

Urban Mobility: Method of Analysis of the Adequacy of Public Policies in Cities Based on the Principles Proposed by the UN

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Abstract: Addressing urban mobility is a priority for government agencies due to increasing problems of travel and lack of accessibility, generated by increasing rates of population growth and motorization. The general objective of this study is to propose a method of analysis of the adequacy of policies, aimed at sustainable mobility and its impacts on urbanism. Methodologically, the analysis is based on the parameters proposed by the UN (United Nations), namely, sectorial planning, mobility funding, management efficiency of urban mobility systems; and mobility system and support for green technology. The object of study is the public policies expressed in urban mobility plans, master plans and regional development plans. Through the applicability of this method, the results show the possibility of verifying the adequacy of public policies as a mechanism that induces improvements in urban mobility with greater levels of sustainability and the possibility of universalized access to users.

Key words: Urban sustainability, universality of access, urbanism.

1. Introduction

The increasing number of urban displacements is due to the demographic growth of cities on a world scale [1]. These factors generate problems in urban mobility, due to the lack of planning and implementation of public policies of sustainability in environmental, social and economic aspects [2-4].

In search of sustainable urban mobility, public policies can positively increase the accessibility of the population. These improvements in urban mobility enhance the ease of travel and use of public or private transport modals [1, 5].

The need to provide accessible urban mobility is justified by the recognition and strengthening of the universal right of the population to urban mobility [6].

Regarding accessibility issues, they pass through urban design and necessarily through population

density levels of the urban sectors [7-9]. This occurs mainly in large centers and metropolitan regions [10].

These urban agglomerations generate narrowing linked to population density. Consequently, they result in different levels of urban dispersion that directly reflect and influence sustainability and transport demand [11].

In this context [11-13], preference for freedom and choices of the population to opt for the transport modal stand out. Thus, social exclusion related to lack of accessibility may interfere with users' freedom of choice in relation to urban mobility.

It should be remembered that public policies aimed at urban mobility should consider the development of cities, not just GDP growth. For public policies, besides guaranteeing access to goods which are important to human life, they should broaden the conditions for human development and social balance [13].

Therefore, development must be considered from three fundamental aspects: substantive freedom, capabilities, and constitutions of democratic

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environments [13, 14]. As a result, they enable [1] access to the public transport system as a governmental obligation.

When addressing factors and needs focused on urban mobility, they allow users to have substantive freedom, which is understood as the possibility of individuals to merge guided choices [15, 16]. Jointly, actions aimed at urban mobility can establish the use of alternative transport modals, according to the individual needs of users.

Simultaneously, the concept of capabilities consists of the set of conditions that the individual has in order to make decisions freely [14]. Therefore, the evaluation of mobility policies should investigate to what extent they allow the population, either individually or collectively, to understand the meanings and implications of different decisions.

Together with substantive freedom and capabilities [13, 14], democratic environment is considered a relevant aspect in promoting sustainability of development.

Therefore, the analysis of mobility policies should consider to what extent it is stimulated by the participation of the population, during the construction of urban mobility plans. Thus, construction and elaboration of studies with methodologies focused on suggestions of public mobility policies are needed.

These transformations which enable quality of urban mobility [17] derive from a complex and variable set of interactions of social, spatial, economic and political factors. In this scenario, public policies aimed at urban mobility play an important role in the structuring of cities [17], determining patterns of displacement and implementation of physical, regulatory and tariff measures [1, 18, 19].

Indisputably, public policies fulfill inductive roles in the development of urban mobility, in the expansion of individual freedom and capacities, in the constitution of democratic environments, thus contributing to sustainability [13, 14, 20].

This concern of the UN (United Nations) in relation

to the factors of local sustainability of urban mobility was expressed at the following conferences: Rio 92 which took place in Rio de Janeiro, Brazil; Rio +10 which was hosted in Johannesburg, South Africa; and Rio +20, which was held in 2012, also in Rio de Janeiro, Brazil. These conferences produced various documents and protocols which resulted in sustainable urban mobility [21, 22].

Thus, the development of cities broadens the capacities of individuals in the creation of public policies to be applied in the built environment, thus improving urban mobility [13]. Therefore, public policies are instruments that need to be effective in inducing projects and structuring urban spaces [14].

The general objective of this article is to propose a method of analysis of the adequacy of policies aimed at sustainable mobility and its impacts on urbanism. Specifically, the aim is to develop parameters and variables for comparative analysis that make it possible to understand the degree of sustainability of urban mobility. Based on this objective, this study will enable the discussion of data as to make suggestions for public policies of sustainable urban mobility.

2. Method and Materials

The variables of sustainable urban mobility suggested by the UN document [23] have a qualitative nature [24]. Subsequently, documentation survey was chosen in the data collection phase, inherent to the qualitative method [25].

The analysis of urban mobility is based on the following documents: urban mobility plans, master plans and territorial development plans [1], through the following variables:

- Sectorial planning;
- Mobility funding;
- Management efficiency of urban mobility systems;
- Mobility system and support for green technology;
- Implementation of mobility policies.

For the interpretation of documentation database, the CAM (content analysis method) [24] was used to perform systematic procedures to analyze the data obtained in this study.

These procedures consisted of compilation and analysis of the document *Urban Sustainability: impact of economic development and its consequences on the process of urbanization in emerging countries* [23]; identification of variables to analyze public policies that induce urban mobility; relation of variables [1] with the documents which orientate public mobility policies; and constitution of a method that allows comparative analysis of how public policies contribute to sustainable urban mobility.

3. Results and Discussions

Intersectoral planning for the design of public transport networks emphasizes the strong relation with urban planning, mainly the need to optimize the use and occupation of the soil by expanding it. As a result, it enables high capacity transport systems through the concentration of demand.

However, in relation to the financing of mobility, the need to seek alternative sources for the costing of public transport systems is emphasized, not only the amount paid by the end-user, who, in this case, can choose another transport modal that is financially more attractive. In this regard, the UN document [23] presents a series of alternative sources that involve other urban actors which were benefited by the improvements and efficiency of collective transport [2].

In this sense, there are other forms of financing of public transport infrastructure, such as taxation of car users, which is also considered as urban tolls. A successful example of this practice occurs in the city of Stockholm [26], which initially faced resistance from the population, but was subsequently considered positive by its users.

Sustainable mobility presupposes the integration of transport modals, which must also extend to active

movements and thus prioritize the connection of pedestrians and cyclists with public transport. Therefore, bicycles demand significantly less public space than motor vehicles [18].

Improving accessibility requires planning of routes with high levels of connectivity, and this includes the use of bicycles, walking and public transports tops. Such actions can help reduce the emission of pollutant gases as automotive vehicles are not used.

In relation to management and operation of public transport services, problems related to the operation of this service by private companies are highlighted, as it is usually the case in Brazil [23]. In this scenario, in addition to the market being largely operated by large companies, the demands of the population for the improvement of this service have their effectiveness reduced by the pressure of the private sector over the public sector.

However, the alternative of this operational system of public transport proposed by the UN [23] is a result of the observation of the European experience, especially up to the 1980s, where the transport system was managed and operated by public or mixed capital companies, thus narrowing the relationship between the user and the service provider. Currently, an example of similar management occurs in the city of Nantes, where public transport planning and operation are carried out by a public-private company [27].

Transport systems are a major consumer of the automotive and energy industries. Thus, the structure and operation of public transport have the potential to implement policies that promote the use of sustainable energy matrices [23].

Thus, the economic viability of this sector presents itself as a triggering factor for the implementation of sustainable practices. Consequently, incentives are required for the implementation of large-scale modals with technologies based on electricity (Subway, Tramway, Trolebus).

For this, through sustainable mobility, the reduction of pollutants emission and the incentive to use

alternative transport [23] are sought. However, implementations of such measures often face difficulties that can be political, social and economic.

In this regard, the creation of a favorable environment for medium- and long-term investments, with the insertion of regional planning, minimizing social and environmental impacts should be considered, as it should mitigate political barriers [23]. Another important aspect in the implementation of mobility strategies is the inclusion of metropolitan or regional scales as they have great influence on mobility patterns.

In this case, collaboration between public transport management and operation agencies at regional or metropolitan scales allows the integration of fleets, through schedules established collaboratively, thus increasing passenger attractiveness [18].

Table 1 summarizes the strategies and actions that can be established and implemented [23]. In the proposed method, these are the strategies that must be used from the official documents that regulate issues related to sustainable urban mobility.

The analysis variables (Table 1) are justified when considering that the urban mobility plans, in their different presentations, constitute the transcription of guidelines and principles for establishing strategies and actions [1, 23].

In relation to the analysis of sectorial planning (A1),

due to its multidisciplinary nature, the list of documents to be consulted extends from those referring to the ways of structuring urban projects, with the attribution of constructive indices, zoning and code of works, as well as those related to the sanitation infrastructure. It is known that the integration of the design of public transport networks is one of the main objects of this analysis and, in this regard, it is of fundamental importance to consider the connections between districts in the design of public transport networks, to the detriment of the almost exclusive downtown-neighborhood network.

In addition, it is important to observe the extent to which the plan for structuring new streets or renewing old ones prioritizes transport modals for collective and non-motorized use, as they provide greater easiness for their traffic to the detriment of motorized personal transport modals.

Another aspect to be observed in the variable of the sectorial plan is the induction of densification along transport corridors by means of the attribution of higher constructive indices, which allow the concentration of the population and, consequently, the demand along these axes. As an effective example of the implementation of this strategy, the Strategic Master Plan of the city of São Paulo, prepared in 2014 and awarded in 2017 by the UN-Habitat-sponsored Public Announcement of Innovative Practices of the

Table 1 Summary of the aspects to be analysed.

Variables	Implementation strategies
Sectorial planning (A1)	<ul style="list-style-type: none"> • Prioritization of active mobility and collective transport at the expense of car use; • Design of collective transport networks; • Planning of micro-accessibilities, facilitating access to collective transport networks by means of walking or cycling, thus improving the attractiveness of transport networks; • Space accessibility promoted by the integration of transport systems.
Mobility funding (A2)	The costing of public transport systems should not be restricted to the fare paid by the user, but include the ones who are benefited by the improvements of the system. Alternative sources of financing can be obtained by the implementation of value capture; subsidies arising from taxation of fuels used in individual motorized transport, urban toll.
Management efficiency of urban mobility systems (A3)	The institutional diversity of the management and operation of transport systems should provide greater proximity between users and service providers. In addition, attention should be paid to promoting actions that allow greater social control and transparency.
Mobility system and support for green technology (A4)	The transport sector has the potential to induce sources of energy to be consumed, promoting the use of sustainable energy matrices. In this regard, consideration should be given to actions aimed at promoting the use of modals (collective or individual), based on electricity and biofuels.
Implementation of mobility policies (A5)	Alignment between different urban scales, such as major cities and regions.

New Urban Agenda [28] can be cited.

The importance of this variable (A1) is evidenced by demonstrating the integration between the aspects directly related to urban mobility with the infrastructure and the structuring of cities.

A second variable to be analyzed is transport financing (A2). For this variable, the central documents are the urban mobility plans and municipal norms that regulate collective transport.

An analysis parameter is the tariff financing model. The most recurring is the financing exclusively for the tariff paid by the users. However, this is the worst mechanism for the sustainability of collective transport.

A more favorable scenario includes strategies with the contribution of agents, indirectly benefited by the improvements in collective transport systems, such as taxation on the productive sector, which happens in countries like Brazil (subsidized passage) and France (versement transport). This system makes it possible to reduce the cost of transport for workers when they commute from home to work, thus encouraging their use and contributing to the viability of collective transport.

However, because it is a policy that depends largely on federal legislation, its consideration in the proposed method is best justified in comparative studies between cities located in different countries [1].

In the same vein, it is also important to verify the existence of other strategies to include indirect beneficiaries in transport financing, such as land value capture, which consist of a series of mechanisms to assess the increase in the value of properties related to the proximity to the implementation or with improvements in the transport infrastructure [29], as implemented in London, as well as the recent taxation of parking and car access in the historic center and the Retiro neighborhood in Buenos Aires [30].

The aspects related to variable (A2) are of utmost importance both to combine the financial sustainability of the collective transport system and to be attractive to

the user.

The third variable of analysis is denominated management efficiency of urban mobility systems (A3) and refers to the operation and the management of the transport systems. In this regard, it is important to observe how companies operating transport systems (public, private or mixed capital) provide direct channels of communication and participation of society in order to facilitate the fulfillment of the demands and improvements in the service. In addition, in consolidated urban agglomerations and possibly having an institutional diversity of operators of this service, attention should be paid to the existence of both tariff and physical integration of transport systems, which is of great importance to enable the displacement of citizens that daily perform the pendular movement. This variable (A3) demonstrates its importance mainly when revealing the capacity to participate in the society regarding decisions related to public transport.

With regard to the mobility system and support for green technology (A4), in addition to the urban mobility plans, attention should be paid to bidding processes and/or, in the case of public companies operating the service, attention should be paid to regulation of vehicles to be used. Inductions in the use of vehicles with energy matrices other than the one based on fossil fuels are in line with the guidelines proposed by the UN. Among these energetic matrices, the use of collective transport based on electric energy, widely used in tramways, urban trains and BRTs (bus rapid transports), constitute environmentally sustainable alternatives.

Therefore, variable A4 has its relevance by analyzing how the plans under study seek to reduce environmental impacts as a result of urban mobility.

In relation to the implementation of mobility policies (A5), the importance of setting objectives to be achieved in short, medium and long term, as well as of the financial means necessary to implement the proposals related to urban mobility as set out in the documents as a whole (mobility plans, master plans

and territorial development plans) is highlighted. In addition, the relationship between strategies and actions thought on both locally and macro scale, such as metropolitan and urban agglomerations, must be verified.

Another important aspect to consider in variable (A5) is the existence of mechanisms for monitoring and evaluating the established objectives in the mobility plans, master plans and territorial development plans. These are the mechanisms that will allow the verification of effectiveness of the plans and their adequacy according to the urban dynamics [23], demonstrating the importance of the analyses related to the variable in question.

Once the stages of analysis of the qualitative variables have been described, quantitative elements that can contribute to the analysis of public policies as a driving force to promote sustainable mobility will then be dealt with.

In order to continue the diagnosis of effectiveness of the public policies implemented in the investigated cities, the present method proposes to investigate the survey of evolution of factors (Table 2) having a direct relationship with urban mobility in the past 10 years, through a study longitudinal retrospective study.

The variables listed for this analysis are the population growth, the number of passengers (users) of public transport, the evolution of per capita income and the number of motor vehicles. The choice of these factors is justified because they jointly represent an indicator of efficiency of public policies aimed at urban mobility employed during the studied period.

After obtaining the data, the stage of standardization of the values which establishes a proportionality of presentation of the temporal variation is followed. This stage allows the diagnosis of correlations when a single city is assessed, and comparatively analyzes the evolution of these aspects in two or more cities. An example of the application of this method is found in the undertaken study [1]. After the tabulation of the data obtained in the analyzed period (10 years), index "1" was assigned to the value corresponding to the first year of the analysis, set as a parameter to observe the evolution quantitatively positive or negative of these factors over time.

Considering this study carried out [1] as an example of the application of the method previously described, the inclusion of two variables in the longitudinal analysis, the evolution of the tariff cost and the IUD (index of urban dispersion) [7] are suggested.

The inclusion of the diagnosis of tariff evolution for users of public transport together with income evolution aids to diagnose improvements in the economic attractiveness of collective transport to users. Another possibility of this variable (B6), through tariff and income evolution, is to identify problems such as the significantly higher tariff increase in relation to the average income of the population, as occurred in Brazil in the period of 2000-2012 [31].

When this occurs, the use of this transport modal becomes less attractive due to its high cost and consequent decrease in the number of passengers. Thus, it creates a vicious cycle, reduces the number of users and increases the tariffs as a result of the higher tariff of

Table 2 Summary of the aspects to be analysed.

Variables	Application in the method
Population growth (B1)	Survey of the number of inhabitants referring to each year in the period.
Number of cars (B2)	Survey of the fleet of vehicles referring to each year of the period.
Income evolution (B3)	Survey of the per capita income to each year of the period.
Index of urban dispersion (B4)	Calculation of the IUD referring to the first and last year of the period.
Modal choice (B5)	Survey of the participation of transport modals in the totality of displacements, referring to the first and last year of the period.
Tariff cost (B6)	Survey of the cost of the public transport tariff regarding each year in the period.

the transport system. In summary, this scenario demonstrates the need to search for alternative sources of funding, such as those presented in Table 1.

Variable (B4) is presented instead of population density maps [1]. The dispersion index seeks to locate the population distribution and the distance between its residences in relation to the SCSC (shopping centers and service centers of the cities). Therefore, it is suggested to apply this it by following the IUD methodology [7], and using it in the first and tenth years of the analyzed period. The main result of the IUD is the understanding of the distribution of the population within the urban perimeter, which directly impacts the mobility system.

Fig. 1 shows the relationship between the quantitative and qualitative variables used in this method.

Considering that the growth of the population and their average income can significantly increase the number of cars and, consequently, the modal choice to be used. On the other hand, the tariff cost is also

directly related to the modal choice, thus justifying its inclusion in the method.

The urban dispersion index, by analyzing the distribution of the population in the territory, indirectly influences the modal choice, since smaller dispersion indices usually carry a variety of urban land uses, reducing the distance of the displacements. In addition, it is directly related to the efficiency of collective transport systems, which depends on the concentration of demand.

In the variables referring to public policies, the sectorial planning and management efficiency of urban mobility systems interfere mainly in the efficiency of the transport systems, both in terms of service of the territory as well as in management. The three other variables (mobility funding, mobility system and support for green technology, implementation of mobility policies) are directly related to the sustainability of urban mobility, encompassing social, environmental and economic aspects.

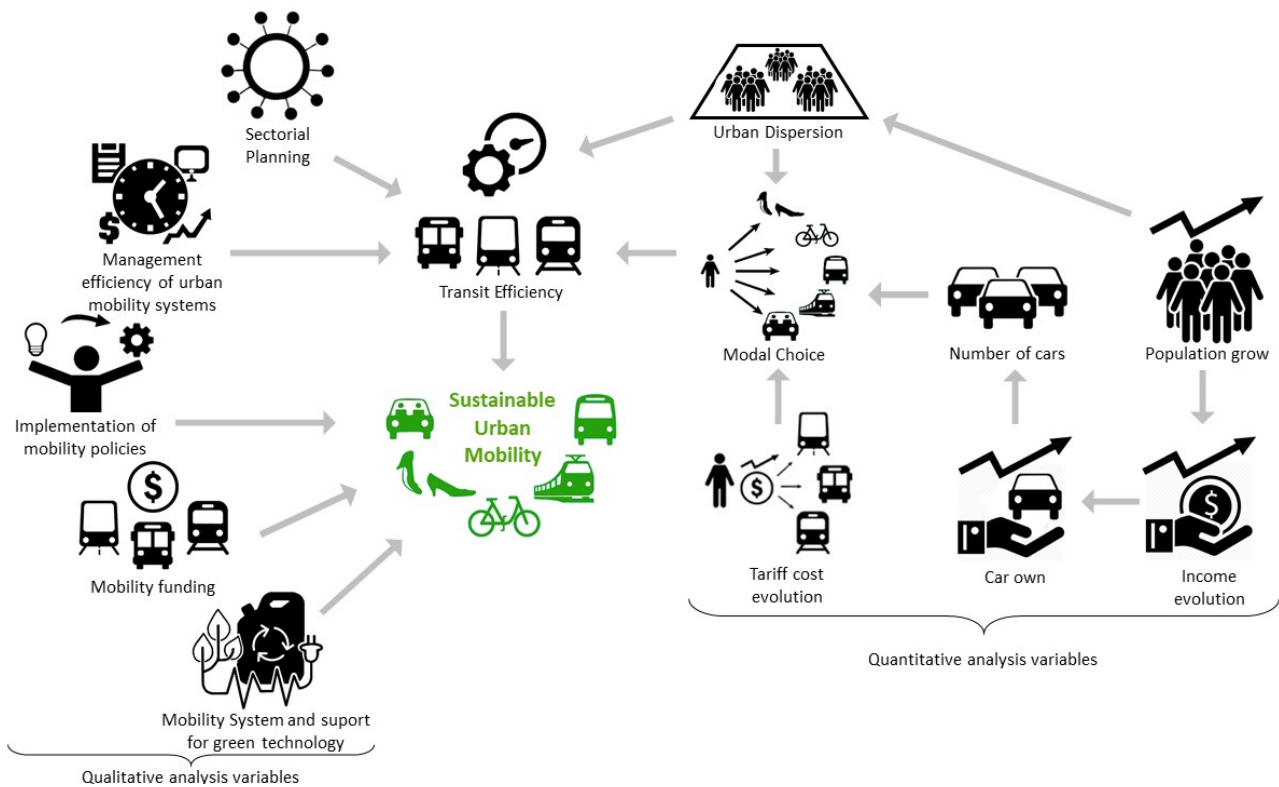


Fig. 1 Flow chart showing the relationship between the analyzed variables.

Source: Adapted from Ref. [1].

4. Conclusions

Public policies are one of the drivers of a development model, not just due to economic growth rates. Therefore, sustainability, capacity to build capabilities, expand the condition of active subjects and the promotion of democratic environments simultaneously become variables and justifications to evaluate planning and effectiveness of sectoral public policies.

The analysis of the qualitative and quantitative variables proposed in this method allows monitoring, evaluating and re-adjusting public policies related to urban mobility so that they can focus on sustainability [23].

In the same context, considering that several of the strategies have direct relationship with the structuring of the cities, the application of this method contributes to conceptions related to urbanism of the studied cities.

The official documents that establish sustainability guidelines (UN) and define principles, guidelines and strategies of local mobility (mobility plans, master plans and territorial development plans) are used as a basis for consultation.

Finally, since these variables are defined by the UN and plans exist in the vast majority of urban centers, the replicability of this method both for analyzing individual cities and for comparative analysis stands out.

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