Spatial Accessibility: a case study to minimize spatial inequality

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1. Introduction

In recent years the emphasis in urban development has been sustainability. A sustainable city is *"a city (...) where achievements in social, economic, and physical development are made to last"*[1]. In this context equity plays an important role in terms of the promotion thereof. From a spatial perspective coordinated policy on public transport and land-use (LU) are well known in the literature as important tools for urban, economic and social development; and subsequently for the enhancement of urban equity.

To support decision making and to analyze actual policy in these fields, accessibility indicators are appropriate measures which are linked to the social context.

The urban space in developing cities is replete with inequalities associated to quality of life, income, fairness and justice. A research on spatial accessibility is very important to assess the degree of inequality, between social groups, in the distribution of activities and the associated impedance to participate or to use them.

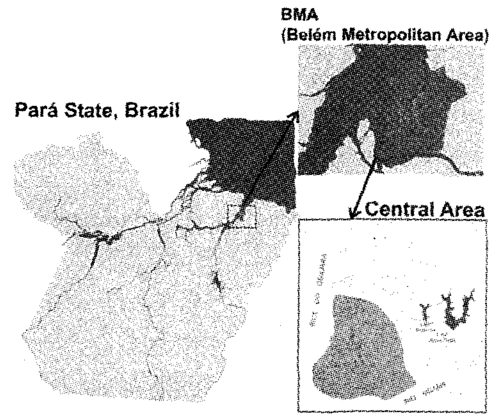


Figure 1: Location of the Study Area

In this study equity is defined as ***spatial equity*** to differentiate it from aspects pertaining to other fields. And ***spatial accessibility***, which serves as a transport and LU indicator, is an expression of the *"spatial distribution of potential destinations, the ease of reaching each destination, and the magnitude, quality, and the character of the activities found there"*[2].

According to Talen and Anselin[3] *"the analysis of spatial equity is concerned with comparing the locational distribution of facilities or services to the locational distribution of different socioeconomic groups"*. In this perspective this work defines population income groups, and their respective accessibility level as basic startup of the analysis.

The research objective is to verify who benefits, and in what intensity, from public transport supply and LU opportunities in the Central Area of the Belém Metropolitan Area (BMA), Brazil. For this research, data on socio-economic and transport were extracted from Census and PT survey, respectively.

2. The Study Area: socio-economic and actual trip characteristics

Figure 1 shows the study area which is a metropolitan center. It is characterized by large low income settlements located at low-lying lands, in poorly urbanized zones. When compared with the highland settlements, living conditions are also inferior. The population in the Central Area is about 650,000 inhabitants, which means 37% of the metropolitan population. The HDI[1] in 2000 was 0.806. **Table 1** shows that approximately 50% of the households in the Central Area earn less than 2MS (Minimum Salary) per month (nearly ¥8,000), a very low household income in Brazil.

In the trip modal share the bus mode corresponds to 44.5% of all trips, and "walk" 37.5%, an expressive participation. In relation to the trip purpose composition *study*, 15.8%, and *work*, 16.6%, are the predominant purposes after the motive *home* with 44.9%. Discretionary trips, such as *shopping*, *personal matter*, *leisure* and *health*, represent 14.7%.

3. Accessibility Appraisal

The process for estimating the accessibility index was divided in three steps, named as, (1) the operational definition; (2) the estimation of the opportunity; and (3) the deterrence function. They are described as follows:

(1) Operational definition - spatial accessibility is defined as follows:

$$ACC_{i,u}^{m} = \sum_{l} O_{l}^{u} * f(t_{ij}^{m}) \qquad (1)$$

Where: $ACC_{i,u}^{m}$ -*Accessibility of census zone **i** by mode **m** to land-use type **u**;* O_{l}^{u} -*Total opportunities of land-use type **u** at the destination census zone **j**;* $f(t_{ij}^{m})$ -*Transport impedance function between census zone **i** and **j** by mode **m**.*

(2) Estimation of opportunity - O_{l}^{u}: Opportunity for shopping, retail and service, is the total built area in census zone l by LU type u. As can be seen in the following expression:

$$O_l^u = \sum_b S_b^u . \delta_{b,l} \quad (2)$$

$$\delta_{b,l} = \begin{cases} 1 & if \quad block\ b \in census\ tract\ l \\ 0\ otherwise \end{cases}$$

Where: S_b^u *-Built area in block* ***b*** *with land-use type* ***u***.

(3) Deterrence function: the transport impedance is expressed as an exponential function:

$$f = \exp\left(-\alpha_u^m t_{ij}^m\right) \quad (3)$$

Where: t_{ij}^m *-Average travel time by mode* ***m*** *between zone* ***i*** *and* ***j***; α_u^m *- Transport impedance parameter to opportunity type* ***u*** *by mode* ***m***.

For the estimation of t_{ij}^m PT survey data was used by considering trips by bus mode for all purposes. The parameter for shopping trips was calculated after trip expansion in the OD table. The parameter α_u^m is important because it means the sensitivity of accessibility to trip disutility that is travel time.

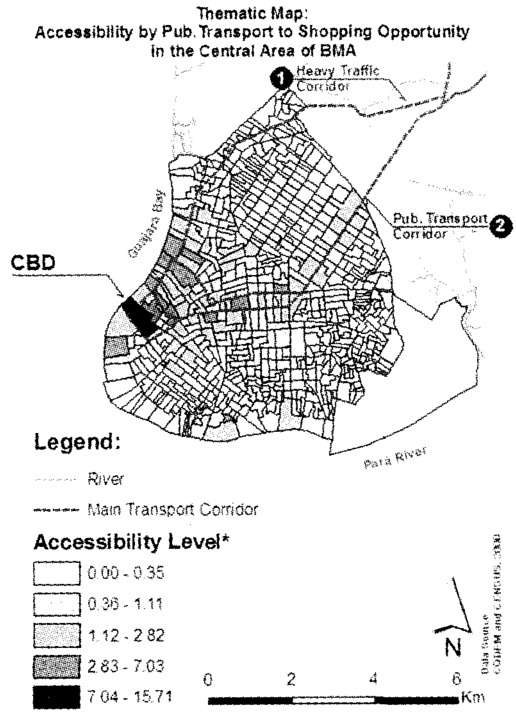
A gravity-based measure was chosen for the formulation of the mathematical problem to estimate α_u^m. The following equation is an expression in terms of logarithm:

$$\ln P_{j|i}^{k,m} = \ln \beta_i + a \ln D_j^{k,m} - \alpha_u^m t_{ij}^m \quad (4)$$

Where: $P_{j|i}^{k,m}$ *-Destination choice, to zone* ***j***, of trips generated in zone ***i*** *by mode* ***m*** *with purpose* ***k***; β_i *-Dummy variable related to trip origin* ***i***; $D_j^{k,m}$ *-Trip attraction in zone* ***j*** *to purpose* ***k*** *by mode* ***m***; a *- Trip attraction parameter.*

Table 1: Household Income Groups in the Central Area of BMA, Brazil

Household Income Group	¥	Household units	%
<2MS	7,994	70,626	46.6
2 – 5MS	7,994 - 39,972	34,087	22.5
5-10MS	39,972 - 79,943	22,273	14.7
>10MS	79,943	24,685	16.3
Total	-	151,671	100



Remark: *the accessibility values were divided by 10^7

Figure 2: Accessibility Distribution

Finally, to estimate α_u^m, multiple linear regression analysis was employed through appropriate statistical software, where was found the value of **-0.007**.

4. Case Study: examining accessibility by public transport to shopping opportunities

The distribution of accessibility in the study area was mapped in five classes. **Figure 2** shows the thematic map that was made with GIS software using "natural breaks" classification. It is observed a high level of accessibility in the CBD, its surrounding zones, and along of the main public transport corridor❶, located in the highland settlements. In low-lying regions it is observed a less favorable level of accessibility, including at beside of the extreme North corridor of transport❷. This may reflects the main tendency of this corridor in receiving heavy traffic for transportation of raw goods, such as timber and live stock, coming from other productive regions in the Pará State, to the main port located near the CBD.

5. Conclusion and Future Research

To improve the methodology for measure spatial accessibility the next assignments are the capture of travel time and recalculation of the parameter for shopping trips. Travel time spent by public transport riders among census zones, instead of traffic zone, can be acquired with more accuracy based on the bus stop and bus route network.

References

[1] UN Habitat, UNHCS/UNHSP (United Nations Human Settlements Programme). Making the modern world, [?]. Access in 2005/12/02 <http://www.makingthemodernworld.org.uk/learning_modules/geography/04.TU.01/?section=6>

[2] Hand, S.L. & Niemeier, D.A. (1997) Measuring Accessibility: an exploration of issues and alternatives. Environmental and Planning A, 1997, vol. 29, p. 1175-1194.

[3] Talen, E. & Anselin, S. (1998) Assessing Spatial Equity: an evaluation of measure of accessibility to public playgrounds. Environmental and Planning A, vol. 30, p. 595-613.

Notes: [1] HDI - Human Development Index for Brazilian cities. Source: 2003, UNDP.