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INDICATORS FOR EVALUATION OF SUSTAINABLE MOBILITY

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Introduction

While cities are all different, face similar challenges and therefore seek common solutions to address problems among which is the gradual engine, a context which imposes a reflection on the question of urban mobility.

A tool that helps in transportation planning and mobility is the use of indicators because they are considered technically suitable for geographical and time comparisons. Good indicators are those convey information to planners so fast, reliable and adequate, to enable an understanding of the interrelationships between the social, economic and environmental issues associated to the local environment, i.e. a holistic view of urban reality.

Due to the high complexity and scope, indicators of sustainable mobility has been the subject of many studies aimed at finding a consensus on what are the key indicators to compose a set pattern or form a line base. This paper develops a set of indicators for which data are prepared by national statistical organizations, to become less costly to the local government, especially when the purpose of monitoring is to support the sustainable planning of the cities.

Mobility indicators

The choice of indicators varies according to the strategies adopted in each country or region and depend, in practice, the existence and availability of data, definitions and consistent methods of collection. Researchers such as Campos and Ramos (2005), Hall (2006), Jeon (2005), Zegras (2006), Litman (2008), Costa (2008), Mikusova (2007) among others, have developed an extensive work to compile those indicators that capture the objectives of sustainable mobility.

Jeon (2005) reviewed the 16 initiatives of organizations in North America, Europe and Oceania, concludes that despite the emerging consensus that to be effective, a balanced

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system of indicators that measure the impacts on the economy, environment and well social welfare, says that sustainable mobility is in part being captured by economic and environmental indicators and to a lesser extent by social factors. [7]

Already, Hall (2006) starts from the idea that the satisfaction of human needs is central to the concept of sustainable development and equity is a key factor. Through analysis of thirteen indicators of transport initiatives, selects 54 indicators that should be measured to achieve sustainability within a holistic perspective. [6]

The study Zegras (2006) on the idea that the ultimate goal of mobility is accessibility. Thus does a thorough analysis of the accessibility indicators showing their strengths and weaknesses. Focuses on the analysis of the project called System for Planning and Research in Towns and Cities for Urban Sustainability (SPARTACUS) that monitors the sustainable urban mobility through nine indicators in three European cities - Helsinki, Naples and Bilbao, through a model (MEPLAN) that measures land use by transport. [14]

Mikusova (2007) reviewed 9 most important European public transport comparative projects and developed 14 indicators that was applied for benchmarking study of Slovak transport system. One of the most important findings of this study was a need to adjust set of indicators to the terms applicable in local conditions of provision of transport services. [15]

Brazil stands out in the Index of Sustainable Urban Mobility (IMUS) developed by Costa (2008) that results from the workshops of "Integrated Management of Urban Mobility," promoted by the Department of Mobility (SeMob) linked to the Ministry of Cities, in eleven metropolitan regions and urban agglomerations in Brazil. The universe of 3.228 selected 87 indicators to format the Imus. This index was applied in the municipality of San Carlos, chosen for having evidence from a recent survey to update the Master Plan. This peculiarity allowed 92% of the proposed indicators could be measured, however, according to the author, this result should be viewed with caution, since "... average in most Brazilian cities there is a lack of human resources, economic and technological developments that prevent or restrict the collection and production of data to feed the indicators proposed in the system". [2]

By other side, Campos and Ramos to analyze the prospective European project, TRANSLAND, Propolis and TRANSPLUS, defined an index of sustainable mobility based on the following themes: (i) Encouraging the use of public transport, (ii) Encouraging non-motorized transport; (iii) Environmental Comfort & Safety, (iv) the relationship between transport costs and the urban economy, (v) intensity of car use. [1]

On the specific issue of public transportation stands out the adequacy of Public Transport (IATP) prepared by Gomide (2004), composed of indicators that measure: amount of the tariff, availability, accessibility and acceptability of public transport. [3]

These initiatives concluded that the complexity in relation to that measure when assessing the impacts of motorized mobility on the quality of life and sustainability, provides a significant extension of the number of options about which measure Themes. Table 1 shows the most recurrent themes found to assess the sustainability of mobility in its three main dimensions.

Table 1 : Comparison of Themes addressed by existing sets of sustainable transportation indicators

Systems | Themes	*SUMMA (2004)*	*LITMAN (2008)*	*TRANSFORUM (2007)*	*HALL (2006)*	*RAMOS (2005)*	*COSTA (2008)*	*JEON (2005)*	*TERM (2003)*
SOCIAL								
Accessibility	✓	✓	✓	✓		✓		
Universal Accessibility	✓	✓	✓	✓	✓	✓	✓	✓
Safety	✓	✓	✓	✓	✓	✓	✓	✓
Mobility	✓	✓	✓	✓	✓	✓	✓	✓
Equity	✓	✓		✓				
Quality of service		✓	✓	✓	✓	✓		✓
ENVIRONMENTAL								
Air Pollution	✓	✓	✓	✓	✓	✓	✓	✓
Noise	✓	✓	✓	✓	✓	✓	✓	✓
GHG Emissions	✓	✓	✓	✓	✓	✓	✓	✓
Energy Use	✓		✓	✓		✓	✓	✓
Mixed Land use	✓	✓	✓	✓		✓	✓	✓
Ecosystem Disruption	✓	✓	✓	✓		✓		
ECONOMIC								
Costs to economy	✓	✓	✓	✓		✓		✓
Productivity/ Efficiency	✓	✓	✓	✓		✓		
Affordability	✓	✓	✓	✓	✓	✓	✓	
Congestion		✓	✓	✓		✓		
Reliability		✓	✓	✓		✓	✓	
Operating Costs	✓		✓	✓	✓	✓	✓	✓

Specifics for selecting indicators of mobility

It takes a careful selection of indicators that reflect the proposed objectives to consider, in this case, the major impacts caused by motorized commitment to individual mobility in the three dimensions of sustainability (see Table 2).

Table 2: Main impacts of transport on dimensions of sustainability

Economic	Environmental	Social
Accessibility	Land Use	Accessibility and affordability
Operating costs	Fossil Fuel Consume	Safety / Accidents
Productivity/ Efficiency	Air Pollution	Health
Benefits to Economy	Pollution to water	Habitability
	Noise	Equity
		Social Cohesion

Source: Litman (2008) [8]

One of the most difficult issues in the selection of indicators of sustainability are their interrelations. Should be avoided: (i) the same costs and/or benefits are taken into account two or more times, i.e., the problem of double or multiple counting, so the need for correlation analysis, (ii) indicators are inconsistent with sustainable mobility, presenting contradictions or ambivalence towards sustainability. [5]

It is advisable to seek a balance between positive and negative impacts that you want to achieve. Moreover, it is necessary to identify the desired direction, i.e., the growth of the positive aspects and reducing the negative impacts. The desired change in one sector can cause an undesirable outcome in another, so you need to make a decision about how much of the negative impacts can be accepted in order to get some good point on another goal. For this indicator is assessed individually to determine if the measured data must advance or regress. [10] [13]

Since a hierarchical set should be symmetrical and have the same number of indicators in the three dimensions of sustainability: Social, Environmental and Economic analysis of the systems surveyed indicators showed that some of concentrated attention to one more dimension than the other leading imbalance and asymmetry of the set. [9] [10] [11] [12] [13].

Themes paragraphs list some common issues that can be identified with more than one dimension which hinders the process of formatting a rate that maintains a balance to measure the dimensions of sustainability. This is the case, for example, accessibility, transport costs and use of resources. The accessibility and affordability are identified in both the social and

economic dimension depending on the approach. While the concept of affordability, in a social perspective, assumes that people can pay for their mobility.

The costs of transport and investment appear in both the economic dimension (cost saving) and the social (equity or public subsidies). It relates both to the users as the cost of the state as funder of transport. The "fairness" takes into account the direct costs of the user while the subsidies are concentrated in the indirect costs of the transport sector and related sectors, for example, the development of Information Technology (IT). [13]

When we speak of sustainable mobility is important to measure their social costs in the public budget. The population pays through tax collection, largely of investments in maintenance and infrastructure construction. Public subsidies also represent a social cost that must be considered and evaluated. Already, indicators for the operational costs of transport should include the issues affecting the efficiency of the transport system as congestion, low level of reliability, factors that increase costs to the user in terms of money and time. [12]

There is also a limitation in the choice of indicators, particularly those relating to environmental issues (noise, atmospheric, built infrastructure, etc.). Due to lack of environmental data. In most cities there isn't routine collection or historical data, many details have not been compiled systematically or aren't accessible.

On the other hand, some indicators require monitoring for a more detailed breakdown of the data. This is the case, for example, accidents - are not available the number of serious injuries, deaths by mode, by income, etc.. On the specific topic of urban public transport, there is a lack of data, because when they exist, often can not be disaggregated by city or neighborhood.

Although there is some consensus on the list of themes, the same is not true when considering the indicators that will support them. There is a wide variance as to what will be measured. For example, accessibility is likely to be measured in several ways, depending on the scale and concept, as the existence of intermodal transport, travel time by mode, % of children who go to school on foot, many people who study and work site, % land use mix, etc..

Depending on the level of technological development of region or country very specific indicators are used. The production data becomes expensive because it requires, in addition to equipment, human resources. They become indicators where data is not safe to feed them. It appears, therefore, a methodological problem of what to measure, and how to measure its

frequency and scale to be measured (country, region, city, or district). Taking as a basis of the themes listed in Table 1 and in view of a selection of indicators adapted to the reality of Brazilian cities, sought to enlist those issues that have an answer quantitative aspects, with existing data and on an annual basis (see Table 3).

Table 3: Characterization of dimensions, themes and indicators

Dimension/ Theme	Indicators	Quantitative Data	Data Available	Annual Period
SOCIAL				
Accessibility	Mixed land use	✓	✓	
Safety	Number of deaths and injuries	✓	✓*	✓
Mobility	Passengers carried by mode	✓	✓*	✓
Equity	Number intermodal terminals	✓	✓	✓
ENVIRONMENTAL				
Air Pollution	Total CO^2 emissions	✓		
Noise	Number of residences exposed to noise above 55dbA	✓		
GHG Emissions	% greenhouse gas emissions	✓		
Fossil fuel consume	*Per capita* gas consumption vs urban density	✓	✓	✓
Land use	% mixed land used	✓		
ECONOMIC				
Costs to Economy	Public investment in transport	✓	✓*	✓
Productivity/ Efficiency	Index of passengers per kilometer (IPK)	✓	✓	✓
Affordability	% household income spent on transportation	✓	✓*	✓
Congestion / Delay	Morning peak	✓		

* partial data

There was a reduction in the number of possible indicators in applying the criterion of existence of data. That is why the availability of data, most of the time, ultimately determine the selection process. Based on these criteria began the second step: find proxy indicators to compose the set.

In the case of environmental indicators, because only the existence of data on fuel consumption, it was decided by the rate of motorization. This indicator may warn of future environmental problems such as: increasing atmospheric emissions, noise, congestion, urban sprawl, consumption of fossil fuels, etc.. In the proposed package, as a balance system, was disrupted if the indicator "fuel consumption" in renewable and nonrenewable, in this case

alcohol. Well, it is understood that this also affects negatively on air pollution, congestion levels, and soil consumption of road infrastructure so as to input planting.

On the social indicators were included for the public transport because, according Gomide (2003), it promotes social inclusion by facilitating access to the city. Already, the economic dimension, a proxy indicator proposed was the relationship between public investment in transportation and municipal GDP, whereas the larger the investment the greater its positive effect on the economy. [4]

Of course, the selected indicators do not measure all, but some of the aspects needed to monitor the impacts on the sustainability of mobility and hence on the quality of urban life.

These were the considerations for the selection of indicators that could be fed annually by data from statistical sources and institutions such as Brazilian Institute of Geography and Statistics (IBGE) , Foundation of Economics and Statistics (FEE), State Traffic Department (DETRAN). Table 4 shows the selected indicators to measure the themes in each of the three dimensions of sustainability and its associated data source.

Table 4: Dimensions, Themes and Indicators proposes

Dimension	Theme	Indicator	Source
SOCIAL (SOC)	SOC01: Accidents involving deaths	% deaths in transit / number of vehicles	DATASUS
	SOC02: Supply of public transport	Passengers carried *per capita*	METROPLAN/EPTC, IBGE
	SOC03: Intermodality	Number of intermodal stations	TRENSURB
ECONOMIC (ECO)	ECO01: Affordability	Average value of the rate*month/ Minimum wage	METROPLAN/ Ministério do Trabalho e Emprego
	ECO02: Efficiency of public transport	Index of passengers per kilometer (IPK)	METROPLAN, EPTC
	ECO03: Public investments in transportation	% of expenditure on transport / GDP	Ministerio da Fazenda, FEE DADOS
ENVIRONMENTAL (ENV)	ENV01: % of motorization	Number of vehicles in circulation *per capita*	FEE DADOS
	ENV02: Consumption of fossil fuels	Sale fossil fuel (petrol +diesel) *per capita*	FEE DADOS
	ENV03: Consumption of alternative fuels	Sale of ethanol *per capita*	FEE DADOS

Conclusions

Brazil is a country where the government recently began to invest in monitoring systems, there is a shortage in supply of information, which explains the absence

of a systematic, human resources and operational, both in collection and in data generation, especially in the environmental, public and non-motorized transport.

A set of indicators can serve as a tool and assist in planning and management of sustainable mobility by providing subsidies of the negative impacts of motorized mobility. Obviously the proposed index is not intended to be conclusive, but a starting point to find away to build and maintain a reliable database in relation to urban mobility.

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