TRANSPORTATION AND SUSTAINABILITY FOR A MEXICAN

NORTH BORDER CITY

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ABSTRACT

Transportation provides multiple benefits in means of goods, access to services, a mobility of people and merchandise, but it is also the cause of an important number of environmental, economic, and social costs. Externalities associated with transport, include, but are not reduced to air pollution emissions, greenhouse effect gases, accidents, noise, and traffic congestion. The challenge to measure the impact and interactions that transport produces as a basic activity of connectivity mainly in urban areas while including sustainability principles such as accessibility, mobility, economic efficiency, urban planning, and equity, enable the development of this type of evaluation as an analysis instrument. This work addressed the state of the art in sustainable transportation while defining its main principles. Starting from this, the criteria hierarchy was performed, resulting in the priorities to implement in the city of Mexicali, Baja California, México.

KEYWORDS: Transportation, Sustainability, Assessment & Hierarchization

INTRODUCTION

Several disciplines such as Engineering, Urbanism, and Economy have addressed the assessment of transport as a system; however, it is now that different efforts intend to assess transport from a sustainability perspective due to the complexity of its interactions, movement of individuals, territory, goods, services and natural resources. Applying this type of assessment may be useful as a common frame so that decision makers and planners understand what individual impacts mean, and how these could be compared between them, with all the arrivals, flows, processes and departures that interact with the environment, showing certain causal relationships between its component elements while defining its specific features, establishing a hierarchy and possible strategies that allow the inclusion of the principles of sustainability in the transportation system while using the scientific method. In general, a single decision–making, problem has more than one perspective and there is always an exchange of priorities between different objectives supported by the different interest groups or actors involved.

Mexicali is located in the Mexicali Valley region in the northwest end of the state of Baja California, bordering on the north to the Imperial County, California and at the northeast with the Yuma County, Arizona, both in the United States. According to the Population and Housing Census conducted by the National Institute of Statistics and Geography (INEGI 2010), the total population of the Mexicali County is 936,826 inhabitants.

OBJECTIVE OF THE STUDY

The objective of this study is to rank alternatives from the sustainability paradigm in the transportation system in the city, analyzing the externalities.

SUSTAINABLE TRANSPORTATION

From the need to reduce the consumption of natural resources, energy consumption, reduction of polluting emissions, improving mobility, security and others, the concept of sustainable transportation has been built, with institutional efforts mainly from the Organization for Economic Co-operation and Development (OECD, 1997)**,** which initially defines an environmentally sustainable transportation as follows:

Transportation that does not endanger public health or ecosystems and meets mobility needs consistent with (a) use of renewable resources at below their rates of regeneration and (b) use of non-renewable resources at below the rates of development of renewable substitutes.

Source: Litman (2012) Victoria Transport Policy Institute

Figure 1: Objectives of Sustainable Transportation

Starting from this definition, it is believed that the concept of transportation that might be most suitable for our environment is that which provides opportunities to access mobility in a safe, affordable, and efficient way, and which limits negative externalities. Transportation as an activity entails the development of sustainable systems, which include efficient energy, multimodal transportation, communication - mainly public transportation-, fuel, and clean vehicles as well as the improvement of transportation systems in rural areas (Zhang, 2013). Sustainable transportation may improve economic growth and enhance accessibility, achieving a better economic integration, as a means to better social equity and health and increasing productivity in rural areas while regarding the environment (Litman, 2012).

In 1992, the concept of sustainable transportation began to crystallize at the Rio de Janeiro Earth Summit, on the Agenda 21-the Declaration of Rio – included in two chapters. Chapter 7, promotes ¨efficient and environmentally sound urban transport systems in all countries should be a comprehensive approach to urban-transport planning and management¨ (UN 1992). To this end, all countries were asked to:

- Integrate land-use and transportation planning to encourage development patterns that reduce transport demand;

- Adopt urban-transport programmes favoring high-occupancy public transport in countries, as appropriate;

- Encourage non-motorized modes of transport by providing safe cycleways and footways in urban and suburban centers in countries, as appropriate;

- Devote particular attention to effective traffic management, efficient operation of public transport and maintenance of transport infrastructure;

- Promote the exchange of information among countries and representatives of local and metropolitan areas;

- Re-evaluate the present consumption and production patterns in order to reduce the use of energy and national resources.

Nowadays, transportation policies differ widely from one city to another, from one country to another, just as travel patterns of people do in such cities and countries. Nevertheless, and in spite of the apparent differences in their operations and technology, they comply with a basic demand for transportation: mobility and accessibility. The way of moving and being able to access transportation influences the location of social and economic activity, it shapes and gives the size of cities, facilitates trade, enables greater economies of scale, moreover, it promotes the expansion of cultural and social connections, increasing job, education and health opportunities.

In contrast, according to Hall (2006), in many cities, particularly in developing countries, many people do not have access to appropriate transportation infrastructure or transportation means since they are not available nor affordable to them.

Planning and management policies have changed with time due to the improvement of vehicle performance, increase of road congestion, and the rise of awareness of environmental issues as well. Strategies and objectives have been also modified, from being able to establish action to fully satisfy transportation demand, to one where transportation planning is oriented, through trial and error, toward effectively knowing what is needed.

METHODS

The methodology proposed to assess the principles of sustainability in the transportation system of the city of Mexicali was the multi-criteria evaluation, particularly applying the Analytic Hierarchy Process (AHP). Based on the Victoria Transport Policy Institute model by Beria (2011), Diappi (2010), Tudela (2006), Ju (2012), the following steps are described:

- **Building Hierarchies:** The hierarchical classification scheme is made of: objective or focus, criteria, sub-criteria, and alternatives.

- **Setting Priorities:** Subject-matter expert panel. Subject-matter experts were selected in order to represent the governmental. business, social and academic sectors involved in transportation.

- **Assignment Method:** Through a subject-matter expert panel, the decision maker directly assigns scores to the steps. Such scores may be assigned in different ways: by the simple arrangement, simple appraisal or successive comparison. The simple appraisal method consists in asking the decision maker to assign a score to each step to a

certain scale. The first step is to normalize the matrix of pairwise comparisons which require measurement in its consistency. (Jiménez, 2015).

The procedure used by AHP to normalize the matrix is in addition. Given a definite matrix each element is substituted: a_{ij} by the quotient of such element and the sum of all the elements in the column where $a_{ij} / \sum a_{kj}$) is located. Once the matrix of pairwise comparisons is normalized, its rows are added and each addition is averaged in order to obtain a vector of global scores. (Dempster, 1967).

Then, the product of the original matrix multiplied by the vector of global scores results in the total row vector; this row vector is divided by the vector of global scores previously calculated, resulting from this quotient a column matrix. All the elements in such column matrix are added and averaged. The average number obtained is: λ max.

In this sense, the pairwise comparison scale is established where the definition of the importance of each criterion primarily regarding the objectives lies. Values are defined through the Analytic Hierarchy Process (Munda, 1993), (i) considering qualitative and quantitative factors; and (ii) taking into account the plurality of the perceptions of the Subject-matter experts involved in decision-making.

From the above, the model proposed by the Victoria Transport Policy Institute (VTPI) is established as a reference model of analysis to identify the externalities and indicator for this assessment of the city transportation.

Table 1: Analytical Framework for Evaluation

VTPI Model	Proposed Factors for Multicriteria Assessment	Strategies
Social: Social Equity Safety and Health Community Cohesion Affordability Culture Preservation	Social Accessibility Accidents	Improving Non-motorized Transportation Accessibility
Economic: Efficient Mobility Local Economic Development Operative Efficiency	Economic Congestion Mobility	Reducing Levels of Congestion Improving Transit Services
Environmental: Noise and Air Pollution Reduction Resource Preservation Open-Space Preservation	Environmental Air Quality Energy Demand	Reducing the Levels of Private Vehicle Use Reducing Energy Consumption Improving Air Quality

RESULTS AND DISCUSSIONS

According to the results obtained, it is observed that the best-positioned alternative in order to achieve the goal to a more sustainable transportation is reducing the use of private vehicles, with a suitable consistency index (0.088), which is accepted as valid. However, this alternative would allow to exploring alternative non-motor means of transportation, a change or re-orientation in the patterns and lifestyles of the user, and a design of the public policies in this matter.

This would imply the establishment of the best-positioned alternative, but it wouldn´t exclude the rest of them, instrumenting them in a transversal way, resulting in sub-strategies or else, creating alternative scenarios that would allow the accomplishment of the objective.

One of the limitations of this sustainable model for transportation relies on the complexity of the measurement of all the variables involved in the system, since there are entropic elements within, such as the concessionaires of public transportation.

Regarding the Victoria Transport Policy Institute (VTPI) model, it is noted that the transportation of the city tends to unidimensional or partial visions more than to a coordinated planning among the different sectors, groups, and government agencies, disconnecting the short-term goals from the long-term strategic ones that might improve the system.

The VTPI implies counting with a diversity in the transportation system offer, where travelers may choose among several means, locations, and prices, particularly, that they are affordable, healthy, and efficient. In contrast, it is found that one of the main weaknesses of the transportation system is the dependence to one means of transportation, the private vehicle, putting other means, such as public transportation, aside.

Urban planning requires tools that address such relationship networks and effects in present reality. Conventional ways of designing plans e implementing public policies for transportation without including elements such as mobility, accessibility, air pollution, and energy consumption, are being exceeded by their responsiveness upon present needs, moreover, upon future challenges. Setting this hierarchization or ranking of alternatives might contribute to the implementation of a more efficient planning that enables a more sustainable development.

CONCLUSIONS

Reducing the use of private vehicles is a priority that must be implemented through the adoption of public policies that enforce or restrict its use. However, it should not be reduced to a single policy, but it should also include improving the offer of transportation services, such as the confined spaces assigned for alternative means of massive transportation. This would result in a change of the paradigm of the system actors (users, concessionaires, and authorities) to a more sustainable one.

Several principles of sustainability of the transportation system of the city are not fully complied. Transportation in some areas of the periphery is not accessible, nor affordable. There are areas that are not covered by collective transportation, resulting in an ineffective mobility that raises social and economic costs. The relevance of the alternative modes of transportation is not privileged, due to the inexistence of policies that encourage the reduction of the use of private vehicles.

The city´s tendency to expand causes a dependence on private vehicles, a result of the lack of alternatives to begin with. Institutional capacity is limited since it does not count with financial, human, legal and technical resources in the Municipal Transportation System, restricted to only verify regulatory standards. There is a dissociation between urban planning and transportation. There are conflicting policies, such as maintenance of the public transportation routes without any adequations to the new dynamics in settlements for over 20 years.

It is found that the multicriteria assessment as applied to different regions of the world, mainly Europe and Asia, as an alternative way to traditional evaluation, represent an appropriate instrument for the incorporation of environmental variables, that will enable decision-makers to better understand relationships and interactions in a complex environment and troubled, to some extent. Transportation planning does not include economic, social, and environmental impact, not in short, nor in long-term, which reduces the opportunities of future generations.

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APPENDICES

Table 2: Ranking of Alternatives

Strategy	Criteria Congestion	Criteria Mobility	Criteria Air Pollution	Criteria Energy Demand	Criteria Accidents	Criteria Accessibility	Average	Priority Ranking
Improving Non-motorized Transportation Accessibility	0.23(2)	0.29 (2)	0.17 (2)	0.03(5)	0.18(3)	0.08 (5)	0.16	3
Reducing Energy Consumption	0.15(4)	0.11 (4)	0.08 (6)	0.32(1)	0.15 (4)	0.04 (6)	0.14	5
Improving Air Quality	0.20 (3)	0.13 (3)	0.39 (1)	0.17(2)	0.13 (5)	0.14	0.21	2
Reducing Levels of Congestion	0.05(6)	0.09 (5)	0.15 (3)	0.15(4)	0.20 (2)	0.19(3)	0.15	4
Reducing the Levels of Private Vehicle Use	0.31(1)	0.32 (1)	0.09 (5)	0.17(2)	0.26 (1)	0.34 (1)	0.23	1
Improving Transit Services	0.06(5)	0.05 (6)	0.12 (4)	0.16(3)	0.08 (6)	0.21(2)	0.12	6