



## **Transit-Oriented Development in Teresina, Piauí**

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#### **ABSTRACT**

Transit-Oriented Development – TOD is an urban planning and landscape strategy which goals are to organize compact neighborhoods with high demographic density, land use diversity, and the offering of public services and space to provide socializing and reduce car dependency. This paper goals to evaluate the potential of sustainable development according to TODs principles, in transport corridor “Avenida João XXIII”, located in Teresina, Piauí, Brazil. Besides that, this paper also goals to evaluate the adherence scale of Teresina’s urban policy to TODS principles and objectives. To this end, the methodological procedures include exploratory research of the bibliographic and documentary type, in addition to quantitative and qualitative research composed of observational and statistical methods. The time frame to be worked on is contemporaneity, using databases from the Census/IBGE (2010) and information from the Municipal Transport and Traffic Superintendency (STRANS) and the Municipal Planning Secretariat (SEMPPLAN). The results demonstrate that the corridor Av. João XXIII has high potential for sustainable transport-oriented development. The TODS potential evaluation may be able to orientate actions and real estate investments of the public and private sectors in order to transform the urban space by the improvement of the transportation infrastructure, environmental sanitation and by offering more efficient public services; besides that, may be able to minimize the urban voids, bringing live and movement to the streets, what may contribute to minimize the urban violence rates and to the improvement of the life quality.

**KEYWORDS:** Population density. Urban planning. Use of the soil.

## **1 INTRODUCTION**

The second half of the 20th century in Brazil was marked by the accelerated urbanization process, mainly due to internal migrations resulting from the social, economic and political transformations of the time. In the 1960s, the urban population surpassed the rural population and reached the 21st century with approximately 138 million people living in Brazilian cities. This rapid growth occurred in a disorganized manner and resulted in perverse and unequal urbanization, which led to urban problems, such as suburban neighborhoods, favelas and invasions lacking essential services and equipment, pollution, violence, among others (Brito, 2006; Maricato, 2000; Oliveira, 2001).

The most common urban model in Brazilian cities is the so-called “dispersed city model”, in which the territory is organized in a sectorized manner, with low population densities and, therefore, spread out, with private transport being the main means of travel. This model results in a spatially segregated city that, in addition to increasing social exclusion, makes access to urban facilities and quality public transport difficult (Brazil, 2013).

The promulgation of the City Statute in 2001 was a historic milestone for the regulation of urban property, in an attempt to make urban space more fair, democratic, safe and environmentally balanced. Since then, there has been a proliferation of projects and initiatives, mainly in the areas of housing and urban mobility, with the aim of reducing the country's housing deficit and improving travel in the urban environment.

The urban policy instruments presented in the City Statute, the most recent studies of contemporary urbanism, as well as the sustainable development objectives of the United Nations (UN), favored the dissemination of an urban model called “compact city”. This model mixes land uses

throughout the urban territory; favors the development of different centralities, with greater population densities; and prioritizes public transport and non-motorized modes. Diversity of use provides greater social heterogeneity, while higher densities save costs on urban infrastructure and the provision of public services (Brazil, 2013).

From this perspective, the concept of Transit-Oriented Development (TOD) became widespread, an urban planning strategy guided by public transport, which aims to establish compact neighborhoods with high densities and diversity of land uses (EMBARQ, 2015).

In view of the above, this article's main objective is to evaluate the potential for sustainable development, according to TOD principles, in the João XXIII Transport Corridor in Teresina, Piauí. To this end, we also sought to verify to what extent Teresina's urban policy is aligned with the TOD principles and objectives.

Thus, section 2 provides a theoretical framework constructed based on bibliographical research in order to present the emergence, characteristics and purposes of the TOD methodology. Then, section 3 demonstrates the methods and techniques used in the research. Section 4 brings the results of this investigation, constructed with the help of documentary and bibliographical research, bringing the main topics of the Territorial Planning Master Plan (Complementary Law No. 5,481/2019) related to the TOD concept, in addition to subsection 4.1 that details the results of the assessment of the TOD potential in the João XXIII Corridor. The fifth and final section sets out the final considerations regarding the theme and repercussions of the research.

## **2 TRANSIT-ORIENTED DEVELOPMENT**

The term Transit-Oriented Development – TOD was systematized by architect and urban planner Peter Calthorpe in 1993, when he published a type of manual for urban planning, called *The Next American metropolis: ecology, community, and the American dream*. The TOD originally presented a series of guidelines and urban design elements focused on ecological issues, with emphasis on transportation. The main guidelines were: organize growth at the regional level to be compact and transport-friendly; allocate commercial, residential, employment opportunities and civic uses within walking distance of public transport stations; create pedestrian-friendly road networks that connect directly to local roads; promote a mix of housing types, densities and costs; preserve risk areas, riverside areas and open spaces of environmental quality; and orient buildings and activities for basic use towards public spaces (Carlton, 2009; Ditmarr, Ohland, 2004).

Several cities in developed countries have had successful experiences with the TOD model, such as Washington (USA), Bilbao (Spain), London (England) and Tokyo (Japan). Among the benefits, we can highlight the reduction in travel time and the consequent reduction in greenhouse gas emissions, as well as the increase in land uses and densities that derive from controlling the sprawl of the urban area (IDB, 2021).

TOD guidelines are sought after by urban planners at both the neighborhood and city scales to this day. Its principles encompass ecological, economic and quality of life issues related to

the design of urban space, prioritizing transport. Therefore, even though they have been discussed since the 1990s, they remain relevant. In Brazil, only from the 2010s onwards did this theme gain strength and began to be considered by experts as an alternative for the sustainable development of Brazilian cities.

Given this context, TOD can be defined as a method of urban planning and design directed by public transport for the development of compact neighborhoods with high densities, diversified uses (housing, commerce, services and leisure) and, consequently, busier and safer routes, squares and parks (EMBARQ, 2015).

The objective of this planning model is “to promote a complete urban life with adequate access to the entire city, quality housing, safe and pleasant mobility, provision of basic needs, low carbon emissions, social integration and generation of employment and culture” (EMBARQ, 2015, p. 15). To achieve this, it is necessary to implement strategies and projects that guarantee the seven elements of a TOD neighborhood: quality public transport; non-motorized mobility; car use management; mixed use and efficient buildings; neighborhood centers and active ground floors; public spaces and natural resources; participation and community identity.

The TOD concept can be summarized by eight principles that, once planned and executed in an interdependent manner, seek to guarantee the development of more structured, active, safer and sustainable neighborhoods. They are **compacting**, as, by avoiding the growth of the urban area, time and energy are saved when commuting; **thickening**, the main strategy for maintaining a compact city, with increased utilization coefficients; **transporting**, in order to prioritize public transport of medium and high capacity with quality and accessibility; **connecting**, with the creation of a harmonious network of roads that enable the integration of different modes of transport and easy permeability for travel. Furthermore, **mixing** and combining housing, institutional, cultural, commerce, services and leisure activities in the same area, in order to shorten commutes and keep the city active at all times and days of the week; **using a bicycle**, as adopting this means of transport offers greater autonomy on routes, and more active and safer streets; **changing**, this principle concerns the change of a cultural characteristic of considering the private car as the most advantageous means of transport. To achieve this, in addition to the previous principles, strategies are needed to reduce the use of this mode, such as parking and traffic control policies; and, finally, **walking**, because when all the principles work satisfactorily, you have walkable streets and cities. Promoting this activity is one of the main objectives of TOD projects, since it is not only a way of getting around, but also a way of experiencing and enjoying urban space (ITDP Brazil, 2016).

TOD projects aim, mainly, at the development of different complementary activities (housing, commercial, services, culture and leisure) located on public transport routes, or at a short distance from them, and the construction of an urban space conducive to the use of public transport, cycling and walking, with the aim of improving mobility and minimizing car dependence (Goodwill; Hendricks, 2002).

Although viable, it is important to recognize the complexity of TOD projects, since to implement them, it is necessary to combine urban planning, infrastructure projects and urban

design, in addition to a set of laws, regulations and public investments. Furthermore, for the projects to be successful, it is necessary to align the interests of public institutions, private investors and the population involved (IDB, 2021).

### 3 METHODS AND TECHNIQUES

In this research, the dialectical approach method was used, since, in addition to examining the urban policy of Teresina and its affinity with the TOD methodology, it was proposed to evaluate the potential for sustainable development of a consolidated urban area that is in constant transformation, resulting from the actions of various social actors. Observational and statistical procedure methods were also used, in addition to exploratory research that involves bibliographic and documentary research to construct qualitative and quantitative research.

The Institute for Transport and Development Policies – ITDP Brazil developed the Tool for Assessing TOD Potential in Transport Corridors with the aim of:

evaluate medium and high-capacity transport corridors in relation to their potential for promoting TOD projects. The results obtained through the diagnosis should provide support to identify opportunities and select areas in which public and private investments result from the urban development of polycentric cities, but compact, dense and with mixed land use (ITDP, 2016, p.15).

The assessment proposed by ITDP takes place in two phases, namely: Phase 1 – Urban space conditions for the development of TOD projects, in which predefined themes and metrics are quantitatively weighted. Phase 2 – Perception of qualified actors on the viability of TOD projects, it is the occasion in which political, economic, social and technical viability is examined (ITDP, 2016).

This research is focused only on the first phase, since the objective is to understand the physical conditions and economic and social characteristics, to evaluate the potential of the study area in relation to the feasibility of implementing TOD projects.

The investigation procedures include field research, with the aid of satellite images, including photographic survey and observation to understand the conditions and characterization of each station area, following the methodology proposed by ITDP Brazil. Station areas are determined by the linear distance between 400 meters and 1 kilometer (400m to 1km radius) from each transport station. In this research, the minimum value of 400m was used as it was considered a comfortable distance to be covered on foot, due to the climatic characteristics of the city of Teresina.

In addition, there is qualitative-quantitative research, with the help of information obtained in field research. This stage corresponds to Phase 1 of the tool for assessing the TOD potential and involves the analysis and interpretation related to the physical and structural

conditions of the urban space, with the help of the global spreadsheet prepared by ITDP Brazil, following the metrics in Table 1.

At this stage, to quantify the metrics, the programs QGIS, Google Earth and Microsoft Excel were also adopted. For each of these metrics, a score of zero to five points was assigned, depending on performance. The result is obtained through a weighted average, with the application of weights, and can reach up to 100 points. The final classification is established as follows: stations with high performance when they obtain a score greater than 60; average performance when they total between 40 and 60 points; and low performance when the score is less than 40 (ITDP, 2016).

Table 1 – Phase 1 indicators and metrics

Indicators	Metrics	Score	Weighting Factor (weight)	Maximum score
Land Use and Occupation (UOS)	Demographic density	0-5	1,0	20
	Monofunctional or incompatible areas	0-5		
	Residential areas with complementary activities	0-5		
	Unbuilt or underused areas	0-5		
Basic Sanitation Infrastructure (SAB)	Households connected to the general water supply network	0-5	2,5	25
	Households connected to the general sewage collection network	0-5		
Urban Space Connectivity (CON)	Block density	0-5	2,0	30
	Transport system integration	0-5		
	Elements that induce segregation of urban space	0-5		
Circulation Conditions for Active Transport (ATV)	Households with surrounding sidewalks	0-5	1,0	15
	Households with public lighting in the surrounding area	0-5		
	Households with surrounding trees	0-5		
Socioeconomic Diversity (DIV)	Income distribution by resident people	0-5	2,0	10
<b>TOTAL SCORE</b>				<b>100</b>

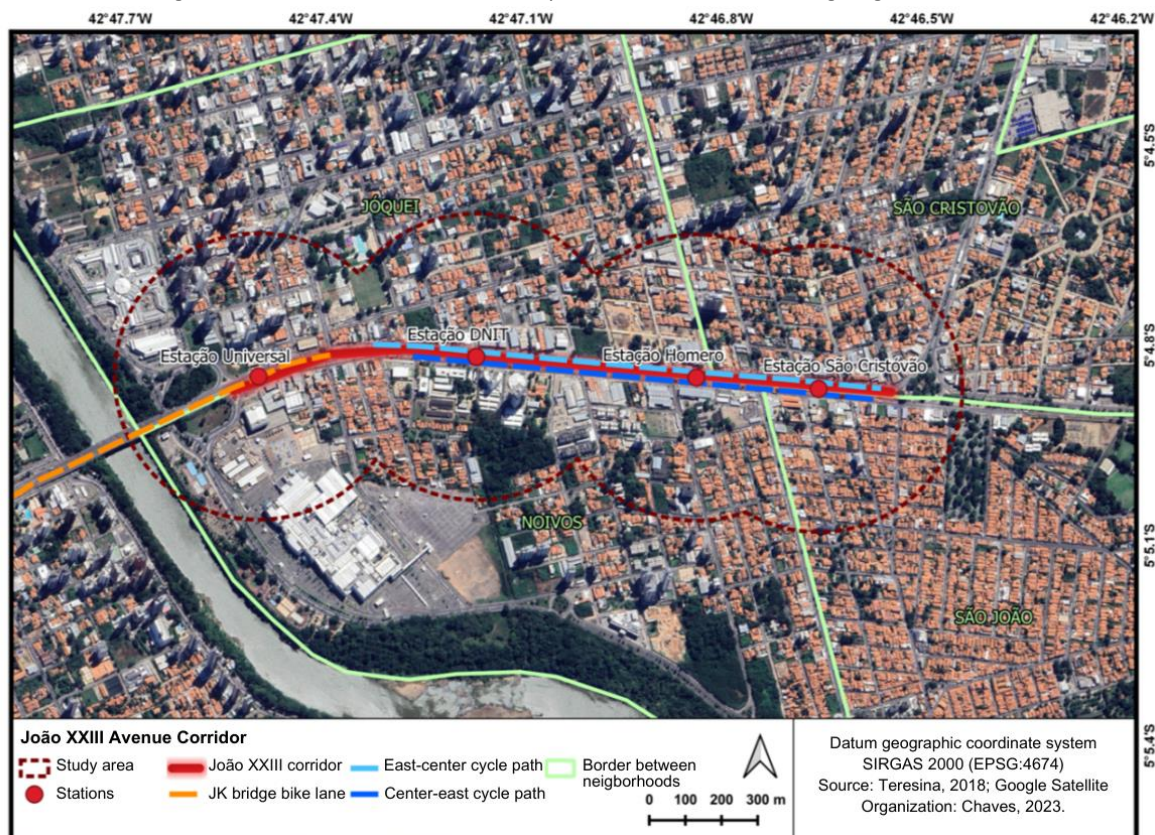
Source: ITDP (2016), organized by Authors (2023).

In this sense, the study area corresponds to the João XXIII transport corridor, located in the east zone of Teresina, and its area of influence. This region was consolidated in the capital of Piauí through road axes: Presidente Kennedy Avenue (state highway PI-112 that connects Teresina to the municipalities in the northeast of Piauí), Nossa Senhora de Fátima Avenue, which crosses the east zone in a north-south direction, Avenida João XXIII Avenue, federal highway BR-343 that connects Teresina (PI) to Fortaleza (CE) and other cities to the east and north of the Piauí state. Therefore, since the beginning of the occupation, minimum accessibility was guaranteed to the population that settled in the region, thus becoming an area attraction (Abreu, 1983).



João XXIII Avenue has a wide roadway, with four lanes in the center-east direction (one of them being an exclusive lane for buses) and another four in the east-center direction, also with an exclusive lane for public transport. It also has four more lanes on the loops (two in each direction) to allow access to properties in the region and local circulation. Furthermore, it comprises a cycle path structure with three components: a two-way cycle lane that starts from the Juscelino Kubitschek Bridge and ends at the intersection with Nossa Senhora de Fátima Avenue; a cycle path in the central-east direction; and a cycle path in the east-center direction, as shown in Figure 1.

Figure 1 – João XXIII Corridor: stations, cycle network and surrounding neighborhoods



Source: Teresina (2018) organized by Authors (2023).

The João XXIII Avenue transport corridor is 1.84 km long and consists of four bus stations: Universal Station, DNIT Station, Homero Station and São Cristóvão Station. This way, it covers the Jóquei, Noivos, São Cristóvão and São João neighborhoods.

The time frame worked is contemporary, with the use of Census/IBGE (2010) databases, information from the Municipal Transport and Traffic Superintendency (STRANS) and the Municipal Planning Secretariat (SEMPPLAN).

#### 4 TOD IN TERESINA, PIAUÍ

In 2019, Complementary Law No. 5,481 was approved, which provides for the Territorial Planning Master Plan – PDOT, Teresina's most recent urban policy instrument that follows the trend of large cities to repress the growth and sprawl of the urban area.

In this way, one of the territorial strategies of the territorial development and resilience policy is precisely to control the expansion of the urban area and stimulate the densification of the urban territory articulated with the “I- Urban mobility policy; II - Offering infrastructure and urban services, valuing public space, sustainable practices and the environment” (Teresina, 2019, p. 4).

Next, the plan brings principles that guide the strategy to make the city compact, coordinated and connected. These principles are based on the TOD methodology and aim to promote diversified land uses, associated with the urban mobility system; development of multi-centralities in urban territory; sociocultural and socio-territorial integration; population density compatible with existing infrastructure and environmental characteristics; expand access to urban services and reduce inequalities; and restrict dispersed urban growth (Teresina, 2019).

Among the guidelines that guide this strategy are: guaranteeing the social function of urban property through the mandatory use and occupation of urban spaces; consolidate new centralities; regulate the construction potential according to the available infrastructure; contain urban expansion; connect the new road layout to the already consolidated one; stimulate housing and population densification in areas with consolidated infrastructure and public transport corridors (Teresina, 2019), in addition to:

XV - Decrease the need for travel through motorized transportation, better positioning social equipment, decentralizing public services, occupying urban voids, consolidating multi-centrality as a way to bring potential workplaces closer and the offer of services to housing sites (Teresina, 2019, p. 5).

An interesting aspect of the current master plan is the division of urban space into four macrozones: Development Macrozone – MZD, Moderate Occupation Macrozone – MZOM, Environmental Interest Macrozone – MZIA and Conditional Occupation Macrozone – MZOC. The MZD is defined by areas in which occupation is already consolidated, therefore, there are few urban voids and a greater supply of infrastructure, urban services and completed road network. In these areas, the densification and qualification of public space must be encouraged, or more specifically, planning and urban design strategies typical of TOD (Teresina, 2019).

The MZD is subdivided into three: Central Development Zone; Eastern Development Zone; and Corridor Development Zones. The latter is divided into six zones (some of them corresponding to public transport corridors and their area of influence): Eastern Corridor Development Zone; Northern Corridor Development Zone; Southeast Corridor Development Zone; Southern Corridor Development Zone 1; Southern Corridor Development Zone 2; Sustainable Management Corridor Development Zone.

According to Art. 59 of the PDOT:

The Corridor Development Zones are distributed throughout the macrozone and are characterized by being the territories that are under the direct influence of public transport



corridors and by the provision of urban infrastructure, in which this PDOT encourages densification and the implementation of compatible diversified activities with housing (Teresina, 2019, p. 20).

It is worth noting that the urban mobility structure of Piauí’s capital has, since 2018, included seven transport corridors: two in the north zone (Rui Barbosa and Duque de Caxias), two in the east zone (Presidente Kennedy and João XXIII); and three in the south zone (Gil Martins, Barão de Castelo Branco – Henry Wall de Carvalho and Miguel Rosa – BR-316).

In PDOT (2019) there is a subsection especially to address the TOD model, in which, in addition to demonstrating the principles, it reinforces that this strategy aims to encourage, around public transport corridors:

- I – Land occupation with highest population density.
- II – Mixed uses.
- III – Commerce and service activities with accessibility and comfort on foot.
- IV – Adequate and safe streets at different times, with greater vitality, attractive to pedestrians and cyclists, which encourage social and cultural diversity (Teresina, 2019, p. 20).

Thus, to promote urban transformation, in accordance with the TOD strategy, the plan defined seven attributes of land use and occupation (Table 2) that must be stimulated through discounts in the value of the Onerous Grant of the Right to Build (OODC) – instrument of the City Statute that allows construction above the basic utilization coefficient adopted by the municipal master plan, with compensation from the interested party (Brazil, 2001; Teresina, 2019).

Table 2 – Land use and occupation attributes for the DOTS model

Attributes	Descriptions
Active facade	Building front with commerce or services, creating integration with the street.
Housing use	Residences close to transportation.
Anchor activities	Large businesses or services, such as supermarkets, schools, hospitals, etc.
Visual permeability	Land enclosure in glass, railing or material that allows vision.
Mixed enterprise	Buildings that contain residences, commerce, services.
Public enjoyment	Open ground floor with public access.
Environmental sustainability	Practices to enable a more significant contribution from private entrepreneurs to improving urban drainage conditions.

Source: Teresina (2019), organized by Authors (2023).

These attributes can be adopted individually or in combination. From this perspective, the discount on the OODC value can reach up to a maximum quota of 50% for the construction of housing projects with an active facade and visual permeability in several regions of Teresina-PI (Teresina, 2019).

In addition to the OODC, another urban planning instrument provided for in the City Statute that PDOT/2019 foresees use in the MZD, for the purposes of urban densification and containment of real estate speculation, is a set composed of compulsory installments, construction or use, progressive IPTU over time and expropriation through public debt securities.

Given the above, it is possible to see how much the TOD theme was explored in the PDOT to guide the territorial development policy of Teresina’s municipality in the coming years. In line with global and national discussions, the plan emphasizes social objectives, related to the social function of the city and urban property and quality of life, combined with sustainability.

#### 4.1 TOD potential in João XXIII Corridor

The analysis tool developed by ITDP (2016) advises that, when there are two transport stations close to each other, so that there is no overlapping of data from the blocks located in their area of influence (radius of 400 meters), they must be treated as a set of “twin stations” – this is the case of Homero and São Cristóvão Stations, which are only around 300 meters apart. Therefore, in João XXIII Avenue Corridor, three station areas were analyzed: Universal Station; DNIT Station and Set of Homero and São Cristóvão Stations. Therefore, the results obtained are synthetically demonstrated in Table 3.

Table 3 – Summary of TOD Potential for João XXIII Corridor

Phase 1 Results				Score by theme				
Station	Corridor	Potential Outcome	Total Score	Land Use and Occupation (UOS) (1-20)	Basic sanitation (SAB) (1-25)	Urban Space Connectivity (CEU) (1-30)	Active Transport Conditions (ATV) (1-15)	Social Diversity (DIV) (1-10)
Universal	João XXIII	HIGH	68	12	15	16	15	10
DNIT	João XXIII	HIGH	61	13	15	12	11	10
Homero and São Cristóvão	João XXIII	HIGH	68,5	12	17,5	20	11	8

Source: Authors (2023).

The TOD potential of the three station areas belonging to João XXIII Avenue Corridor is high, as they all achieved a total score above 60 points in relation to the metrics analyzed. Therefore, regarding the conditions of the urban space for the development of TOD projects, the corridor in question, as a whole, is convenient for the implementation of this proposal.

The João XXIII corridor presents very diverse land use (Figure 2). In the Universal Station area, the number of lots dedicated to Commerce and Services and unbuilt or underused land stands out, which contributes to the low demographic density. However, the low demographic density is understood as an opportunity, as it indicates the region's potential for densification. It is important to highlight that “increased population, construction and housing densities allow for more efficient use of infrastructure and urbanized land” (WRI Brazil, 2018, p.56) and, in the case of TOD projects, this densification must be related to public transport systems.

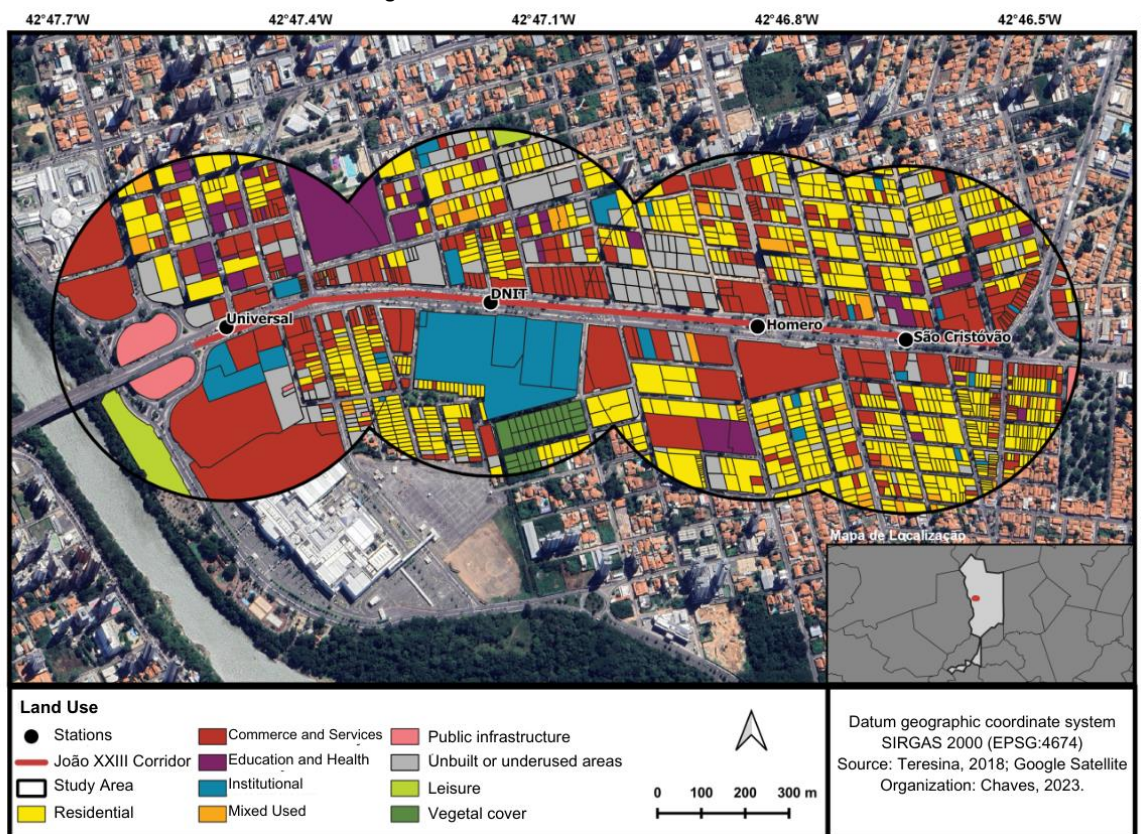
In the DNIT Station area, land use is also diverse, however there is a concentration of residential lots in some areas, as well as a reasonable amount of unbuilt or underused areas (16%),

given that, in this case, it can also be considered as a potential from the perspective of receiving new real estate developments aligned with the TOD elements and principles. In the area of the Homero and São Cristóvão Station Complex, land use is somewhat diverse. In this way, it is possible to notice the concentration of Commerce and Services in the lots adjacent to the busiest roads, while inside the blocks there is a strong presence of residential lots, which also justifies this being the area with the highest population density.

In general, throughout the João XXIII corridor’s area of influence, it is possible to see that the number of mixed-use lots is insignificant. This construction typology can bring diversity of land use to the scale of the building, in addition to having the power to increase population density. Therefore, it is a type of enterprise that should be encouraged by municipal management, through urban policy, whether through exemption from IPTU or discounts at OODC.

Regarding the Basic Sanitation Infrastructure, it is worth highlighting that, according to data from the Census/IBGE (2010), in the Universal Station area 78% of households are connected to the water supply network, while in the DNIT Station 92% of buildings are connected, and in the Homero and São Cristóvão Station Set this metric reaches its maximum value with 96% of households connected to the general water supply network. Concerning the sewage collection network, 95% of households at Universal Station are connected to this infrastructure, while 87% of properties in the DNIT Station area and 84% of households at Homero and São Cristóvão Stations are connected to the sewage collection network. These data demonstrate a mismatch between water distribution and sewage collection. Therefore, this is an aspect in which public management needs to improve, as it is a service owned by the municipality and needs to be in full operation before any instrument that encourages population density, as it is a topic that is directly associated with human and environmental health (Costa, 2017).

Figure 2 – Land Use – João XXIII Corridor



Source: Teresina (2018) organized by Authors (2023).

Urban Space Connectivity has low or medium performance throughout the João XIII Corridor. This is because, despite there being a reasonable number of blocks that allow urban permeability in the region, the Integration of Medium and High-Capacity Transport Systems metric had a score of zero in all stations. This is because there is no other public transport system complementary to buses in the study area.

Regarding the Elements that Induce Physical Segregation of Urban Space, a large block was identified in the Universal Station area, which houses a shopping center (Teresina Shopping) and other commercial and institutional developments that, in general, can be considered segregation inducer, since it occupies a huge, closed area that makes it difficult for passers-by to pass through the region. In the DNIT Station area, two components were identified that were considered to induce segregation: the institutional block that houses several federal bodies (CGU, DNIT, MPF, TRT, PRF) and has considerable dimensions, without allowing free movement between buildings; in addition to the large area of vegetation coverage neighboring the institutional block.

The Circulation Conditions for Active Transport indicator evaluates the existence of sidewalks, public lighting and trees around the homes that make up the station areas. From this perspective, data from the Census/IBGE (2010) indicate that, in Universal Station’s area of influence, 99% of households have sidewalks, at DNIT Station this number drops to 98% and, in Homero and



São Cristóvão Set, 97% of homes have sidewalks around them. Regarding public lighting, the three station areas analyzed have 99% of their properties with this infrastructure in the surrounding area. The presence of afforestation in the surrounding area is evident in 96% of the homes at Universal Station, 79% at DNIT Station and 77% at Homero and São Cristóvão Set. This data alerts to the need to intensify tree vegetation in the vicinity of homes, especially the DNIT, Homero and São Cristóvão Stations, in order to guarantee thermal comfort for pedestrians and cyclists, since “vegetation in urban areas is an important component of the microclimate, contributing to the increase in relative air humidity, the decrease in temperature and, consequently, to the improvement of thermal comfort in tropical environments” (Neres; Silva; Pereira, 2021, p. 2).

The Socioeconomic Diversity theme had its metric Income Distribution of People Resident in the Station Area with very high performance in the Universal and DNIT Stations and high in the Homero and São Cristóvão Station Set. This data indicates that the inhabitants of the João XXIII Corridor’s area of influence belong to diverse economic classes, even though it is an area considered noble in the capital of Piauí.

In view of the above, it was observed that there are no major divergences in the conditions of the urban space along the João XXIII Corridor, so that both the metrics that relate to physical characteristics and social and economic characteristics showed similarity.

## **5 FINAL CONSIDERATIONS**

As seen in the results, the entire corridor has a high potential for population density, while it has an insignificant number of mixed-use buildings. It is also possible to perceive the João XXIII Avenue Corridor as a whole, presenting diverse land use, mixing residences, commerce and services, health and education, institutional use, public infrastructure and leisure. In general, these metrics are related to each other. Therefore, municipal management can, through urban policies, implement TOD projects in this space.

Another important aspect is related to basic sanitation infrastructure. It is essential that municipal management intensifies the coverage of water supply and sewage collection with the appropriate size for the population density sought to be achieved, to avoid the collapse of this infrastructure. The proposed ITDP methodology does not consider other aspects of basic sanitation, such as urban cleaning and solid waste management, and drainage and urban rainwater management, essential services for the consolidation of sustainable communities, therefore, they must also be considered by the municipal management.

Regarding circulation conditions for active transport, it is important to emphasize that the ITDP tool considers the existence or absence of sidewalks, public lighting and trees around homes and not their quality, so that attention would be needed regarding the sidewalks’ physical conditions, to make sure they are in accordance with current legislation (NBR-9050/2020 – Accessibility to buildings, furniture, spaces and urban equipment and Complementary Law No. 4522/2014 –



Establishes new standards for sidewalks and criteria for their construction, reconstruction, conservation and use of sidewalks in the Municipality of Teresina), offering accessibility and safety.

Furthermore, it is urgent to observe the characteristics of public lighting and encourage the use of more efficient and sustainable devices. As for urban afforestation, special attention should be paid, mainly because in the DNIT Station and in the Homero and São Cristóvão Complexes, less attractive rates were found. It is emphasized that urban afforestation has the capacity to improve air quality, provide thermal and acoustic comfort, improve the aesthetics of the urban landscape and the feeling of well-being.

In circulation conditions for active transport, the ITDP tool makes no mention of the existence or not of cycle paths, cycle lanes or cycle routes, neglecting this type of structure, fundamental in the design of urban roads in sustainable communities. However, it is important to highlight that the area studied has coverage of cycle paths and cycle lanes, although it is not possible to say, for methodological reasons, whether they are in accordance with the Brazilian Traffic Code – CTB.

Regarding the Integration of Medium and High-Capacity Transport Systems metric, throughout the João XXIII Avenue Corridor, there was no other public transport system that could be used in a complementary way to buses. Still, all three station areas performed highly relative to their potential for TOD projects. From this perspective, the Inter-American Development Bank (IDB) highlights that “bicycles and pedestrians should be the main modes of feeding the public transport system” (IDB, 2021, p.288), since these two modes could expand the radius of action of TOD areas, highlighting the importance of integration between active and public transport.

Therefore, the high potential of the João XXIII Corridor is especially because the corridor has diverse land use, with the possibility of increased density. In addition, it has a reasonable basic sanitation infrastructure, sidewalks and public lighting. Another very particular and interesting characteristic of the study area is that, even though it is located in a prime region of the capital of Piauí, it has socioeconomic diversity among residents, a condition that contributes to the potential for implementing TOD projects.

In this scenario, municipal management and real estate investors must direct efforts towards the construction of housing with complementary use (mixed use) in station areas, including social housing. This investment must be accompanied by improved infrastructure – basic sanitation, accessible sidewalks, construction of cycle paths, afforestation, free areas for public enjoyment. These actions can be supported by urban policy instruments that seek to guarantee the social function of urban property and the densification of structured urban areas, in addition to avoiding socio-spatial segregation and real estate speculation.

This work was carried out with the support of the Coordination for the Improvement of Higher Education Personnel – Brazil (CAPES) through Project No. 88887.568476/2020-00 – Renewable

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