A COMPARATIVE EVALUATION OF MOBILITY CONDITIONS IN SELECTED CITIES OF THE FIVE BRAZILIAN REGIONS

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ABSTRACT

The objective of this study is to evaluate and compare the mobility conditions of cities belonging to the five Brazilian macroregions based on the outcomes of the Index of Sustainable Urban Mobility (I_SUM). The Index has a hierarchical structure, which is formed by nine Domains, thirty-seven Themes and eighty-seven Indicators. It was applied in the following cities: Belém, Curitiba, Goiânia, Juazeiro do Norte, Uberlândia and Itajubá. The study involved two phases. In the first one, it was investigated if the selected cities have the data needed for the application of the index, considering two criteria: data availability and data quality. Next, an extensive data collection procedure was conducted and the index values calculated. The evaluation of the mobility conditions in the selected cities was followed by a comparison of those conditions, in order to look for the aspects that might be driving some of them towards sustainable mobility. In general, the cities located in the wealthier part of the country performed better, although city sizes also seem to have affected the performance. The differences regarding the context are also among the highlighted aspects, given the marked regional dissimilarities among the cities, affecting the availability and quality of the data.

Keywords: sustainable urban mobility, Brazilian cities, I_SUM, Index of Sustainable Urban Mobility, mobility indicators

INTRODUCTION

Many of the urban problems currently observed nearly anywhere in the world are derived from or related to transport. Some examples are: traffic accidents, congestion, noise, air pollution and mobility constraints for certain groups of the population. The influence of transport also goes beyond the urban boundaries, with social, economic, political and environmental impacts. As a consequence, there is a generalized understanding that all cities must search for strategies to promote more sustainable patterns of mobility, notwithstanding the fact that several of those issues are strongly context dependent, as observed by Rodrigues da Silva et al. (2008).

Despite a few variations, the concept of sustainable urban mobility is based on a series of common points, as observed by Brasil (2006, 2007), Costa (2008), Alves da Silva (2009) and Black (2010), among others. It assumes for example, in general terms, the satisfaction of the basic needs of the individuals and a freedom of movements for the society as a whole. This includes the free choice of transportation modes, in a safe manner and without jeopardizing the human health and the ecosystems. It also involves the use of renewable energy, and the establishment of limits for the emissions and residuals that are compatible with the capacity of the planet to absorb them. In short, the concept of sustainable mobility is an extension of the concept of sustainable development. For some authors, such as Maffii et al. (2010) and Poli (2011), for example, the concept of sustainability goes beyond simply managing roadway traffic and reducing the associated impacts of such traffic in urban areas.

One of the alternatives for dealing with the challenges of mobility planning is the use of indicators and indices for monitoring the mobility conditions of the urban areas. An example of this kind of approach is the Index of Sustainable Urban Mobility, or I_SUM, which was created by Costa (2008) and shortly after applied to a few Brazilian cities (Miranda, 2010; and Pontes, 2010). Also, other applications of the index are being discussed in different parts of the world, such as in Germany (Bernhardt, 2010) and in Indonesia (Midgley, 2011). However, despite the growing number of initiatives (for an updated view, see Azevedo Filho, 2012), the applications in Brazil are still limited in number. Among the recent initiatives are the cities selected for this study, which aims to evaluate the mobility conditions of cities belonging to the five Brazilian macroregions. This may be a very important initiative, given that regional elements are in some cases so distinct from one another that the context may play an important role for sustainable urban mobility.

The assessment of mobility in each selected city is a first step for a subsequent comparison of those conditions. It may help to identify aspects that can be driving these cities towards sustainable mobility. The evaluation is based on the outcomes of the Index of Sustainable Urban Mobility (I_SUM). Given the hierarchical structure of I_SUM, which is divided in nine DOMAINS, thirty-seven Themes and eighty-seven *Indicators*, the results are suitable for comparison. The index was applied in the following cities: Belém, in the Northern region, Curitiba, in the Southern region, Goiânia, in the Centre-West region, Juazeiro do Norte, in the Northeastern region, and Uberlândia and Itajubá, in the Southeastern region. The selection of two cities in the same region is explained by their different sizes. The studies involved two phases. In the first phase, it was investigated if the selected cities have the data needed for the application of the index. Two criteria were considered: data availability and data quality. In the second phase, an extensive data collection procedure was conducted in each location, and the values of the indicators were obtained for the calculation of the index values. Results of both phases are summarized in this paper. Some of the main points are selected for analyses and discussion. They lead to some interesting, albeit preliminary, conclusions.

SUSTAINABLE URBAN MOBILITY

A new paradigm for transport planning has been developed over the last one or two decades. According to this new view, public transportation, traffic circulation and urban planning activities must be considered altogether in a combined approach known as mobility planning. According to Litman and Burwell (2006), there is an increasing interest on sustainability. Therefore, the new line of action is based on concepts such as sustainability and sustainable development, which are now well established. As a consequence, the concept of sustainable mobility is not difficult to grasp. In practice, however, it may have complex implications when associated to transportation planning.

If the concept of sustainable transportation is seen as an extension of sustainable development, it could be expressed as the development that provides for the present transportation needs without compromising the provision of adequate mobility for the future generations (Gudmundsson, 2004; Richardson, 2005). Also, the concept of sustainability is often linked to economic, social and environmental aspects (World Bank, 1996; TRB, 2001; Gudmundsson, 2004; Richardson, 2005; Litman and Burwell, 2006; May and Crass, 2007; Rodrigues da Silva et al., 2008; Litman, 2009, 2011).

New procedures and planning tools are being developed to deal with mobility problems under this new paradigm. Among them are improvements in the use of traditional indexes and indicators. These are useful to portray the behavior of the several elements and functions shaping the urban environment. Generally, indicators had been initially developed to evaluate economic, social and environmental impacts for different scenarios. Later on, other indicators have focused on specific sustainability aspects, such as accessibility, mobility and environmental capacity (Black et al., 2002; Nicolas et al., 2003).

However, as stated by Maclaren (1996), indicators are simplifications of complex phenomena. As such, they may produce hints about the state of a certain piece of the system. As observed by Gudmundsson (2004) in Europe and North America, a more reliable portrait of this system may be achieved only by a combination of indicators, so that different dimensions and aspects of particular problems are depicted. For Litman (2009), this combination of indicators facilitates integrated and more comprehensible analyses, providing support to decision makers in the identification of planning choices and specific policies that influence sustainability goals.

Within this perspective, Costa (2008) conceived the Index of Sustainable Urban Mobility (I_SUM) by combining the main DOMAINS and <u>Themes</u> necessary for urban mobility monitoring. It is a tool for supporting the mobility management and the formulation of public policies. The I_SUM's hierarchical framework (Table 1) was designed based on a set of indicators that, as suggested by Litman (2009), were carefully selected to reveal several mobility impacts and perspectives. Additionally, according to Costa (2008), the indicators are based on data that are easy to obtain and of simple and direct calculation. The main characteristics of the index are:

- It uses a hierarchy of criteria based on concepts and elements identified by technicians and managers working for urban planning agencies and transportation authorities of eleven Brazilian capital cities or metropolitan areas, as described by Rodrigues da Silva et al. (2008) and Costa (2008).

- The hierarchy of criteria is associated to a weighing system defined by a panel of specialists of different countries (Brazil, Portugal, United States, Australia and Germany). The use of these weights allows the detection of the relative significance of each element or concept considered for the Index. It also permits the evaluation of the effect of any change on the index's elements concerning the sustainability dimensions (social, economic and environmental).

- The hierarchical structure allows trade-offs between the elements (9 DOMAINS, 37 Themes and 87 *Indicators*). In other words, low values of some elements may be compensated by high values of other ones.

- It is a tool easy to learn and to apply, which does not require special computer software or complex mathematical models..

Table 1 - I_SUM's criteria hierarchical framework with elements' weights

Domain	Theme	Indicator
Accessibility (0.108)	Accessibility to transport systems (0.290)	• Accessibility to transit (0.333) • Public transportation for users with special needs (0.333) • Transport expenses (0.333)
	Universal accessibility (0.280)	• Street crossings adapted to users with special needs (0.200) • Accessibility to open spaces (0.200) • Parking spaces to users with special needs (0.200) • Accessibility to public buildings (0.200) • Accessibility to essential services (0.200)
	Physical barriers (0.220)	• Urban fragmentation (1,000)
	Legislation for users with special needs (0.210)	• Actions towards universal accessibility (1,000)
Environmental aspects (0.113)	Control of environmental impacts (0.520)	• CO Emissions (0.250) • CO_2 Emissions (0.250) • Population exposed to traffic noise (0.250) • Studies of environmental impacts (0.250)
	Natural resources (0.480)	• Fuel consumption (0.500) • Use of clean energy and alternative fuels (0.500)
Social aspects (0.108)	Support to the citizens (0.210)	• Information available to the population (1,000)
	Social inclusion (0.200)	• Vertical equity (income) (1,000)
	Education and active citizenship (0.190)	• Education for sustainable development (1,000)
	Public participation (0.190)	• Participation in decision-taking (1,000)
	Quality of life (0.210)	• Quality of life (1,000)

Table 1 (cont.) - I_SUM's criteria hierarchical framework with elements' weights

Political aspects (0.113)	Integration of political actions (0.340)	• Integration of different government levels (0.500) • Public-private partnerships (0.500)
	Acquisition and management of resources (0.330)	• Acquisition of resources (0.250) • Investments in transport systems (0.250) • Distribution of resources (public x private) (0.250) • Distribution of resources (motorized x non-motorized) (0.250)
	Urban mobility policy (0.330)	• Urban mobility policy (1,000)
Transport infrastructure (0.120)	Provision and maintenance of transport infrastructure (0.460)	• Density of the street network (0.250) • Paved streets (0.250) • Maintenance expenditures in transport infrastructure (0.250) • Streets signaling (0.250)
	Distribution of transport infrastructure (0.540)	• Transit lanes (1,000)
Non-motorized modes (0.110)	Bicycle transportation (0.310)	• Length and connectivity of cycleways (0.333) • Bicycle fleet (0.333) • Facilities for bicycle parking (0.333)
	Pedestrians (0.340)	• Pathways for pedestrians (0.500) • Streets with sidewalks (0.500)
	Trips reduction (0.350)	• Travel distance (0.250) • Travel time (0.250) • Number of trips (0.250) • Measures to reduce motorized traffic (0.250)
Integrated planning (0.108)	Managers training (0.120)	• Expertise of technicians and managers (0.500) • Training for technicians and managers (0.500)
	Central areas and historical sites (0.110)	• Vitality of the central area (1,000)
	Regional integration (0.120)	• Intercity partnerships (1,000)
	Planning process transparency (0.120)	• Transparency and responsibility (1,000)
	Planning and control of land use (0.140)	• Vacant land (0.200) • Urban growth (0.200) • Urban population density (0.200) • Mixed land use (0.200) • Illegal settlements (0.200)
	Strategic and integrated planning (0.140)	• Integrated urban. environmental and transport planning (0.500) • Implementation and sequence of planed actions (0.500)
	Infrastructure and urban facilities planning (0.130)	• Parks and green areas (0.333) • Urban facilities (schools) (0.333) • Urban facilities (hospitals) (0.333)
	Master Plan and urban legislation (0.120)	• Master Plan (0.333) • Urban legislation (0.333) • Urban legislation actual application (0.333)
Urban circulation Traffic (0.107)	Traffic accidents (0.210)	• Traffic accidents (0.333) • Accidents with pedestrians and cyclists (0.333) • Accident prevention (0.333)
	Traffic education program (0.190)	• Traffic education program (1,000)
	Freedom of movements and circulation (0.190)	• Congestion (0.500) • Average traffic speed (0.500)
	Traffic operation and enforcement (0.200)	• Violation of traffic rules (1,00)
	Private transport (0.210)	• Motorization rate (0.500) • Vehicle occupation (0.500)
Urban transport systems (0.112)	Transit availability and quality (0.230)	• Total extension of the transit network (0.125) • Transit service frequency (0.125) • On-time performance (0.125) • Transit average speed (0.125) • Transit fleet age (0.125) • Passengers per kilometer (0.125) • Annual number of passengers (0.125) • User satisfaction with the transit service (0.125)
	Diversity of transportation modes (0.180)	• Diversity of transportation modes (0.333) • Public versus private transport (0.333) • Motorized versus non-motorized modes (0.333)
	Transit regulations and enforcement (0.180)	• Contracts and limitations (0.500) • Informal transport (0.500)
	Transit integration (0.220)	• Intermodal terminals (0.500) • Transit integration (0.500)
	Fare policy (0.190)	• Discounts and free rides (0.333) • Transit fares (0.333) • Public subsidies (0.333)

METHOD

This study is totally based on applications of I_SUM. Therefore, it is important to initially characterize the structure and operation of the index. The Index of Sustainable Urban Mobility establishes a measure of the urban mobility quality by a number ranging from "0" to "1". The closer the value is to "1", the better and more sustainable are the mobility conditions of the population. The index is calculated by data compilation of 87 indicators. Each indicator is calculated with specific data that are normally available in mobility-related agencies of each city.

The Indicators are distributed into diverse Themes according to related subjects. Each Theme has a global value equivalent to "1.0", which is divided among their indicators. When it is not possible to compute an indicator, the weights are redistributed in order to guarantee that the final sum is equal to 1.0. All the themes are grouped in nine DOMAINS of interest, as shown in Table 1. The domains are important parts of the index structure and all of them must be considered for the computation of I_SUM. Moreover, the exclusion of any Theme could also result in a biased evaluation, given that some basic problems related to urban mobility would not be considered in the calculation.

Once the city where the index will be applied is determined, the study is undertaken in two phases. The first one is meant for checking for data availability, what leads to the definition of the indicators to be computed, whereas the second one involves the computation of I_SUM. The classification of the information is performed with the support of local authorities in charge of transport and mobility. Data is also obtained from other official databases, such as those maintained by state and federal agencies or even private sources, if reliable.

Next, the information available is evaluated according to two criteria: availability and quality. A method created for the OECD (Organisation for Economic Co-operation and Development) was adapted for this evaluation. The method was developed for analysis of a set of indicators whose objective was to integrate environmental aspects with transportation policies (OECD, 1999).

Considering the availability, the data can be obtained in the short run (SR), in the medium run (MR) and in the long run (LR). For the purpose of this investigation, these periods correspond to one year, one administrative term, and more than one administrative term, respectively. With regard to quality, the data can be classified as High, Medium and Low quality, following a decreasing scale of reliability. According to OECD (1999, p. 24), the data needed to compute an indicator must be available in the short run or be obtained in a reasonable cost/benefit rate. It must also be registered in an adequate way and have a known quality. Finally, it must be updated at regular intervals according to reliable procedures. The authors state that those criteria describe "ideal" indicators, which are not always available in real life. According to OECD (2007, p. 60-62), the validity and the quality of the data, and their consequent acceptance for the agencies, depend on the credibility of the provider of the information. Also, the required accuracy of the information will depend upon the application that will be made.

In this study, the researchers selected the information sources always by looking at the experience of the agencies in charge of data collection and/or storage. The data collection procedure was easier where a more recent or comprehensive transportation plan, such as a Transport or Mobility Master Plan, was available. In this research, the quality of the data was classified according to the following criteria:

- HIGH (H) - when the data are available from a recent survey or where they can be obtained rapidly and inexpensively. Some of these indicators are collected on a regular basis for local agencies, as it is the case of traffic accidents or passenger volumes transported by public transportation systems.

- MEDIUM (M) - when the information comes from studies that are not so recent (i.e., more than two years). As a consequence, the data need to be updated by statistical computation or estimated by local officials based on a specialized knowledge of the problem. An example could be the updating of data related to the characteristics of urban trips (travel time, trip length and modal split) that are normally collected in more comprehensive and expensive surveys.

- LOW (L) - when the data sources are older studies (i.e., more than five years) or if the data are derived from the application of models developed for other cities. An example would be the computation of air pollution based on fuel consumption and using the model developed by CETESB (Companhia de Tecnologia de Saneamento Ambiental do Estado de São Paulo) for the city of São Paulo.

The ideal conditions for the computation of I_SUM occur when high quality (H) data are available in the short run (SR). However, according to Costa and Miranda (2010), it is possible to combine “SR - M” and “SR - L”, considering the initial difficulties for obtaining the data. However, if the index eventually becomes part of the work procedures of the cities, the quality of the information will be improved after some time. This is a natural consequence of better data collection and storage procedures, together with the development of methodologies for compilation and analysis. This process will also allow the improvement of I_SUM.

The next step involves the effective computation of I_SUM. The information is analyzed with computational tools, including spreadsheets, GIS and database management packages. The use of internet is also necessary to access public databases. A step by step procedure to calculate I_SUM is provided by Costa (2008). In the present study, the methodology is applied to six cities. They are listed in Table 2, along with population and fleet data.

Table 2 - Population and fleet data of the cities selected for this study

City	Population		Total fleet		Vehicles/inhabitant	
	2000	2010	2000*	2010	2000	2010
Belém	1,280,614	1,393,399	131,779	291,799	0.10	0.21
Curitiba	1,587,315	1,751,907	682,441	1,247,998	0.43	0.71
Goiânia	1,093,007	1,302,001	445,167	870,900	0.41	0.67
Uberlândia	501,214	604,013	152,127	311,127	0.30	0.52
Juazeiro do Norte	227,774	249,939	17,995	62,411	0.08	0.25
Itajubá	84,135	90,654	12,067	33,336	0.14	0.37

Sources: IBGE (2011a) and DENATRAN (2011)

* Estimations based on the municipal fleets of 2001 and on the ratios of city and state fleets in 2000 and 2001.

The research coordinator was careful regarding standardization procedures in the classification of data availability and quality. This was emphasized during the meetings and visits to the teams of the local universities participants of the project. Each team identified the data sources and availability for the computation of the respective indicators. Later, the results were directed to the research coordinator for aggregation and a joint analysis. The comparisons and evaluations focused on the variables “availability” and “quality”. The analysis procedures are described in the next section, together with the results of I_SUM calculations.

RESULTS AND DISCUSSIONS

The results are presented in this section in two parts, in the same order of the actual procedures that generated them. First, it was investigated the availability and the quality of the data needed for the calculation of the index in the selected cities. Second, the index values calculated for the six cities, after an extensive data collection procedure conducted in each location, are presented and discussed.

Evaluation of the availability and quality of the data

The evaluation process of the availability and quality of the data consisted of a survey performed by the local technical staff in order to determine the information sources and how they can contribute for the calculation of the indicators. From the classification of data availability as at short, medium and long run and the quality as high, median and low, a joint analysis of the data was performed. The first analysis focused on data availability. In that phase, the indicators of the six cities have been aggregated based on the nine I_SUM domains, as shown in Figure 1.

It can be observed that most indicators can be calculated at the short and medium run. Only indicators of the domains URBAN TRANSIT SYSTEMS, NON-MOTORIZED MODES, SOCIAL ASPECTS and ENVIRONMENTAL ASPECTS were classified as obtained in a long run basis. The indicators referred to the two first cited domains depend on the information about modal choice and trip characteristics by each mode, which means they depend on an origin/destination survey. In many cities (such as Curitiba and Juazeiro do Norte, for example) this is not available.

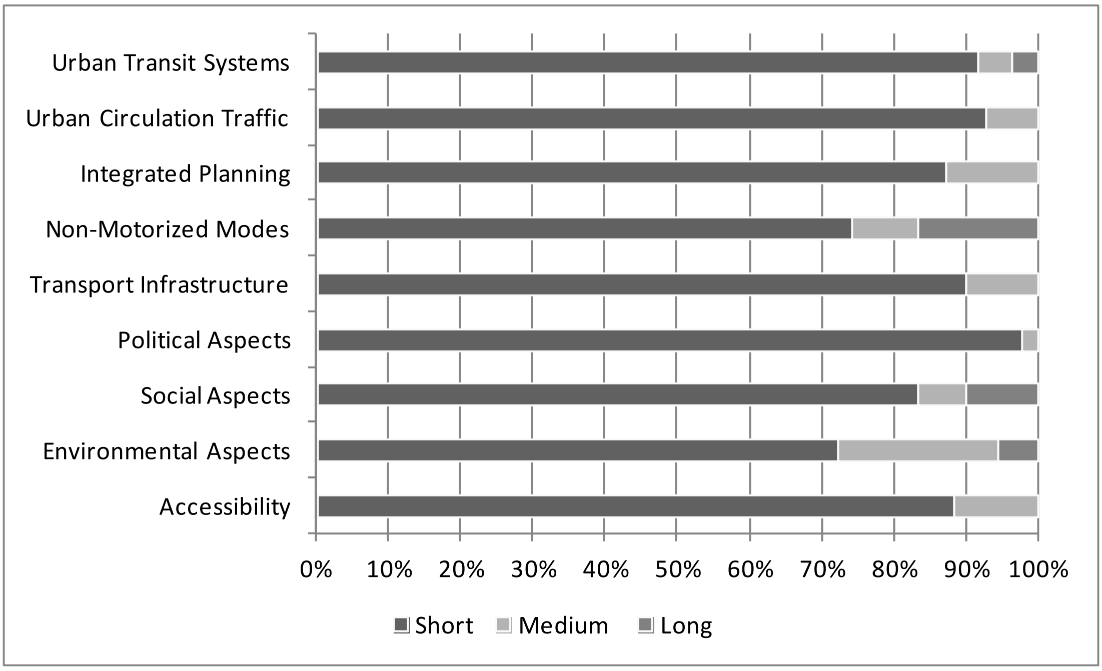

Figure 1 - Estimated time periods for gathering the data required for the calculation of the I_SUM indicators, by Domain, for the six cities.

The aggregation of data in another way (Table 3), allows an evaluation and comparison of the conditions found in each city. It can be identified an advantage of the state capitals (i.e., Belém, Curitiba e Goiânia) over the countryside cities, such as Itajubá, Juazeiro do Norte and Uberlândia. The state capitals have more indicators for which the data would be available in the short run.

Referring to the quality of the information, the distribution among categories is less concentrated, although there are many indicators which have only low quality data available for their calculation. Many data are obtained, for instance, from the Demographic Census (IBGE, 2011b), from official vehicle registration databases, and from spreadsheets commonly used in Brazil to calculate public transportation fares. These databases are normally very reliable, what is inherent to their applications.

In the case of some datasets, such as traffic accident logs, the data quality is not very good, although they are important to public administration. The data more directly related to the operation of urban transit systems and to the construction and maintenance of infrastructure are, as a general rule, easier to be obtained and have better quality. Nevertheless, contrary to the normal expectation, data related to the domain POLITICAL ASPECTS seems to be easier to obtain than anticipated. This can be attributed probably to a recent Brazilian legislation, according to which governments are forced to publicize all their actions, investments and expenditures. Figure 2 shows the aggregated results by domains, considering the six cities.

Table 3 - Percentage of indicators classified according to the availability and quality of the data, for the six cities.

Term	City	Quality		
		High	Medium	Low
Short	Belém	65,5%	14,9%	16,1%
	Curitiba	86,2%	4,6%	2,3%
	Goiânia	63,2%	25,3%	3,4%
	Itajubá	60,9%	14,9%	0,0%
	Juazeiro do Norte	56,3%	17,2%	8,0%
	Uberlândia	60,9%	4,6%	18,4%
Medium	Belém	0,0%	2,3%	1,1%
	Curitiba	0,0%	0,0%	1,1%
	Goiânia	4,6%	1,1%	0,0%
	Itajubá	4,6%	11,5%	1,1%
	Juazeiro do Norte	0,0%	3,4%	9,2%
	Uberlândia	2,3%	1,1%	12,6%
Long	Belém	0,0%	0,0%	0,0%
	Curitiba	0,0%	0,0%	5,7%
	Goiânia	0,0%	2,3%	0,0%
	Itajubá	0,0%	0,0%	6,9%
	Juazeiro do Norte	0,0%	0,0%	5,7%
	Uberlândia	0,0%	0,0%	0,0%

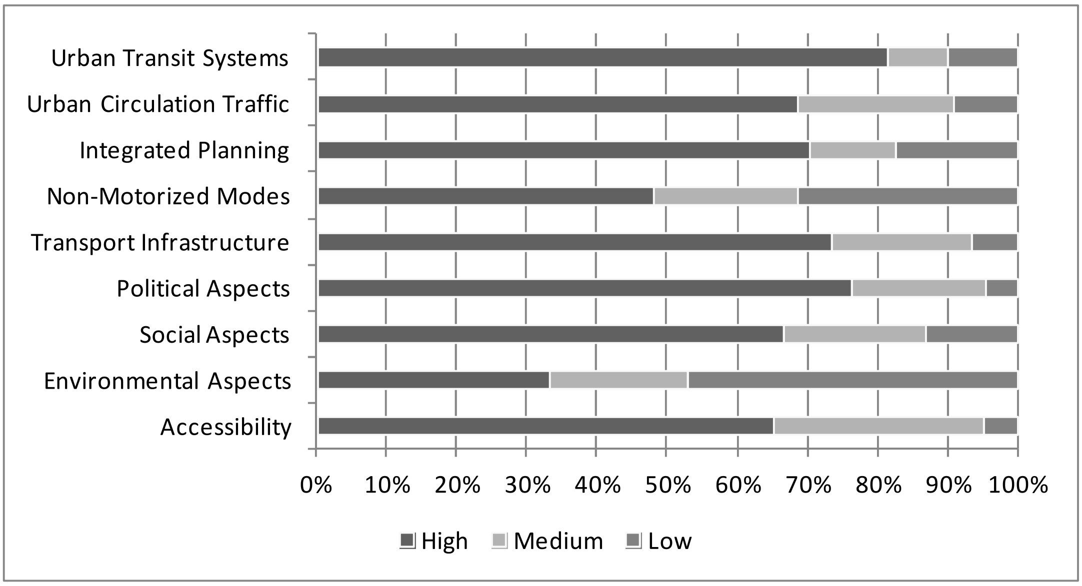

Figure 2 - Evaluation of the quality of data required for the calculation of the I_SUM indicators, by domain, for the six cities.

Assessment of the mobility conditions

The second part of the study focused on the assessment of the mobility conditions of the six cities using the Index of Sustainable Urban Mobility. The values of I_SUM varied considerably, as well as the number of indicators calculated in each city. The main outcomes are summarized in Table 4. It must be highlighted that three table rows contain values of I_SUM, what requires an additional explanation.

Table 4 - Selected results of the calculation of the index of sustainable urban mobility (I_SUM) in six cities of the five Brazilian regions

CITIES CALCULATION RESULTS	Curitiba	Uberlândia	Goiânia	Itajubá	Belém	Juazeiro do Norte
Indicators calculated	75	80	83	72	62	68
Indicators calculated as a percentage of the total number of indicators	86.2%	92.0%	95.4%	82.8%	71.3%	78.2%
I_SUM Value *	0.74	0.71	0.66	0.50	0.37	0.36
I_SUM - Best estimate **	0.79	0.74	0.67	0.59	0.53	0.48
I_SUM - Worst estimate ***	0.66	0.67	0.64	0.40	0.32	0.26

* The index is calculated only with the available indicators and the weights of the indicators are redistributed accordingly.

** All indicators that are not calculated receive the maximum possible normalized value (one).

*** All indicators that are not calculated receive the minimum possible normalized value (zero).

The first one (called I_SUM Value) is the outcome of the calculation only taking into account the indicators that are effectively calculated. Regardless of the number of indicators considered, the index value will always result between zero and one. This is a particularity of the method, which assumes total trade-off in the hierarchical structure. However, this index value is not adequate for comparisons, as the number of indicators is not the same in all cities. In order to reduce this effect, the index must be calculated again under two different conditions. In the first case, to all indicators that are not calculated is attributed the maximum value (i.e., one). This would be the best possible estimate for them. In the second case, all indicators that are not calculated receive the minimum value (i.e., zero) and therefore this would be the worst possible estimate for them. The results of the three calculations for each city indicate a range of values that must contain the actual I_SUM value of any studied city. This range is suitable for comparisons, as indicated in Figure 3.

The comparison of the ranges shows, for example, that Curitiba, Uberlândia and Goiânia perform much better than Itajubá, Belém and Juazeiro do Norte. Even the worst estimates of the first group of cities are better than the best estimates of the second group of cities. Another important consideration is the variability of the estimations. In this case, the situation in Goiânia is much more interesting, from a planning perspective, than the situation in Belém or in Juazeiro do Norte, where the differences between the minimum and maximum values are very large.

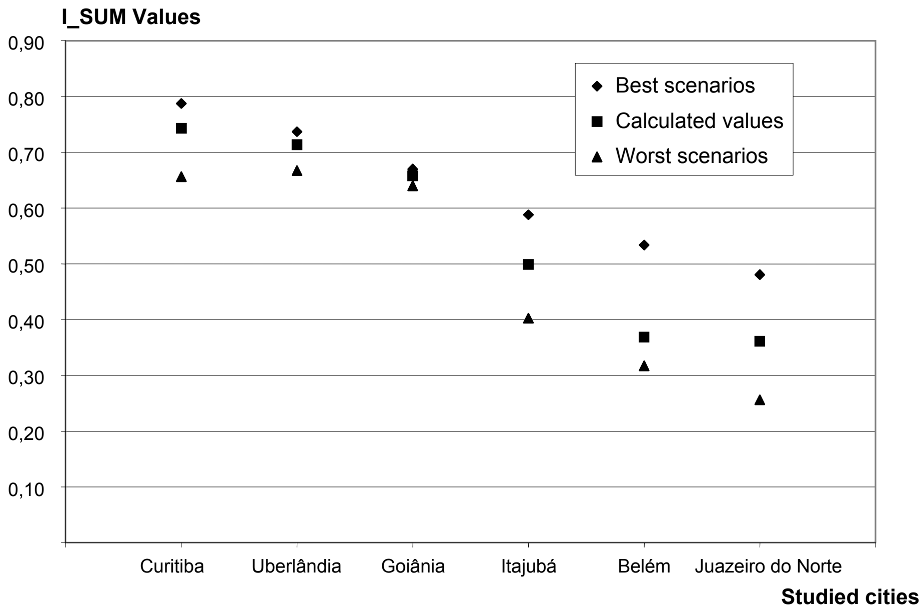

Figure 3 - Values of the index of sustainable urban mobility in six cities of the five Brazilian regions

Another way of looking at the results is to compare the performance of the cities in the specific subdivisions of the index (i.e., DOMAINS, Themes, or *Indicators*). This is shown in the case of domains, for example, in Figure 4. It is interesting to notice the strengths and weakness of the different cities studied. In terms of strengths, for example, Itajubá is performing remarkably well in the domains ENVIRONMENTAL ASPECTS and URBAN CIRCULATION TRAFFIC. On the other hand, the domain NON-MOTORIZED MODES is the weakness of Curitiba (as already discussed by Miranda and Rodrigues da Silva, 2012). Many other analyses can be done with the results obtained, as suggested here.

CONCLUSIONS

The applications conducted in the selected cities have produced two sets of results. In the first set are the results of an evaluation of data availability and data quality aiming at the application of I_SUM in the six studied cities. In the second set are the final results of the Index of Sustainable Urban Mobility.

According to the results found for the six cities that were analyzed in this study, there are no major problems to obtain the data needed to calculate the Sustainable Urban Mobility Index in the short run. The worst condition was detected in the domains ENVIRONMENTAL ASPECTS and NON-MOTORIZED MODES and in the indicator *Vertical equity*, included in the theme Social Inclusion of the domain SOCIAL ASPECTS. In the first two cases the difficulties are related to the need for more expensive and sophisticated data collection about pollutant emissions and also about urban trips characteristics. In the third case, the main difficulty is related to the absence of disaggregated databases in the Census that also show the need for more expensive and sophisticated data.

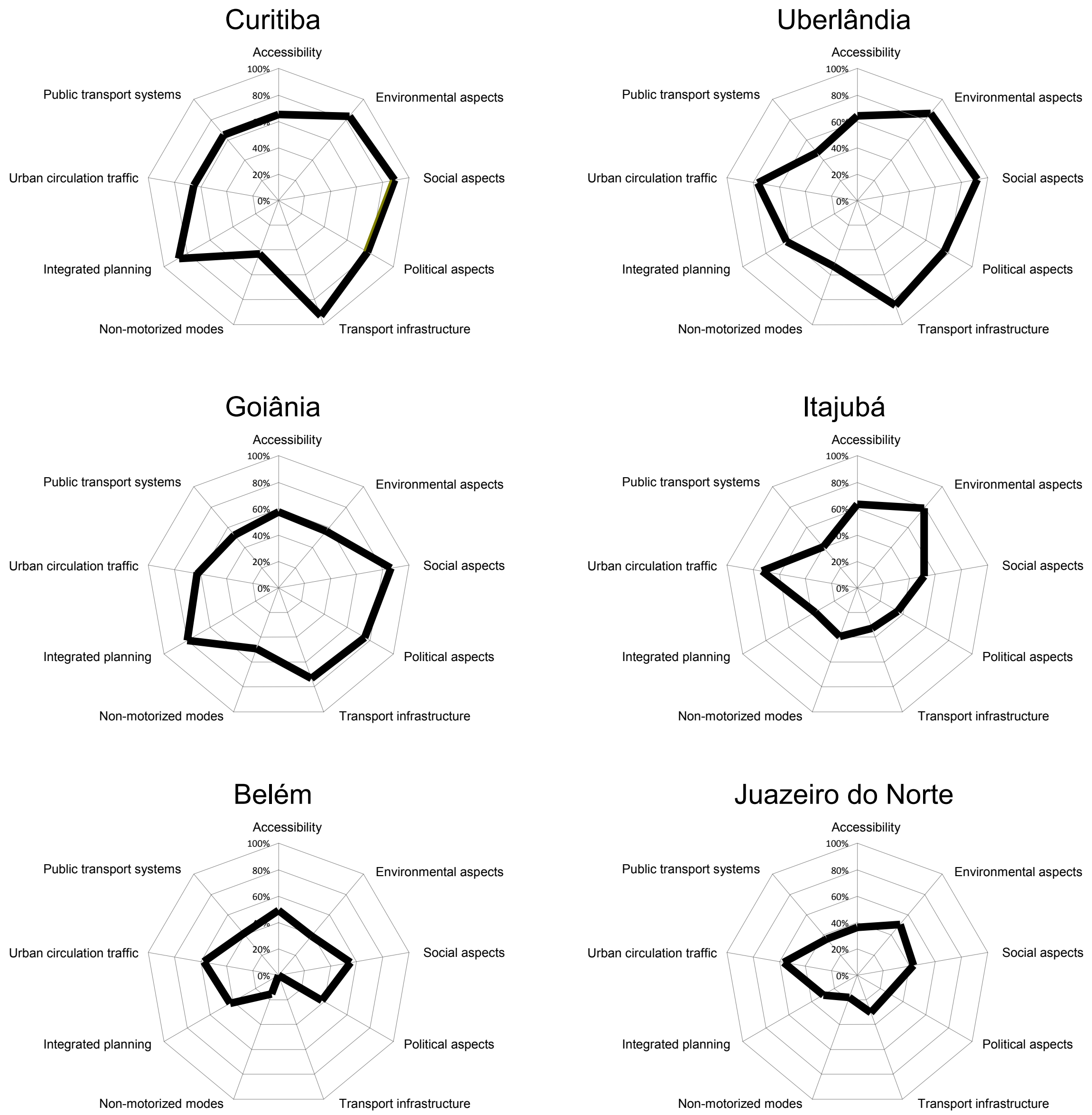

Figure 4 - Performance of six cities of the five Brazilian regions regarding the nine DOMAINS of the Index of Sustainable Urban Mobility (I_SUM)

The larger availability of data in the short run does not guarantee, however, the good quality of these data. Nevertheless, the technical staff classified the quality of the data for four domains as high, and between high and medium for three others. Only the domains ENVIRONMENTAL ASPECTS and NON-MOTORIZED MODES were classified as being of medium quality. The facts that have played a major role for this classification were the difficulty of data acquisition concerning air and noise pollution in the domain ENVIRONMENTAL ASPECTS, and the data related to the bicycle fleet and characteristics of non-motorized trips, in the domain NON-MOTORIZED MODES.

Generally speaking, it was found that the cities that have an urban development master plan or an urban transportation or mobility plan have a greater availability of information. An exception to such finding is Curitiba, a city that despite the fact that has never developed a "traditional" Urban Transportation Master Plan, considering the origin and destination of trips, is very careful with its transportation system when planning the urban development. The data availability is also associated with the size of the cities. Major cities tend to have more complex problems, including mobility problems. In order to better manage these problems, these cities generally have a more robust and integrated institutional framework, which is not only in charge of urban mobility issues. It is also frequently involved with environmental, land use, infrastructure, and related aspects of urban planning and management.

The highlights also include the fact that there is a great amount of data generated in a day by day basis in the operation of transit systems. Many cities already have, for example, bus tracking systems by satellites, traffic count devices at main streets, and cartographic information and other databases updated on a regular basis. This doesn't mean, however, that these data can be used immediately and effectively for urban and mobility planning. Straightforward tools for organizing the data and extracting from them the information needed for the calculation of indexes that can be useful for urban planners and managers (e.g., I_SUM) are essential.

In general, the cities with the best performances were those in the wealthier part of the country, although the city sizes also seem to affect this performance. The outcomes of the index calculation in distinct cities of the different Brazilian regions provided several elements for analysis. They may be relevant for both policy formulation and further research. The differences regarding the context are among the highlighted aspects, given the marked regional dissimilarities. They affect the availability and quality of the data and the values of the indicators that form the overall I_SUM value for each city. As a consequence, the results may suggest directions for the formulation and implementation of policies not only by local authorities, but also by state and federal agencies. These policies can affect a wide range of activities, which may vary from data acquisition and management, to land use planning, and transportation planning and operation.

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