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CURITIBA: URBAN PLANNING AS A TOOL TO FOSTER MORE SUSTAINABLE URBAN MOBILITY

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The Brazilian city of Curitiba is internationally recognized as a case of good practices in the use of urban planning for the promotion of an efficient public transport system, encouragement of mixed land use, and creation of superior green public spaces. This case study seeks to highlight the process of implementing the so-called structural axes of the city of Curitiba, which have become organizing elements of the road system and public transport. Curitiba used these axes to plan the allowed densities in order to manage the city occupation. The strategies adopted have positive effects related to the dimensions of smart cities: Smart Mobility, Smart Environment, and Smart Citizen, and can be adapted in other contexts to implement more efficient public transport systems, discouraging the use of individual motorized transport.

Keywords: Curitiba; Urban mobility; Urban planning

CURITIBA: LA PLANIFICACIÓN URBANA COMO HERRAMIENTA PARA FOMENTAR UNA MOVILIDAD URBANA MÁS SOSTENIBLE

La ciudad brasileña de Curitiba es reconocida internacionalmente como un caso de buenas prácticas en el uso de la panificación urbana para la promoción de un sistema de transporte público eficiente, el fomento del uso mixto del suelo y la creación de espacios públicos verdes superiores. Este estudio de caso busca resaltar el proceso de implementación de los llamados ejes estructurales de la ciudad de Curitiba, que se han convertido en elementos organizadores del sistema vial y del transporte público. Curitiba utilizó estos ejes para planificar las densidades permitidas para gestionar la ocupación de la ciudad. Las estrategias adoptadas tienen efectos positivos relacionados con las dimensiones de las ciudades inteligentes: Movilidad inteligente, Entorno inteligente y Ciudadano inteligente y pueden adaptarse en otros contextos para implementar sistemas de transporte público más eficientes, desincentivando el uso del transporte motorizado individual.

Palabras clave: Curitiba; Movilidad urbana; Planeamiento urbano

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1. Introduction

As urbanization rates increase, the search for planning strategies that leads to more sustainable urban environments gains relevance. The United Nations 2030 Agenda, which presents the Sustainable Development Goals, confirms the relevance of urban planning as a tool to promote sustainable urban development in Objective 11: Sustainable cities and communities. By implementing strategies that promote mixed land use and compact development, create friendly streets for pedestrians and cyclists and provide green public spaces, cities are able to use urban planning as a tool to impact positively the quality of life of its citizens, as well as to induce them to adopt habits that contribute to a more sustainable urban development.

The use and occupation of urban land has a direct impact on the distribution of activities (commerce, service, industry, leisure and housing), as well as on the pattern of daily displacement of the population. Diversifying land uses makes it possible to ensure a wide range of urban services close to where the city dwellers live. This configuration makes public circulation spaces more attractive, as the reduced distance to access commerce and services can stimulate travel on foot and by bicycle. In addition, the dynamism that this concentration of activities and housing produces on site can enable the implementation of efficient and attractive public transport systems, once again reducing the need and attractiveness of car use as a means of transport (WRI, 2014).

This search for sustainability in urban mobility is also one of the objectives of smart and sustainable cities, defined by Viale Pereira et al. (2020, p. 527) as “a progression of how cities apply digital technologies to serve their populations, pursue sustainable socio-economic development, and transform themselves”. Inside the concept of smart city, the smart mobility dimension is one of its six dimensions (the others being smart economy, smart living, smart governance and smart environment) and it is defined by Lyons (2018) as a mobility that integrates systems and means of transportation that uses ICTs tools to interact with users and aim to create a sustainable, safe and accessible environment to meet the citizen’s daily mobility needs.

Some cities are labeled as good examples of the potential of urban planning as a tool to promote sustainable development, and among them, the Brazilian city of Curitiba is a well-known case for exploring the relationship of urban development and the promotion of a transport system efficient public, encouraging mixed land use and creating high quality green public spaces. The city is recognized for its vanguard in the creation of public transport corridors that accompany the densification of the surroundings that shaped the city’s built environment, and the creation of urban mobility solutions based on the Bus Rapid Transport (BRT). The history of urban planning in Curitiba, with positive impact in more sustainable modes of displacement, dates back to the end of the 1960s, when trinary systems were conceived in the so-called structural axes, at the same time that densification along these axes was stimulated, concentrating population near public transport.

Considering Latin American cities context, where car-centric designed cities are common, the city of Curitiba, with its long tradition of urban planning oriented to transit, creating strategies that find consonance with current concepts (e.g. TOD and smart mobility) was chosen as a case to present the implementation of its initiatives in the field of sustainable urban mobility.

2. Objectives and methodology

This case study has the objective to present the process of implantation of the public transport axes, known as trinaries, in the city of Curitiba - Brazil, and how actions related to land use, public transport and urban design contributed to the development of a urban context that

aggregates dimensions of smart cities such as: smart mobility, smart citizen and smart environment.

The collection of data was made trhough the the local governments platforms (Curitiba City Hall website) and urban planning agencies responsible for the design, implementation and operation of this initiatives, such as the IPPUC (Institute of Research and Urban Planning of Curitiba) and URBS (Urbanization of Curitba).

3. Urban Planning and Sustainable Urban Mobility

The sustainability approach aims at satisfying the basic needs for access to individuals and societies in an affordable, efficient and environmentally friendly manner (Perra et al., 2017). For the authors, the conventional approach on urban mobility planning was pointed to optimize the motorized traffic flows and increasing the capacity and travel speed by adding more road infrastructure, whilst the approach for sustainable urban mobility focus on optimize the use of current infrastructure and provide cost-effective solutions, with a primary aim of provide accessibility to citizens and increase its quality of life. Hence, the urban mobility planning process evolves from a traffic engineering subject to an interdisciplinary planning process integrating land, social needs and environmental objectives (Perra et al., 2017).

In order to promote more sustainable urban mobility, cities need to promote transportation modes that optimize space and energy, such as public transport, the use of bicycles and walking, to the detriment of the use of the car. The survey by the Institute for Sensible Transport (2018) presents the disparity in the occupation of urban space by different commuters, where users of an individual car occupy 9.7m², while a passenger on a bus occupies 0.8m², 1.5m² as a cyclist and only 0.5m² when walking. This contrast in the occupation of space also directly reflects in the performance of the road system, where the roads dedicated only to the circulation of cars have a circulation potential of about 1350 people / hour in a strip with 3.6m, while a strip of the same width allows the circulation of 6000 pedestrians, 4500 cyclists or up to 13,500 people on a BRT (Bus Rapid Transit) line (Pereira and Lindau, 2018).

Accordingly to ARUP (2016), creating a city that promotes sustainable mobility can increase the street accessibility and attractiveness, unlocking the city to everyone. For those inhabitants who do not want or are not able to drive a car, focusing in the street design can promotes independence. Also, investing in walking infrastructure benefits inhabitants with mobility limitations like the elderly and those with special mobility needs, creating inclusion by design.

The Transit Oriented Development (TOD) is a concept that presents the systematization of a holistic approach necessary for the development of strategies and plans aimed at promoting sustainable mobility. The primary objective of TOD is “to reorient policies and strategies for urban planning and design, through the construction of compact, high-density neighborhoods that provide people with a diversity of uses, services and safe and active public spaces, favoring social interaction” (ITDP, 2017, p. 22). Strategically, it is based on urban mobility planning solutions aiming to satisfy most of the needs citizens commutes at the local level by walking or cycling, and in longer distances through public transport, reducing the car dependence. For that, the ITDP (2017) has developed eight principles for Sustainable Transport Oriented Development (TOD):

- Compact: compact cities creates greater proximity between activities, reducing the need and time dedicated to commuting as a result of the shorter distances;
- Densify: intensive land use allows cities to grow more compactly, improving the capacity of public transport and its financial viability;
- Transit: urban density should be prioritized in public transport corridors, enabling high and medium capacity systems;

- Connect: cohesive road networks facilitate accessibility to different destinations. Highly permeable locations shorten distances and provide greater variety in the choice of modes;
- Mix: mixed land use promotes social and activity diversity, encouraging shorter trips;
- Cycle: bicycle use facilities provide the population with an efficient and inexpensive option for commuting over short and medium distances. The presence of a bicycle network can also increase the coverage of public transport;
- Shift: implement policies that discourage the use of private vehicles, such as parking and traffic controls;
- Walk: the conjuncture provided by an urban context with mix of uses, social diversity and cohesive networks of roads makes it possible that a large part of daily commuting is carried out by walking;

The implementation of these principles focused on urban mobility provides an attractive environment for travel on foot, by bicycle and by public transport and, consequently, making travel with individual vehicles gradually less attractive (ITDP 2017). The idea of bring daily needs of services and resources closer to citizens, at a comfortable distance for walking or cycling from their homes, is also explored in other concepts, such as the “15-minute city”. Considering the cases of smart cities, the positive outcomes of the adoption of strategies to promote a more sustainable mobility are relevant for the smart mobility dimension, but also for the smart people (by improving accessibility) and smart environment (by reducing fossil fuels consumption and optimizing urban space).

Besides commuting patterns are greatly influenced by the urban configuration as a whole, local characteristics (e.g. street design) are also relevant factor for the choice of travel modes. Street design is one of them, and can be used to increase the attractiveness of alternative means of transport, while discouraging the use of individual cars. The World Resources Institute (2016) suggests interventions at the street level to promote the use of sustainable means of transportation: a) reducing car speed by narrowing lanes, adding speed bumps and covering its surfaces with rough paving; b) giving priority to pedestrians’ crossings by extending sidewalks or raising roadway surfaces at intersections; and c) creating specific infrastructure for cyclists, where motorized traffic is too intense.

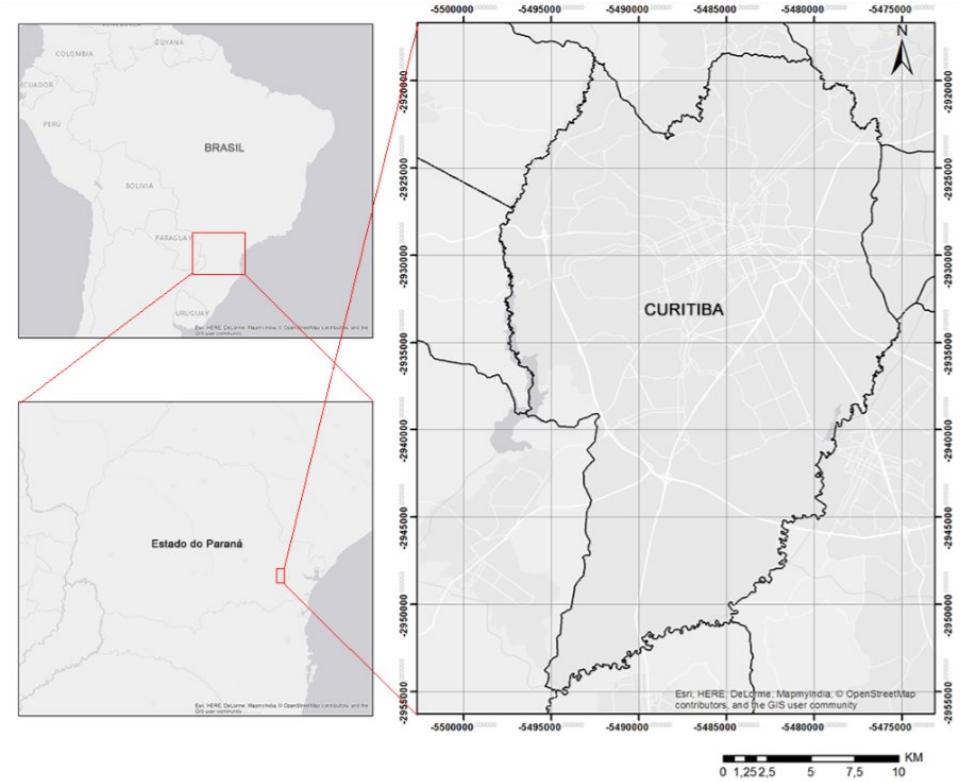
In addition to the strategies presented above, Pucher and Buehler (2010) argue that for the effectiveness of the measures to promote sustainable means of transportation, limitations to individual motorized transport are mandatory; a strategy that the authors call push and pull measures. Thus, facilities that encourage car-centric development should be restricted, (e.g. by reducing parking availability and applying parking fees).

4. Case study

The city of Curitiba is located in the southern region of Brazil, being the capital of the state of Paraná (Figure 01). With almost two million inhabitants and covering an area of approximately 435.03 km², the city divided into nine administrative regions that encompass seventy five

neighborhoods. The city is also the center of a metropolitan region composed of 26 municipalities, with a total population of about 3.2 million inhabitants.

Figure 1: Curitiba city location.



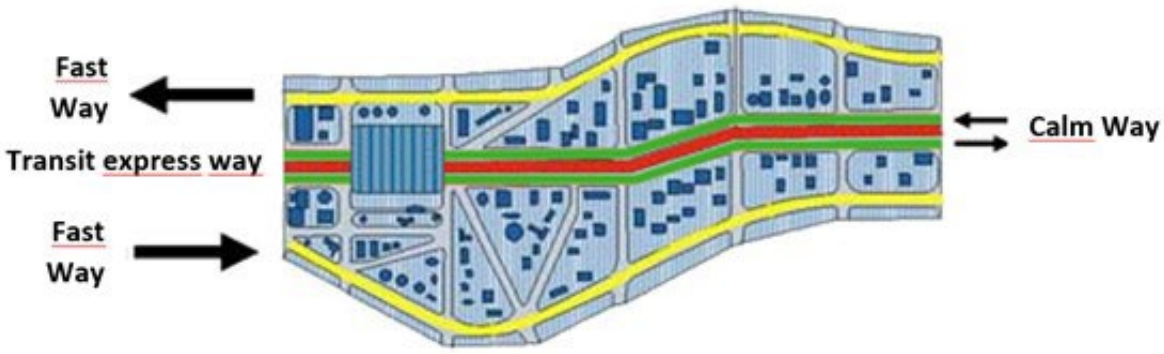
Source: Kunz (2018)

The city is well known for its avant-garde concept on public transportation planning, which started decades ago. The Structural Axes of Curitiba were conceived in the late 1960s in order to improve the reach of the public transport network in the city, improving the accessibility of the population to it (Curitiba City Hall 2015). The axes were distributed in five directions, connecting public transport in different areas of the city. However, to increase the accessibility to this public transport lines, it was important to densify adjacent areas.

In order to stimulate occupation along these axes, zoning rules were developed to allow high construction potential in nearby areas. The axes road configuration, proposed by former president of the Urban Planning and Research Institute of Curitiba (IPPUC), architect Rafael Dely, was based on three parallel lanes, among which the central lane would be destined for slow traffic, concentrate commerce and have lanes dedicated to express transit lines (Gnoatto 2016). Such system, called “trinary”, also has two streets parallel to the central lane dedicated for automobile circulation, in reverse directions.

This configuration of the trinaries became the backbone of public transport in Curitiba. In the central lane, an exclusive channel was installed for the express public transportation lines. According to IPPUC (2020), this exclusive route provides a significant increase in the operational speed of these transit lines. Figure 02 shows the distribution configuration of the trinary axes.

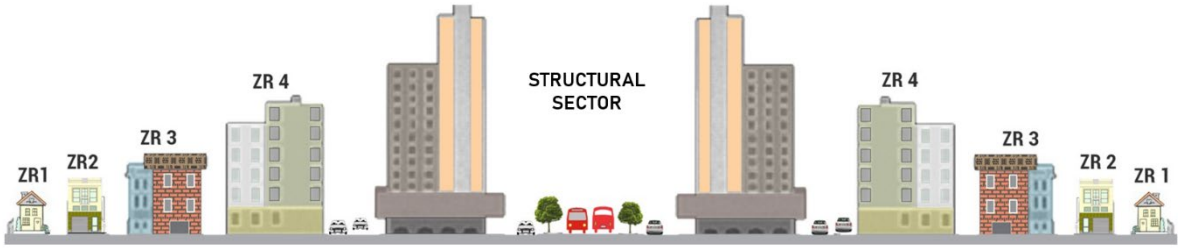
Figure 2: Trinary System Configuration.



Source: adapted from URBS (2020)

According to Gnoatto (2016), after the implantation of the Structural Axes, where the tallest buildings are located, these became a mega structure for Curitiba and defined its urban design. In the contiguous areas of the structures, characterized as ZR4 (Residential Area 4), construction indices were assigned that allowed medium density buildings, with up to ten floors. The adjacent blocks to the structural sector were defined as ZR3, with a lower construction potential than that of ZR4, but still allowing a comprehensive overview of activities for commercial use and services. Figure 03 shows the land use and regulation scheme, which establishes greater construction potential and diversity of permissible uses near the structural axes.

Figure 3: Land use regulation scheme in the structural sectors of Curitiba.



Source: adapted from URBS (2020).

The Trinary System is the backbone of the structural sectors IPPUC (2020). It comprises a set of four blocks, in the middle of which there are two parallel and side streets for one-way cars (highways) on the margins, used for travel between city regions; and a central street divided into three lanes: an exclusive central lane for express buses (where BRT is installed) and two side roads for low speed vehicles and access to local activities and local travel as seen in Figure 04.

Figure 4: Trinary system nowadays.

Source: URBS (2020)

The public transport corridors were installed in central channels within the trinary systems, and constitute reference elements of the structural axes development. According to the IPPUC (2020), these corridors:

- directed a linear growth of the city;
- present the highest demographic and construction densities;
- are priority areas for urban equipment installation;
- define their own urban landscape;
- evidence the possibilities for implementing the mechanisms for integrated land use planning;
- are organizing elements of the street network and public transport;

In order to make the trinary system viable, channels were built in the middle of the structural ones for express buses transit, which optimize travel time and can transport more passengers. Tube stations were also installed on these channels, allowing physical integration between different transport lines without the need to pay for another ticket. This measure encouraged the use of the system by the population, due to its greater economic attractiveness and speed of operation.

According to the IPPUC (2020), currently, it is estimated that around 2 million people use the buses of the Integrated Transport Network, which also integrates lines that serve the metropolitan region. The public transport system is currently managed by URBS / SA, an agency linked to the Curitiba City Hall.

Despite its long existence, the configuration of the trinary system continues to evolve. In 2010, an improvement program was started on the exclusive public transport routes. The aim of this program was to create a third lane next to the intermediate stations, allowing overtaking in these places and enabling greater diversification of lines, with the creation of direct lines that carry out stops only at terminals and in the central area of the city, reducing travel time.

Another improvement implemented in some sections of the Trinary System was the creation of cycle lanes on the side roads adjacent to the BRT axes, in the first half of 2014, taking advantage of the existing configuration of the road that led to low vehicle speeds (up to 40 km / h) to improve the city's bicycle infrastructure (Ferraz, 2017). Such bike lanes are also equipped with bike-boxes, to improve the visibility of cyclists at intersections. Figure 05 shows an intersection of the trinary system in a section with an implanted cycle track.

Figure 5: Bicycle lane and bike box installed at the Via Calma - Curitiba.

Source: Authors (2018)

5. Conclusions

Although trinary systems were idealized in the late 1960s, strategies adopted are in line with current understanding of good practices such as Transport Oriented Development. By integrating the highest population densities with diversity of land uses and proximity to public transport networks, the region of structural axes creates a dynamism of activities that allows less need for large displacements (due to the offer of trade and services close to housing) and when long commutes are needed, they can be done via public transport.

In addition, recent offer of bicycle infrastructure along these axes includes yet another modal to complement daily commutes of the population, once again increasing accessibility both to public transport systems and final destinations.

This development of accessibility is also a main positive outcome from the long planning and implementation process of the urban mobility structures and built environment shaping. By increasing the population and activities nearby transit axes, which also presents cycling and walking infrastructures, more people are able to perform their daily commute using public transport, bikes or walking, thus reducing the need for private cars use. In addition, the concentration of people and services in those areas reduces the distance of commuting and allow financial viability of efficient transit systems.

Considering a case for smart cities, these positive outcomes appear to match the whole series of objectives for the Smart Mobility concept: reducing mobility costs, air pollution, noise pollution and traffic congestion, and improving safety and speed of mobility. Additionally, the rise in accessibility, the reduction in fossil fuels consumption related to transport and the optimization of urban space are outcomes that impact on the smart people and smart environment dimensions of smart cities

6. Limitations

As the case study covers a planning process that lasted for decades, relevant steps might be absent for the lack of data and the limitation of the paper scope.

7. Future Works

Comparative case studies with other Latin American cities with similar scale, with a standard instrument for data collection, allowing the application of cross-sectional analysis can provide a clearer view of the strategies better adapted to Latin American cities.

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Communication aligned with the Sustainable Development Objectives