EVALUATING THE POTENTIAL OF BRAZILIAN RAILWAY NETWORK REDEVELOPMENT BASED ON LIGHT RAIL TRANSIT

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ABSTRACT

The potential of Brazil's railways was for long neglected, despite its key role in the country's past development. The arousal of the transit problems in medium and small cities poses the possibility of reconverting sub-utilized cargo railways in efficient and modern commuter rail systems. The objective of this paper is to analyse the economic and political viability of implementing these projects.

Keywords: LRT, GIS, Spatial Analysis, Urban Renewal

1. INTRODUCTION

Nowadays, the concept of urban sustainability tends to point toward the renovation and redevelopment of the existing urban space. Public transport plays a vital role in this context, since its efficiency is directly connected to the quality of life experienced by the population in its surroundings. Recently, in Europe, railway stations have assumed a strategic role in urban redevelopments to provide efficient and liveable urban and metropolitan systems (Conticelli, 2011).

This scenario of revitalization is even more necessary in Brazil, seeing that the process of degradation of the rail network was even more intense here than in the European context, as shown on Figure 1. De Bonis (1997) claims several factors that could explain this dilapidation. Some that stand out are the competition with the roads and air transport, cost factors (explained by incident taxes and idle capacity) and unfavourable funding conditions. Due this scenery, it becomes clear that any renovation initiative of rail systems should before cleanse these hindrances in a proper way.

At the same time, it is important to note that population in metropolitan areas is increasing in a rate above the national average (Ipea, 2011), especially in medium cities. Whilst most jobs

still remains in the CBDs, also is noticed an increase in the inter-city trips that don't have the metropolitan center as its destination. (Ipea, 2011).

This urban sprawl eventually creates an obstacle somewhat delicate: while the displacements between the center and the suburbs are limited by the system capacity, the solutions for mobility in low-density suburban regions are much more complex, mainly because of the high demand that is necessary to implement high capacity rail systems. Aside also stands the political factor, once that, in Brazil, investments in this sector always had its success related to high passenger counts (Ipea, 2011).

In this context, the main goal of this study is to study more profoundly the viability of medium capacity modes that show themselves suitable solutions to the problem. In order to do that, will be proposed a decision tree that verifies socioeconomically and spatially which railways are more likely to be successfully refurbished.

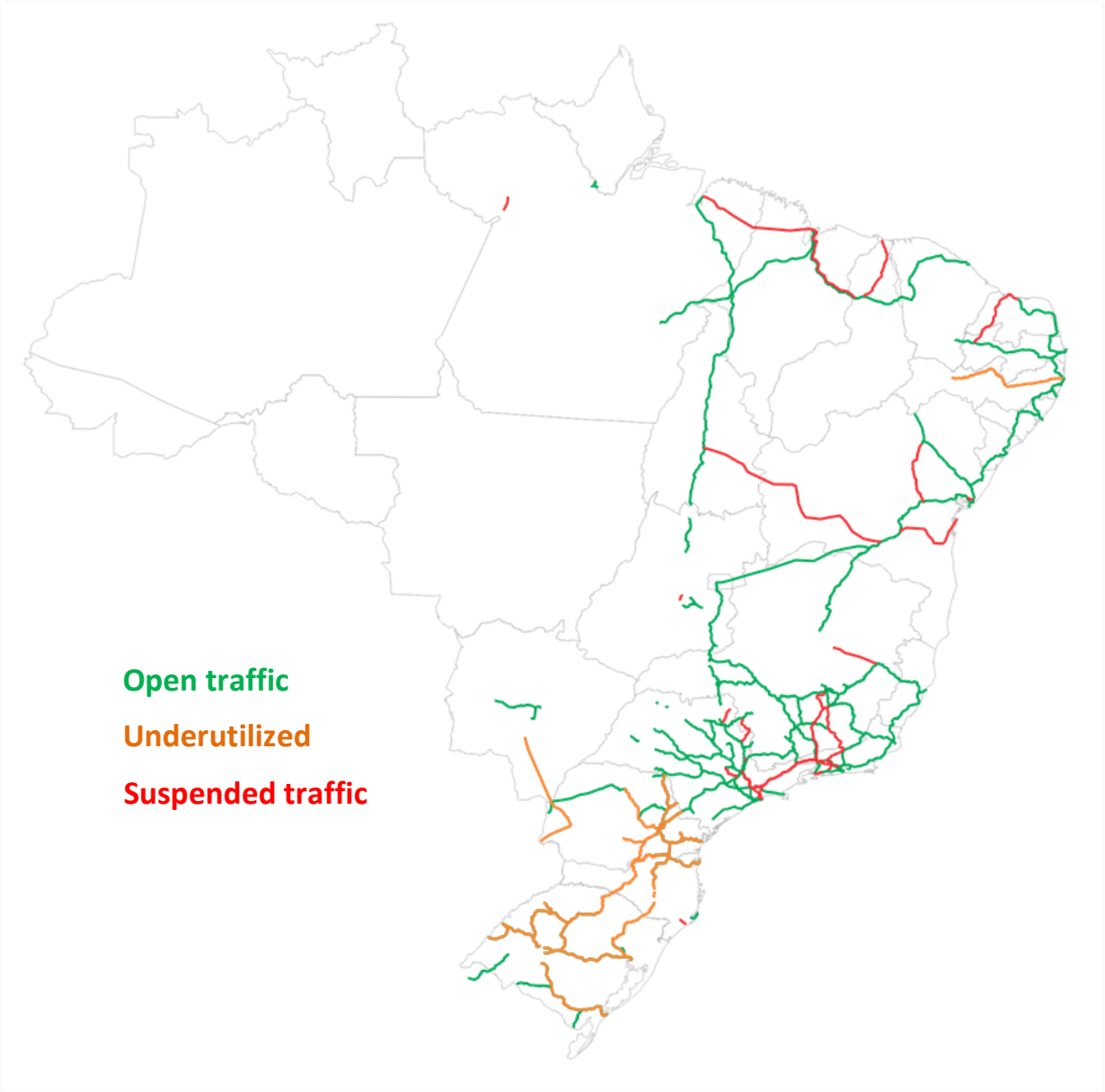

Figure I: Brazilian Rail network GIS base map (Adapted from PNLT, 2010)

2. METHODOLOGY

In order to achieve the goal of the work here is proposed a literature review on the criteria that influence viability of implementation of light rail systems, gathering a range of approaches and assessing which ones can be globally measured by the use of GIS tools.

Before that, however, it is necessary to do a brief research on existing LRT experiences in Brazil, in order to contextualize more properly the international experiences described in the reviewed literature, pointing out which technology would be more adequate to this kind of railway reconversion.

Based on this reviews lays an initial step to this methodology, that follows with the selection of the parameters that will constitute a decision tree that, once properly calibrated, would indicate the preliminary viability of future projects.

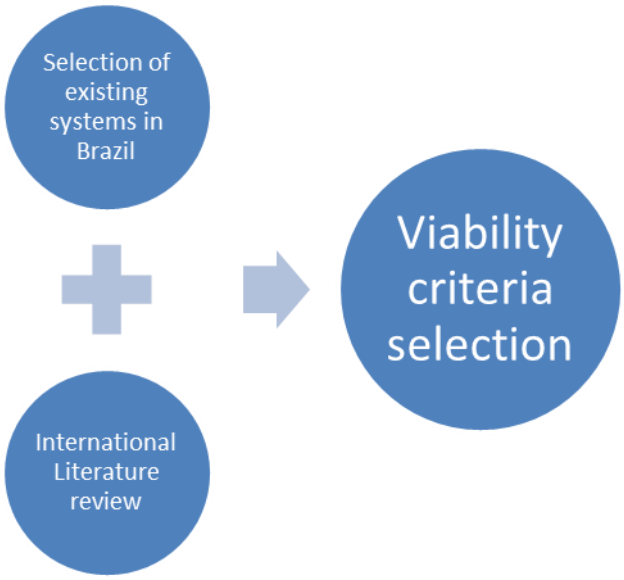

Figure II: Proposed Methodology

3. BRAZILIAN CONTEXT

Brazil has some unique aspects on the implementation of light rail systems. This chapter presents some of these features, contextualizing with the problem here presented.

3.1. Historical reflections

Even though the experience with biodiesel moved light rail vehicles started only a few years ago, medium cities have been implementing low capacity rail systems for a long time. At the same time that the metro systems were being built in large capitals, the focus shifted to the large and subtilized rail network.

Indeed, the Mass Transport National Plan, conceived in 1987 by EBTU, already predicted the adoption of rail transport as solution to the medium cities (Gusson, 2008). In Table 1 we can observe some of these suburban systems that were implemented as a consequence of that policy.

Table I - Comparison between suburban systems with similar characteristics in Brazilian context

	Year of inauguration	Demand (pax/day)	Ext. (km)	Stations	Investment	Technology
VLT de Macaé[4]	2012	5.000	23	8-10	R$72 million	Diesel LRT
VLT de Maceió[3]	2011	6.000	32	9	R$174 million	Biodiesel LRT
Metrô do Cariri[2]	2009	1.200	13,6	9	R$25 million	Diesel LRT
VLT de Campinas[1]	1990	3.000	7,9	8	US$120 million	Electric VLT
Vila Inhomirim[5]	2013*	3.900	15,3	8	R$96 million *	Diesel LRT

*Investimentos previstos para revitalização

Fonte: [1]Gusson (2008), [2]Governo do Ceará (2009), [3]CBTU(2011), [4]Prefeitura de Macaé (2012), [5]Lima e Silva (2005)

However, not all these implantations presented satisfactory results. A remarkable example of failure is Campinas LRT, which had as premise the use of the rail bed of Sorocabana and Mogiana railways, already deactivated. A thorough analysis about the problems that lead to the system failure was done by Gusson (2008), who came to the following conclusion:

> "Integration with the existent bus system was inexistent, and there was no proper care concerning the surroundings nor the users. Lines were isolated from urban life and station accesses did not presented the facilities observed in a LRT system. That's why Campinas project became a failure." (Gusson, 2008)

Thus, we can observe that demand analysis ignored a series of factor related to land use, as we can observe on Figure 3. Even if in theory the trunk axis was being contemplated, a series of micro-spatial factors were not taken into account. Isolated in urban context, the lack of integration with the bus network only aggravated the demand issues.

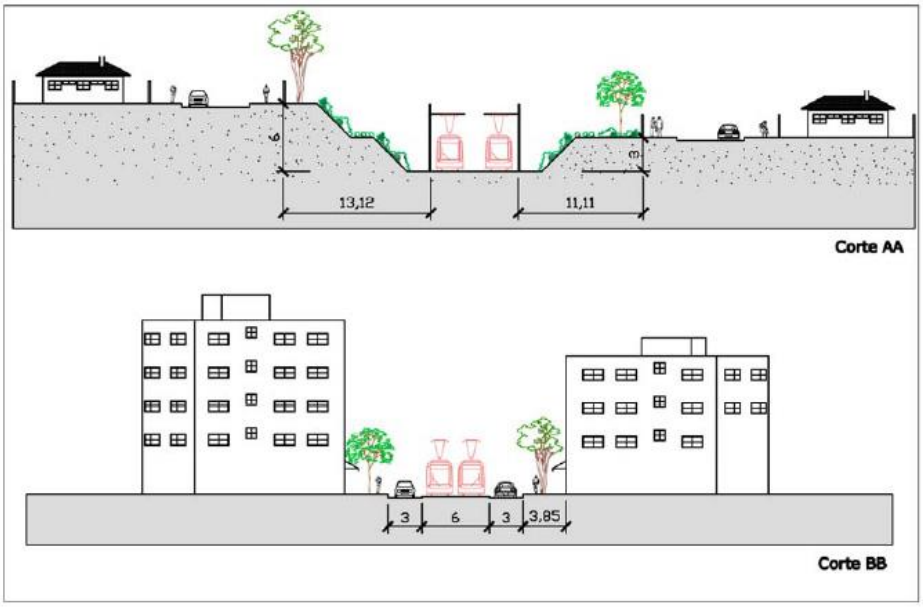

Figure III - Comparison of Campinas LRT versus typical European systems

3.2. The resurrection of modern trams

In the past few years, the rail sector has been reinforcing its image as a clean, safe choice, capable of induce significant advances in life quality. Based on these principles, it has been observed a resumption of railway revitalization projects, using as rolling stock the diesel-hydraulic light locomotives, popularly known as LRT.

Figure IV - Diesel-hydraulic train travelling between Crato and Juazeiro (Ceará State Government, 2010)

A few years after its maiden trip on Cariri metropolitan area, nowadays this LRT is being implemented on six other systems, in Fortaleza, Recife, Maceió, Sobral, Macaé and

Arapiraca. Based on the city of Barbalha, on Ceará State, the manufacturer Bom Sinal has also built a plant in Botucatu, São Paulo, in order to fulfil the rising orders.

A relevant aspect that should be considered is the need of special attention to the problems already verified in Campinas LRT. These projects of LRT usually commit the mistake of using strictly the deactivated railway, that often runs distant from the urban occupation and don't meet the desire paths of the passengers.

This problem was verified at Cariri LRT, once the population complains about the spacing between the stations and the commercial centres. This wasn't faced as a distress at principle, since the project is an experimental subsidized system, but can be a source of explanation to the short demand responses.

In Macaé LRT project the situation is somewhat different. The city developed around a branch of the Leopoldina Railway Co., currently operated by FCA, and the rails crosses the urban fabric almost totally, as we can see of Figure 5. As even the CBD will be served, in that case are expected much more concrete demand responses.

Figure V - Macaé LRT path, alongside the bed of the Litoral Line of Leopoldina Railway (Macaé City Hall, 2012)

4. INTERNATIONAL DEBATES

Land use influence on transportation demand has been widely researched in academic literature. However, one should highlight the different approaches on this theme.

Litman (2007) analysis is based on the traffic congestion perspective and its subsequent urban costs. That way, the benefit of a transit implementation is directly related to the financial gains obtained with congestion reduction. He sustains that these benefits have a great potential of overcoming the system subsidies, making it sustainable.

The same path was also briefly followed by Kuby et al (2004), that also mentions individual transport issues by stating that congestion has completely eliminated the speed advantage that cars have over trains. However, the main focus of his work is on the broader use of land use variables in the immediate station surroundings, in a polycentric approach.

The problem with these approaches is that, even though they have been initially designed for rail systems, they consider only the migration of car users to public transportation. Variables like park-and-ride e car possession are somewhat important to acquire new users, but have little effect on those that are captives.

Only from these studies we're not capable of stating why the government should invest on an expensive LRT system instead of a regular bus system. This sort of evaluation is essential to contextualize these models in the Brazilian context.

Thus, Samanta and Jha (2011) radial analysis is more significant, since it considers the inherent characteristics of segregated rail systems, even if on a preliminary basis. Performing an microscopic detailed analysis allowed considering network variables inside the model, that have shown high significance on demand.

Table II: Summary Table of the topics covered by leading authors

	Litman (2007)	Kuby (2004)	Samanta (2011)
Operational Costs			X
Intermodality	X	X	
Environmental Conditions	X		
Accident Reduction	X		
Infrastructure Costs Reduction	X	X	
User Costs Reduction	X		X
Congestion Reduction	X		
Public Health	X		
Efficient Land Use	X	X	
Socio-economics	X	X	
Public Transportation Speed			X

4.1. Reduction of urban costs

On his work, Litman (2007) brings out the debate about the real benefits of the investment on rail transit systems. From the author's perspective, investments in urban railways have been considered as ineffective in the task of reducing congestion, been characterized just as a big waste of money.

Table III: Rail transit benefits (Litman, 2007)

Benefits
Congestion reduction
Maintenance costs economy
User costs reduction
Transport Diversity Increase
Safety
Environmental Quality
Efficient Land Use
Economic Development
Community cohesion
Publich health

This polemic opinion makes more sense once we consider the North-American reality experienced by the author. In this scenario, many rail transit options were designed improperly, without being accompanied by the necessary policies. This created a situation of contempt towards this type of transport, in a way, very similar to the process occurring in the Brazilian reality in the mid-60s.

Therefore, Litman sustains that rail transit - when segregated and of high quality - effectively reduces traffic congestion. And going further, he suggests that such improvements show themselves financially viable when considering all the economic impacts involved.

This feasibility becomes clear when we enumerate the three main ways by which these objectives are met: by reducing travel time to the user; by reducing the impedances in parallel ways; and by encouraging transit oriented development (TOD).

It is noteworthy that the author himself points out that this reduction in travel time is not always manifested directly and might be only a matter of user perception (through the comfort, cleanliness, safety, etc.). Therefore, one can infer that travel time reduction is not a relevant variable when studying new rail transit projects.

The impact that rail transit has on land use orientation is way more important, providing a number of accessibility and mobility benefits that would hardly be achieved through

conventional bus systems. Within this context, Litman (2007) highlights the many benefits directly related to the influence of public transport on land use, which can be seen in Table 2.

Although quality of life measurements are more complex, they are necessary in any viability assessment of new transportation alternatives. After all, sometimes welfare justifies an option being considered or not viable in the long term.

4.2. The Importance of Land Use

Kuby et al (2004) research examines the contributing factors to LRT systems demand. This was made using a multiple regression to assess the importance of different variables, involving a total of nine cities whose systems were researched and evaluated.

One problem raised by the authors is the difficulty of gauging how many passengers a LRT system can attract in low-density auto-oriented areas, especially in polycentric cities. Although initially these regions have been pointed by critics as improper to rail transit, data reality reveals that commuting is not as intense as one would expect, and there are many trips outside the CBD.

So, the conclusion was that the demand analysis should consider other variables beyond the number of jobs within the CBD and the population surrounding the stations. Encompassing not only land use factors, five categories of independent variables were surveyed in all stations without distinction, in a polycentric multimodal approach.

Breaking the paradigm of considering density as the only important spatial factor, it was found that some cities that are less dense and more populous had more demand than smaller compact cities, indicating the relevance of other variables such as the adoption of government policies, for example.

The methodology adopted was to select the walking distanc and then calculate a multiple regression for 17 independent variables, adjusting the coefficients in order to obtain the average weekly boarding as the dependent variable.

This list was reduced through a heteroscedasticity test. That approach eliminated “spacing between stations”, “metropolitan area population”, “college enrollment” and “CBD dummy”. The non-significance of the dummy variable shows that CBD no longer plays a privileged role within rail transit.

The significance found for the remaining 12 variables were similar at a certain level, with some highlight on “number of jobs in a walkable distance”, which showed a high significance. Another aspect that can be highlighted as relevant variable was indicative of extreme temperatures, often overlooked in similar studies.

Table IV: Fatores influenciando os embarques em VLT nos Estados Unidos (Kuby et al, 2004)

Summary of Independent Variables	
Traffic generation / land use	*Employment*
	Population
	Airports
	International borders
	College enrollment
	CBD Dummy Variable
Intermodal Access	*Park-and-ride*
	Bus Connections
	Other railways
Regional Coverage	*Days of inadequate temperature*
	Metropolitan Area Population
Network Structure	*Terminal station*
	Station Spacing
	Transfer Designed Station
	Normalized Accessibility
	Employments Percentage
Socio-economics	*Number of Rented Properties*

4.3. The Operational Approach

The work of Samanta and Jha (2011) aims to create an optimized model for locating a railway on a GIS base, considering a concentric demand. While considering large areas, it is a microscopic approach, whose case study was carried out considering the Washington DC area. The genetic algorithm was developed taking into account a function of three objectives, regarding:

- Minimize cost per passenger;

- Maximize demand or geographic coverage;

- Reduced user costs - considered planning most decisive factor.

To achieve these goals, in addition to the trips matrix and land use GIS, were used input variables. These variables were divided between those for the cost and demand estimation, and those to optimize the stations location. Thus, input data collection is as follows in Table 5.

The methodology adopted was to initially locate stations, and then connect them with public transportation lines. The criticism here is that improvements along the path are not considered, as well as the interference caused by the adoption of segregated solutions without considering the existing routes.

And finally, although the work focuses more in the tool than in the theory, the authors are aware that the simplifications may have left out relevant variables, like community receptiveness, environmental impact, political decisions, etc. Thus, the different alignments generated by the algorithm would just serve as an indicator, based on which the planner would make the final decision considering the existing conditions.

Table V: Input variables used in Samanta e Jha (2011) model

Variables
Transit vehicle speed
User Access Cost
User Trip Cost
User Waiting Cost
Operational Costs (per mile)
Operational Costs (per hour)
Fixed Operational Costs
Maximum and minimum Spacing
Maximum and minimum number of stations

5. CRITERIA CHOICE

The literature review presented in the preceding chapter corroborates the criteria to be observed in the evaluation of a rail public transportation project. However, there are several questions to be considered, whereas the researches are usually restricted to the American conditions. The context in other countries would probably be different, especially respecting to car possession.

The adjustment of these criteria was based on the IBGE's questionnaire for the 2010 census. These data are easily accessed and can be disaggregated in censitarium sectors, making it easy to perform spatial analysis. Besides, these kind of data allows to use the model in national scale on future applications.

The proposal here is about a decision supporting system (DSS) based on a tree of variables, materialized in 14 variables divided in 5 groups.

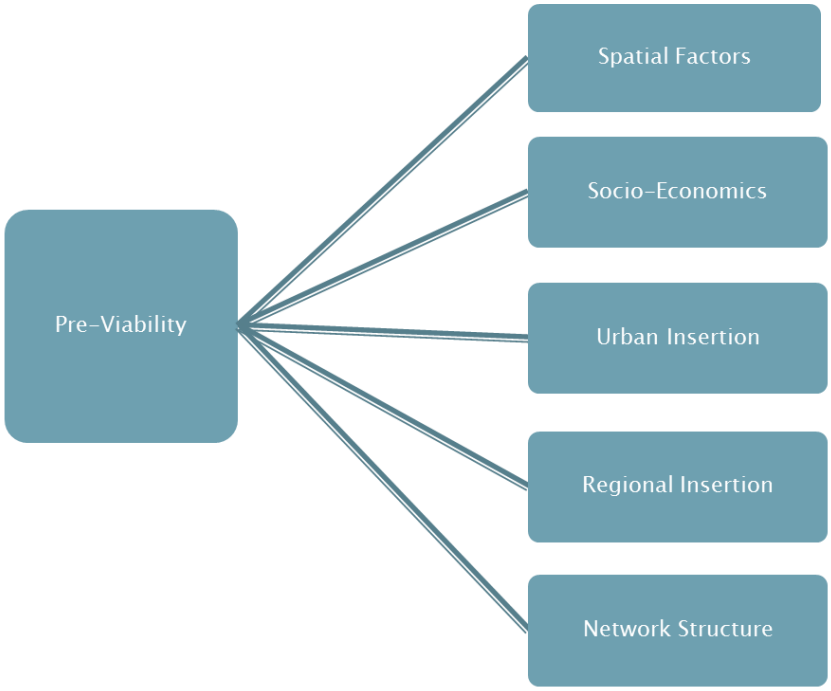

Figure VI: First level of the proposed decision tree

a) Spatial Factors: the population and the jobs inside the influence area;

b) Socioeconomic Factors: average income and schooling;

c) Urban Insertion: urban land use percentage in the section, average distance to the nearest urban center and roads measure in the influence area;

d) Regional Insertion: distance to the capital and municipal PIB per capita;

e) Net Structure: average travel time to work, integration with other rail systems, rail line idleness and car fleet of the city.

6. CONCLUSIONS AND FUTURE APPLICATIONS

The several criteria compiled along this work illustrate properly all the dimensions involved in the demand and the feasibility of a rail transit systems. This plurality results in a non-linearity, which deserves special attention during the calibration of the established decision tree.

As seen in the literature review, none of the criteria indicated by the authors considers the political factor, which is varied and heterogeneous. Even being difficult to measure, it is extremely important to give a greater weight to government politics, which were only superficially cited by Kuby et al. Thereby, variables that are not directly related to the demand increase can be essential to the political feasibility of an alternative.

Moreover, this group of political variables should be able to evidence government support to the project and its implications in the public policy plans. So, some variables that don't seem to be relevant in the Kuby el al (2004) model could be more significant for the implantation analysis of new projects. For example, the dimension of the studied metropolitan region.

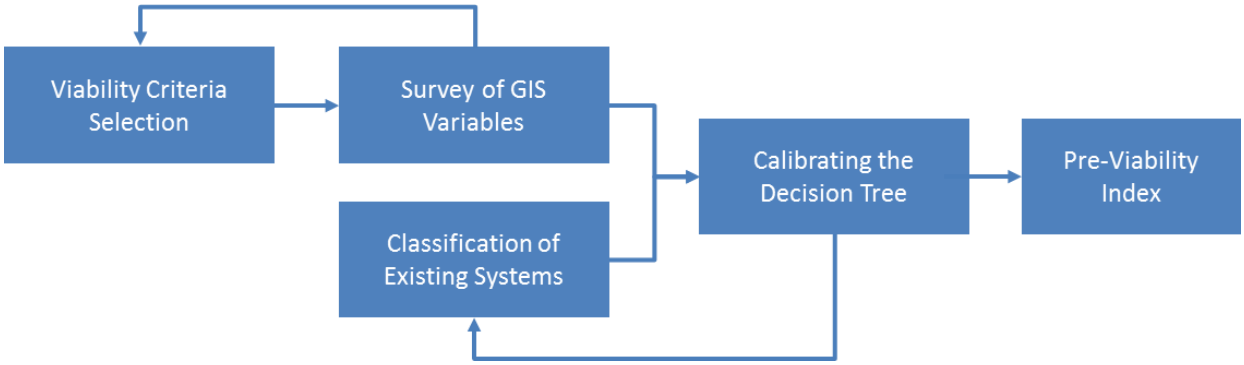

Figure VII: Proposed methodology to the development of further researches

These reflections constitute the main reason for using the above methodology in an iterative way, in which each calibration feeds back the system incoming data. So the indicatory of prefeasibility could be obtained more accurately.

Allied with the appropriate GIS tools, the development of this kind of models in future works could be a relevant guiding of public investments in mass transport, especially in Brazilian medium and small cities.

From this portfolio of possibilities, it becomes easier for planners to attest individually the potential of each section through analyzing more specific demands.

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