Extended Abstract


This study presents a BRT Transoeste project evaluation in the city of Rio de Janeiro, from a sustainable mobility and urban development perspective. The BRT Transoeste is the first Bus Rapid Transit system implemented in the municipality and was proposed initially to fulfill the agreement between Rio de Janeiro City Government and the International Olympic Committee for the 2016 Olympic Games. This system crossing the city neighborhoods in Planning Area 4 (Barra da Tijuca) and 5 (West Side) was envisioned to work as a passenger transportation structuring system for its area of influence. The Geographic Information System – GIS helped analyze indicators associated with the system’s spatial coverage, urban space circulation conditions, land occupation, use and zoning laws in its direct area of influence. The Móible Research Group (COPPE/UFRJ) developed six principles for sustainable city design to analyze results obtained for these spatial indicators. These principles make clear the need to integrate transportation and land use planning to promote sustainable mobility and urban development.
Introduction

As part of the urban mobility agreement signed with the IOC (International Olympic Committee for the Olympic Games in 2016) – the Municipality of Rio de Janeiro is implementing BRT (Bus Rapid Transport) systems. To improve service and operation, the BRT uses articulated buses on segregated lanes and boarding and disembarkation stations, similar to railway systems.

The Transoeste is one of such designed BRT lines already partially in service. This line, inserted in Planning Area 4 (Barra da Tijuca) and 5 (West Zone, Figure 1) was created as a structuring system for mass transit in the areas crossed by its path. The main objective of this axis is to provide better access to Olympic Games facility areas and also improve mobility in the operation region.

![Figure 1 – BRT Transoeste line (in red), surrounding neighborhoods serviced by the system and the limits of the Planning Areas (in white) in the Municipality of Rio de Janeiro.](image)

The BRT Transoeste implementation raises the following question: does this project take into account principles and strategies of integrated transport and land use planning, capable of promoting mobility and sustainable urban development?
Objectives

Our study evaluates the BRT Transoeste project from the viewpoint of sustainable mobility and urban development and includes the following specific objectives:

- Project analysis using spatial indicators supported by geoprocessing tools (Geographic Information System);
- Evaluation of findings based on sustainable cities design principles proposed by Martins et al., (2004);
- Possible recommendations for project.

Sustainable Cities Design Principles

We use the six urban design principles (Table 1) proposed by Martins et al. (2004) as a reference for evaluating the BRT Transoeste project in terms of sustainable mobility and urban development. These principles were developed based mainly in European experiences of transport and land use integrated planning, adapted to Brazilian reality.
### Table 1 – Sustainable Cities Design Principles.

<table>
<thead>
<tr>
<th>PRINCIPLE</th>
<th>DESCRIPTION</th>
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<tr>
<td>Environmental Zones VS Thru-Traffic</td>
<td>Since Buchanan’s classic <em>Traffic in Towns</em> (1963), an environmental zone has been defined as a territorial unit whose access or connection point with the structural urban mass transit network preserves its inside area from the need for motorized travel, and especially any thru traffic within its perimeters.</td>
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<tr>
<td>Macro and Micro Accessibility Integration</td>
<td>Density limitations in the aforementioned zone is tied to environmental capacity and transportation limitations in and out of the zone, namely, integration conditions between the zone’s internal (micro accessibility) and external (macro accessibility) circulation systems respectively.</td>
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<td>Land Use and Transportation Integration</td>
<td>Each traffic generation pole should promote a mobility management plan to facilitate passenger boarding and disembarkation, provide customer information on its transportation services and sell tickets or fares.</td>
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<td>Non-Motorized Transportation Campaigns</td>
<td>As far as possible, micro accessibility should be based on the possibility of non-motorized commuting (walking and cycling) in environmental zones through the necessary use of joint urban design, traffic calming and landscaping techniques for adapting urban environment landscape.</td>
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<tr>
<td>Strategic Locations and Mixed Use</td>
<td>Defined strategic locations best suited to take advantage of complementary economic activities (residential, business, services and leisure) around stations and public transport terminals within environmental zones. Mixed use should be encouraged in environmental zones and specialized land use avoided to reduce impact on passenger circulation according to principles 1 and 3.</td>
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<tr>
<td>Social Integration and Inclusion</td>
<td>Promoting equal access to urban opportunities for different social groups means giving priority to what is used by the public and in interest. Nonetheless, despite guidelines for standardized service or product quality, it should be noted that comfort features may be used to generate additional revenue sources for cross investment in social interest areas and services with acceptable environmental quality indicators. Thus, all rather than a few can enjoy access to urban life with &quot;total quality&quot; and acceptable standards and total social inclusion is ensured.</td>
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Methodology

Spatial Indicators Definition

To examine the BRT Transoeste project from the perspective of sustainable mobility, we have adopted the definitions of spatial indicators and explanatory variables for each of the six design principles proposed by Martins et al. (2004).

- **Spatial Coverage Transportation System**: with a maximum distance of 800 meters as a reference point, isochrone\(^1\) mapping shows the system’s spatial and population coverage in its Area of Direct Influence (ADI). For population coverage, the limits of the isochrones were crossed checked with a georeferenced database on census tracks from the 2010 IBGE Census;

- **Urban Space Circulation Conditions**: the georeferenced database on census tracks in the 2010 IBGE Census shows pedestrian circulation conditions in the system’s surrounding ADI residential units. Furthermore, georeferenced data on the city’s bike paths provided by the organization Transporte Ativo (2014) examined bicycle infrastructure circulation conditions;

- **Land Use and Occupation**: primary and secondary data base showed the proximity between traffic generation poles, other urban equipment and the transportation system in the ADI;

- **Spatial Planning**: we examined all current zoning laws and ordinances in the system’s ADI.

Data processing

Following Pinto’s (2011) methodology as our main guideline, we used the extensions of the ArcGIS software 10.2.2 of the Environmental Systems Research Institute (ESRI) and other geoprocessing tools for data processing.

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\(^1\)Isochrones consist of contours that express the spatial distance and commuting time relationship. In this study, these represent the relationship between distance and user walking time to BRT Transoeste stations and from these to shops, services, education, health and leisure and other urban facilities.
According to criteria from Martins and Bodmer (2001), we defined Environmental Zones\(^2\) (EZs) associated with the system for spatial referencing in our BRT Transoeste analysis. As a whole, these zones consolidate the system’s ADI. Accessibility levels and mobility conditions in these zones are directly affected by the project.

![Conceptual model of the ADI and EZs for BRT Transoeste spatial indicators.](image)

**Figure 2** – Conceptual model of the ADI and EZs for BRT Transoeste spatial indicators.

**Results Analysis**

We used thematic maps, tables and graphs to illustrate and support our analysis of results associated with different indicators and variables.

**Results**

**BRT Transoeste Area of Direct Influence (ADI)**

The system’s ADI encompasses the neighborhoods of Barra da Tijuca, Recreio dos Bandeirantes, Vargem Grande and Curicica, with 29 stations and two system terminals (Figure 3).

\(^2\) According to Martins and Bodmer (2001), an environmental zone may be defined, on the urban scale, as a territorial unit having a functional, landscape and social identity. Identification criteria include: function (typology of land usage and circulation characteristics – local and main distribution); form (building and road typology, relief and landscape features); and structure (urban population density, commuter socioeconomic profile, public areas, passenger capacity and environmental infrastructure transport and services limitations).
Environmental Zones (EZs) were marked out as well as reference spatial subunits for analyzing the system (Figure 4).

Figure 4 – BRT Transoeste Environmental Zones (EZs) map.

Analysis of sustainable cities design principles in BRT project

Below is a summary of our analysis of results obtained compared to the sustainable cities design principles previously described.
- **Environmental Zones VS Thru Traffic**: lower population coverage in certain environmental zones (especially EZs 2 and 7) could increase local car circulation and this also applies to service provided in their limits, especially the traffic generation poles in EZ 3. Moreover, unsatisfactory urban space circulation conditions for pedestrians and bikers discourages non-motorized transportation and favors car circulation in this zones (EZs 1, 6, 8, 9 and 10);

- **Macro and Micro Accessibility Integration**: Pedestrian circulation conditions were generally satisfactory except in EZs 1, 6, 8, 9 and 10 regarding some variables. As mentioned earlier, the bike path network installed in the ADI that could potentially make the BRT Transoeste more effective is percentage-wise negligible (only 23.7%) and includes only 3 of 10 EZs identified herein;

- **Land Use and Transportation Integration**: system coverage in relation to urban equipment is generally satisfactory in the ADI, totaling 64.5% covered. However, approximately 30% of the traffic generation pole lie outside the coverage area, which could encourage car use and have negative impact on traffic and environmental quality in the especially in EZ 3;

- **Non-Motorized Vehicles Campaign**: pedestrian traffic conditions appear satisfactory, including EZs 2 and 7, the most populated parts of the BRT Transoeste ADI. However, data presented on bike path networks reveals poor exploitation of the biking potential for feeding the system;

- **Strategic Locations and Mixed Use**: spatial and population coverage shown in the ADI is unsatisfactory, with a significant percentage (approximately 60%) lacking coverage revealing no occupation density associated with the system. Generally speaking, main zoning laws (Decreto Municipal Nº 3046/1981 and Lei Complementar Nº 104/2009) have created occupation density in relatively remote areas from the system which may contribute to lower ridership levels in the system among local residents in these areas;

- **Social Integration and Inclusion**: spatial coverage revealed a percentage of the following social groups associated with the system: school-age youngsters, the economically active labor force and senior citizens. Percentages in the BRT Transoeste ADI were very close to those for the resident population as a whole which indicates insufficient coverage restricting wider access of these social groups to the system. Conditions for urban riders with special needs, specifically wheelchairs, are critical, with approximately only 30% of households in the ADI near public parks equipped with access ramps. Whereas EZ 2 and 7, the most populated in the ADI, showed a lower percentage regarding this variable (29.1%
and 21.4% respectively), EZ 8, 9 and 10 lack wheelchair ramps altogether in their public parks.

Conclusion

In light of what we have shown, without accompanying measures for land use and occupation and encouraging ridership in the ADI, the BRT Transoeste runs the risk of failing to improve circulation conditions and promote more sustainable urban mobility. We recommend:

- **Improvement of pedestrian circulation conditions**: through investments in EZs with unsatisfactory results regarding the variables analyzed. Noteworthy are other important factors for encouraging walks, for example, roads and sidewalk designed for pedestrians. Although the issue is not addressed here, we strongly recommend investments for designing pedestrian spaces in the ADI aimed at encouraging access to the system by foot. This should not be merely restricted to stations and surrounding areas as on the Avenida das Américas;

- **Bike path network expansion**: integrating these paths with BRT stations will further feed the BRT system. Bikes can play a very important role in increasing BRT system ridership and promoting a more sustainable form of mobility in areas near the system path, especially in EZs with low population coverage;

- **Urban facilities and equipment implementation control**: urban equipment in the BRT Transoeste ADI should take into account the proximity to the system to widen accessibility and encourage ridership. Traffic generation poles should not be installed outside the system coverage area. Furthermore, the system’s capacity to meet the potential demand from new poles in its ADI must be analyzed;

- **Land occupation control**: recommended, especially in the region covered by the PEU (Urban Structuring Project) in Vargens, to avoid occupation density in remote areas of the system and the risk of multiplying urban spaces that encourage car commuting.

**Keywords**

BRT Transoeste; Geographic Information System - GIS; Spatial Indicators; Sustainable Mobility and Urban Development.