Application of Multi-Criteria Analysis Model to Evaluate Integrated Transport Systems (ITS): A case study in Florianópolis, Brazil

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Abstract

Public transportation is a great challenge Brazilian cities are facing nowadays. The accelerated growth of cities boosts the demand for transport, which generates an increase in the number of vehicles on urban roads, as well as the need for improvement of road infrastructure. Public transport services should play an important role in promoting good transport for users, being more attractive and generating greater efficiency in the use of urban space. This study is aimed to develop a multicriteria evaluation model for public transport services. Using this method it was possible to structure an evaluation model which displays the perception of users on evaluation aspects. After the structuring of the model, a field survey was carried out to evaluate part of the Integrated Transportation System (SIT) of Florianópolis. The evaluation model developed can help the management of public transport services, supporting the decisions of public managers and administrators.

Introduction

In Brazil, some major problems faced by cities, which are aggravated by bad transport systems, are related to low accessibility, badly maintained vehicles, discomfort, congestion, pollution and accidents. This results in a shift of policies and priorities; the transition towards a more sustainable urban mobility in cities were supported and driven by a governmental policy, which in 1998 defined "the service of public transportation as an essential public service of municipal responsibility" (da Silva et al., 2008; da Silva et al., 2014).

This policy was supported by the creation of the City Statute (by the law number 10.257 of June 10th in 2001) and the establishment of the Ministry of Cities in 2003, increasing the debates on the necessity of new means of transportation in Brazilian cities. The City Statute stated that cities with more than 500,000 inhabitants must create an Integrated Transport Plan. Due to the inefficiency of public transportation systems in Brazilian cities, which were mostly focused on bus transport, some alternative transports emerged due to new public regulations and policies (da Silva et al., 2008; Orrico Filho et al., 2015).

With nearly two million inhabitants spread in 430 km^2 and a high Gross Internal Product, the city of Curitiba, Brazil, initiated its process towards sustainable mobility and efficient city planning back in 1965. This was done with the creation of the Curitiba Research and Urban Planning Institute to develop and implement the city's master plan.

The municipal public transport system, named Integrated Transportation Network, "is a trunk-feeder system with physical integration provided mainly by terminals and tube stations", operating inside the city and in some surrounding municipalities (Miranda and da Silva, 2012, p.143).

Despite the success of the transportation system, Curitiba has one of the highest motorization rates of Brazil and a high automobile dependence, which stimulated the city's planners to implement some measures to improve the mobility network (e.g. the creation of traffic binaries to enable better traffic speeds in parts of the system).

However, some alternatives, such as incentives to use non motorized modes of transport, are still not really considered by city planners to reduce dependency on automobiles (Miranda and da Silva, 2012).

Nowadays, Brazil has several Public Passenger Transport Systems (PPTS) across its' cities (e.g. road, subway, rail, waterway). However, there is a need to improve these systems (Lacerda, 2006). In this regard, many alternatives have been discussed, such as the use of differentiated tariffs per hour of the day, with the objective of stimulating users to use the transport at off peak times (Cruz, 1999; Ferronato, 2002). This is a practice successfully executed in several countries

(Ferronatto, 2002), and could be implemented in Brazil as well.

To obtain efficient systems, several actions are required to study and understand how these transportation systems are today, and how they could be improved to meet the future needs of the population (Dell'olio et al., 2010). In order to understand the quality, efficiency and effectiveness of PPTS, it is necessary that studies evaluate and analyze these systems, aiming to improve the quality of the services by identifying the current negative and positive aspects of these systems.

With the rapid population growth of Florianópolis, after the 2000s, the city's traffic is suffering several transformations. With the increase of cars, traffic jams are inevitable in the city (Makowiecky and Carneiro Filho, 2015). As an answer for this problem, in 2000s, the Integrated Transportation System (ITS) was created. It is a public transport system based on buses and integrated bus stations. The ITS of Florianópolis is based on one central station and on five secondary stations for integration, grounded in strategic neighborhoods. There are two in the north, one in the south, and two in the east of the city (Mobfloripa, 2016).

This paper aims to apply the multicriteria evaluation model developed by Barbosa et al. (2017) to the Integrated Transport System (ITS) of the city of Florianópolis, Brazil. The city was chosen because it is an emerging city in South America, detached as an important technological and sustainable city in South Brazil (Guerra et al., 2016). The purpose of this application is to find out the critical factors related to transport service in Florianópolis, especially related to user service, information, safety and accessibility.

Multi-criteria analysis model to evaluate transport systems

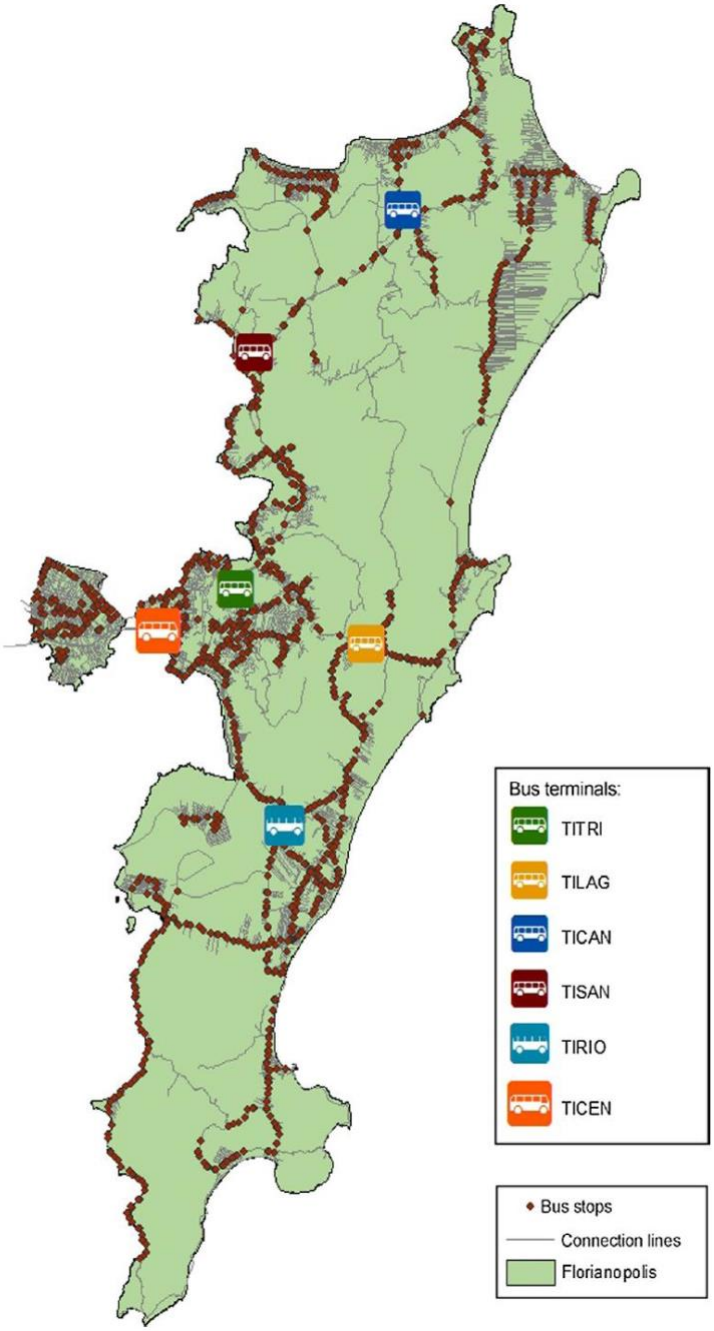
During the last five decades diverse lines of multicriteria analysis were created. Multiple Criteria Decision Making/Aiding (MCDM/A) (Hillier e Lieberman, 2001) is an approach which focuses in decision making problem solving involving multiple criteria. Another well known method in literature is the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), originally developed by Hwang e Yoon (1981), in 1981, advances were made further by Chen e Hwang (1992), in 1992.

The AHP (Analytical Hierarchical Process) is another multicriteria analysis method (Saaty, 1980). In this method the structure of hierarchy for the decision problem is made through the definition of a general objective, the criteria and subcriteria of evaluation, and the variables. As for the Pattern Method (Planning Assistance Through Technical Evaluation of Relevance Numbers) emerged in 1963, while Honeywell Corporation has utilized the american spatial and military research program. It is one of the most well-known applications of the "Relevance Tree" or "Pertinence Tree", which objectives to create a hierarchy of decision paths, according to the importance of its contribution for the achievement of the initial goal. The method helps to select actions which satisfy global goals.

Specifically in the transportation area, the multicriteria evaluation methods has been use in a broad way, with diverse objectives. Yedla and Shrestha (2003) analyze many qualitative criteria for the selection of transportation alternatives in New Delhi, India. The authors used six different criteria for evaluation: potential for energy saving (energy), potential of emissions reduction (environment), operation cost (cost), availability of technology (technology), adaptability of the option (adaptability) and implementation barriers (barriers). Zubaryeva et al. (2012) present a multicriteria evaluation method to evaluate the potential of the Market for electric vehicles in Europe. The researchers combine many economical, social, environmental and transportation factors. Besides that, multicriteria methods can be used to analyze political measures related to transportation. Taefi et al. (2016) evaluates political measures related to the adaptation of electric vehicles in urban transportation of loads.

Also regarding the transportation sector, the multicriteria approaches can be applied for the evaluation of public transportation systems. It is possible to analyze how a particular service behaves through a determined number of variables. The performance of a transportation service can be evaluated by quantitative and qualitative criteria, in a way that the subjectivity involved in the service can be evaluated alongside the quantitative attributes. In this point of view, the user, who is the main beneficiary of the transportation service, establishes and evaluation of the service involving many attributes at the same time.

Figure 1. SIT Florianópolis' terminals and bus stops.



Source: Barbosa et al. (2017).

ITS was implemented in Florianópolis' as an revolutionary transportation system and it has some specific characteristics.

To evaluate service quality level of the Integrated Transport System (ITS) Barbosa et al. (2017) presented a multi-criteria analysis model. This model is based on 30 evaluation criteria, clustered in 10 groups. The 30 evaluation items were obtained from service analysis tools, such as Customer Journey Map and Service Blueprint. Through the use of these two tools, supported in Florianópolis ITS user query, it was possible to obtain a model which grouped the most important evaluation items for user perception of the quality of the service (Barbosa et al., 2017).

Conclusions

The presented model was applied specifically in the South region of Florianópolis' ITS. The results of the evaluation allowed to obtain a general vision of users evaluation, as well as a vision of the evaluations by specific user groups. It was also possible to understand that there are differences in evaluations due to users age rate (youngsters, adults and elders), type of bus line (feeder lines and trunk lines) and frequency of use (low and high usage).

The periodic application of the transportation services might be done through the use of this model, allowing to understand if there was an improvement of the service or not through time. The evaluation of parts of the transportation system separately (i.e., lines, city regions) might aid in the understanding of the discrepancies of the transportation system, identifying variations in the quality of the service inside of a same town or region.

The use of the evaluation model as a support for concession contracts, as used in the paper of Mokonyama and Venter (2013), might be an alternative which allows the government to monitor the quality of the transportation service. That way public transport agencies may realize constant evaluations of transportation lines, linking evaluations to concession contracts. Through that dealerships will try to answer to a minimum level of quality, linked to a specific evaluation index. For example, it is possible for the level of quality of the service to be always above 0.7, being this index obtained through semiannual evaluations. If in any semester the value of the evaluation index is under 0.7, the dealerships may be penalized for low quality service. This periodic evaluation, with a determined quality index, might be established in concession contracts.

From the present research it is possible to develop an evaluation model which can be applied in a national level, in a way that allows to evaluate the level of quality of a transportation service in Brazilian cities which use integrated transportation services. A national level evaluation will allow public transportation agencies, such as Brazil's National Public Transportation Agency (ANTP), to have a comparative view of the quality of the service.

Lastly, it is important to highlight the importance of public transportation for the development of more sustainable cities in the future. Big cities must assume their transportation systems as their greatest priority, developing ways to orientate growth and urban development in a way that public transportation acts as a central element.

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