfort, placing as a necessity the planning of a rapid public transport system for the city (IPPUCc, 1969). Figure 4 shows an outline of the schedule that the IPPUC team for the construction and implementation of the subway, with the project schedule.



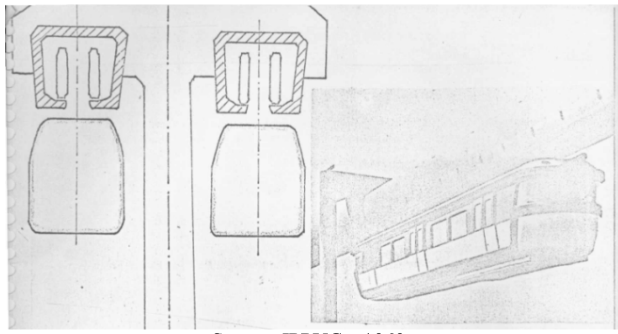
Source: IPPUCc, 1969.

Figure 8. Outline of the schedule for the implementation of the subway system in Curitiba

Even with the project for the construction of an underground subway and with the concern in serving the inhabitants with efficient public transportation, Curitiba's city managers decided not to invest in this modal and currently the city does not have a subway system. A public transport alternative that can be used in the city of Curitiba to improve urban mobility is the implementation of an overhead monorail system, which can be deployed in the currently existing lanes for BRTs. Figure 4 shows a scheme of this system that was raised as a modal to be used in Curitiba in the preliminary study of the subway of Curitiba of 1969 (IPPUCc, 1969), showing that since the 1960s this was a model of public transport thought by IPPUC's engineers as a solution to urban mobility for the city. The advantage of its use is that it does not need to use the city's traffic light system, since the monorail is above ground, and passes over the other modes that cross the expressway making the system faster to complete its route.

Regarding the cycling network, it is important that the city of Curitiba keeps the existing network and think about expansion projects. The bicycle is a practical modal, does not pollute the environment and does not cause traffic jams, and therefore its use should be encouraged, but it is vitally important that the bicycle network is safe. The first idea for a bicycle path built in Curitiba was in 1977, in a 3 km route. In 1988 there were investments integrating some important avenues in the city, in a 35 km route. In 1990 the road network was extended through some important neighborhoods and totaled 85 km, and then in 2011 it started to connect the Green Line, and with this, encouraging workers who use the modal as a mechanism for health and sustainability.

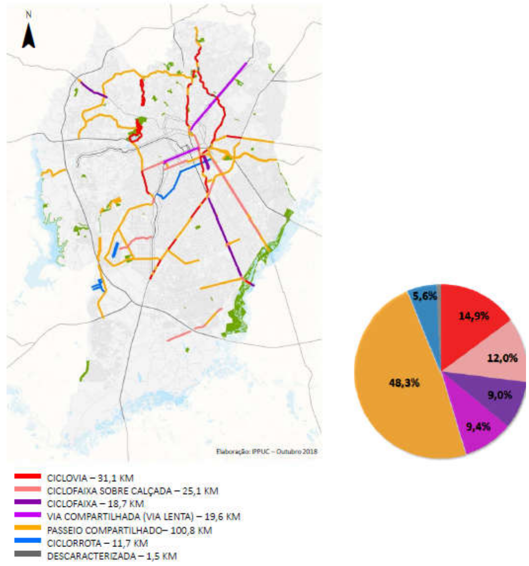
As of 2018, there was the implementation of bike lanes, slow lanes, bike paths, reaching 208.5 km in length (JANKOWSKI, 2021). Curitiba, known as the sustainable capital of the country, brought to its rulers, increasingly, the concern to offer a fast, clean, fluid transport, linked to aspects of quality of life of its population. With this, it could seek to promote actions of revitalization, increase of bicycle lanes, and comfort for cyclists. Therefore, seeking to adapt to the new mobility needs and within the aspects of Smart Urban Cities, strategic points were duly evaluated, such as strategic planning in the definition of the network, support equipment, and management programs, seeking to offer better signage, paving, lighting, furniture and comfort to its users.



Source: IPPUCc, 1969.

Figure 9. Overhead monorail system

Due to the large number of annual accidents involving cyclists from Curitiba and evaluating the Urban Mobility Plan, an inventory was prepared pointing out the main causes, types and occurrences, in order to point out the problems. From the inventory were evaluated the types of accidents, quantities, frequencies, times, and possible reasons (hit by a car, collision, fall). With this, it was possible to evaluate the possibilities of improvements in the road, information that should be passed on to users and the collection of suggestions for improvements. Today, Curitiba has 208.05 km of bike paths, and the project is to have 408 km in 2025, thus allowing greater fluidity and trafficability among citizens, promoting quality of life by encouraging exercise, eco-citizenship, lower levels of pollution and gas emissions caused by vehicles. Besides, this modal offers agility and flexibility in its use, both for work and leisure. Making a comparison between decision making and continuous improvement, we can see a great evolution of new routes and access to strategic points, facilitating the cyclists' daily lives, but there is still a lack of investment in the area, starting from the principle of awareness of drivers, respect for signs on both sides, analysis and planning of critical points such as places with higher accident rates, signage, lighting, safety and road maintenance.



Source: (IPPUCd, 2019)

Figure 10. Curitiba's 2018 bicycle structure plan

It can be observed in Figure 10, that the concern of safety and urban mobility offered by bicycle paths, point out the need for adaptation in a particular way in each stretch of road. The fact that could be evidenced, when facing the high rates of accidents, where a portion involved cyclists (DE ALMEIDA SANTOS, 2021). Therefore, according to the studies carried out (in the road network, access loops and traffic flow of vehicles), it was realized that the bike path still has a discontinuity of accesses, within the routes and links connecting the central region to other neighborhoods. With this, we seek greater synergy between existing roads, added to the expectations of improvement and comfort to users, increasing the perimeter, striving for intermodality, connecting individuals to major points and urban centers (shopping malls, universities, bus station, industries, shops, hospitals, parks and internet connectivity points - IoT). Although urban mobility accesses are treated by the city as a vital icon for smart growth and development, there is still much to be done to reduce the negative impacts (health and safety) in relation to users. It is projected that by 2025 Curitiba will have almost double the mileage of bike lanes, but for this to happen, it is necessary to make quality urban investments that expand sidewalks, safety devices and signage, among others.

Source: IPPUCd (2019)

Figure 11. Proposed mobility on bicycle paths (slow lane)

In addition, it is necessary that managers conduct educational campaigns to guide about the importance of respect of citizens on urban roads, whatever their means of locomotion (car, motorcycle, public transport, bicycle, or on foot), to raise awareness about attention and respect for other people, so that everyone can collaborate for the viability and fluidity of traffic in a strategic way. In the future, with the help of digital tools (IoT, Big Data, AI), which will be used to indicate the best times and routes to follow. One way to minimize the negative impact of vehicle congestion in large cities is the flexibilization of the working hours, allowing the worker to fulfill his or her working hours at alternative times, in order not to use the modal during rush hours, circumventing the problem of congestion at busy times. A good practice that can be implemented to encourage companies to make the workday more flexible is in the form of incentives that the municipal government can offer to companies/industries to change the hours of the workday, to avoid that the departure time is the same for everyone, thus avoiding possible congestion at peak hours and traffic jams.

CONCLUSION

Large cities are suffering an impact on urban mobility due to population growth and the increase of private cars that are using the public roads, causing congestion and slow traffic. The city of Curitiba, even though it has been a model of urban mobility for years, is suffering the impact of these transformations and finds itself in a situation in which it is necessary to apply public policies for the implementation of new modalities so that the public transportation system does not collapse in the coming years. The present study made a case study of urban mobility in the city of Curitiba, with a survey of some solutions that can be used by managers in order to solve the problems of urban mobility that the city presents. Among the most important modalities that could have a greater impact on the reduction of urban mobility problems in Curitiba, the underground subway and the overhead monorail stand out, which are fast, safe and high capacity public transportation for passengers. These two modalities were put forward as a solution for Curitiba's urban mobility since the master plan and preliminary study of the subway, carried out in the 1960s, but as the financial cost of its implementation is high for its construction, it was opted for the implementation and maintenance of the BRT, which for many years was the adequate solution for the city. As there is the problem of intense congestion, several projects were created for the implementation of new modalities, and the bicycle was one of the focuses, since it is an ecologically clean, healthy and simpler solution than other projects. In recent years Curitiba has invested in the creation of new bike lanes to create a more appropriate infrastructure for cyclists, but this implementation is still far from expected, since on the main streets and avenues of the city, especially in the city center, bicycles still share the space with other modalities such as cars, buses, motorcycles and BRTs. For this modal to become an important means of transportation, it is necessary to have a safe and exclusive infrastructure for it, so that traffic accidents and possible deaths do not occur. The flexibilization of the working hours is a viable solution, since no investments in infrastructure are required. For its implementation, the Curitiba City Hall can give tax incentives to companies that adopt a more flexible working hour, avoiding entries and exits during peak hours, in order to reduce congestion on public roads. Another way to avoid congestion in the city is to use a device with Global Positioning System (GPS) software, such as Waze, to get around the city. This software has the ability to choose the best route to the destination, avoiding congested stretches. A positive point of the city is that it is part of the Integrated Network of Public Transportation with the RMC, through the integration terminals, allowing users to pay a single ticket, with the possibility of using several lines. It can be concluded that Curitiba, even having an efficient transportation system with the use of the BRT and the exclusive lanes, needs investments in new modalities and for this, public policies must be applied in order to avoid the exhaustion of the public transportation system in the city. It is also necessary to promote projects to help the current public transportation system such as making working hours more flexible, the creation of new bike lanes and the use of software to guide the avoidance of congested routes as fundamental points for the maintenance of urban mobility in Curitiba.

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