



urbe. Revista Brasileira de Gestão Urbana

ISSN: 2175-3369

Pontifícia Universidade Católica do Paraná

Fontoura, Wlisses Bonelá; Ribeiro, Glaydston Mattos
System Dynamics for Sustainable Transportation Policies: A Systematic Literature Review
urbe. Revista Brasileira de Gestão Urbana, vol. 13, e20200259, 2021
Pontifícia Universidade Católica do Paraná

DOI: <https://doi.org/10.1590/2175-3369.013.e20200259>

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System Dynamics for Sustainable Transportation Policies: A Systematic Literature Review

Dinâmica de Sistemas aplicada a políticas de transporte sustentável: uma revisão sistemática

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How to cite: Fontoura, W. B., & Ribeiro, G. M. (2021). System Dynamics for Sustainable Transportation Policies: A Systematic Literature Review. *urbe. Revista Brasileira de Gestão Urbana*, v. 13, e20200259. <https://doi.org/10.1590/2175-3369.013.e20200259>

Abstract

Systems Dynamics (SD) is an efficient method that allows to analyze systems with dynamic complexity and policy resistance. The holistic approach of SD is suitable to analyze the current transportation problems. Among the applications of SD in the transportation sector, the use of this tool in the development and implementation of sustainable transport policies stands out. In this context, this paper aims to conduct a systematic literature review to assess the use of SD in the development and implementation of urban policies focused on sustainable transportation. The results show that most studies analyze policies focused on reducing the negative externalities of transportation, highlighting the efforts to reduce air pollutant emissions and traffic congestion. However, we did not find a study that analyzes non-motorized and motorized modes by economic, environmental, social, spatial and traffic variables. At the end of this study, the gaps found in the literature are pointed out, being available to further exploration in future studies.

Keywords: Sustainable transportation. Urban mobility. Urban policies. System dynamics. Systematic literature review.

Resumo

A Dinâmica de Sistemas (DS) é um método eficiente que permite analisar os sistemas com complexidade dinâmica e resistência política. A abordagem holística da DS é adequada para os atuais problemas de transporte. Entre as diversas aplicações da SD no setor de transporte, destaca-se o uso dessa ferramenta no desenvolvimento e implementação de políticas de transporte sustentável. Nesse contexto, este artigo tem o objetivo realizar uma revisão sistemática para avaliar o uso da DS no desenvolvimento e na implementação de políticas urbanas focadas no transporte sustentável. Os resultados mostram que grande parte dos estudos analisa políticas focadas na redução das externalidades negativas do transporte, destacando os

esforços para reduzir a emissão de poluentes e o congestionamento. Entretanto, não encontramos na literatura um estudo que analise os modos não motorizados e motorizados por meio das variáveis econômicas, ambientais, sociais, de uso do solo e de tráfego. Ao final deste estudo, são apontadas as lacunas encontradas na literatura que podem ser exploradas em estudos futuros.

Palavras-chave: Transporte sustentável. Mobilidade urbana. Políticas urbanas. Dinâmica de Sistemas. Revisão sistemática.

Introduction

Intensive urban growth can lead to environmental, economic, social and traffic issues (Khakee, 2014; Hassan and Lee, 2015). Among the sectors impacted by the rapid unstructured urbanization, transportation is one of the highlights (Lin and Du, 2015). The new travel pattern exacerbates the negative externalities in urban areas, resulting in frequent traffic congestion, air pollution, increase in the number of accidents, health problems, noise, among other problems (Bubel and Szymczyk, 2016; Valdes et al., 2016).

In this context, it is noted that the rapid urbanization and motorization are threats to sustainable development (Pérez & Carillo, 2014). Therefore, measures must be taken to ensure urbanization in a sustainable way. For this, urban planners must identify the causes of the negative externalities in order to develop sustainable transportation policies (Li et al., 2012). These policies must incorporate economic viability, environmental stability and social equity through the management of travel demand and efficient land use (Machado and Piccini, 2018; Litman, 2019).

Due to its complexity, the transportation systems should not be analyzed by linear approaches (Wang *et al.*, 2008). Thus, System Dynamics (SD) is an alternative for analyzing these problems, as this approach helps to understand complex systems (Sterman, 2001). Used for design policies, SD is an efficient method to achieve a good interpretation of the systems in situations of dynamic complexity and policy resistance (Sterman, 2000).

SD is an interdisciplinary approach that has been widely applied to several management issues (Leopold, 2016). In the transportation sector, the applicability of this method has been evaluated by several authors. In one of the first studies about the subject, Abbas and Bell (1994) compared SD with the traditional transport modelling and simulation approaches, pointing out that SD is a useful tool to support policy analysis and decision-making in transport systems.

Regarding the urban transportation systems, the holistic approach of SD is suitable to analyze the current problems (Shepherd, 2014). Therefore, this tool is useful for urban transportation planning, helping city managers to design and to implement urban policies focused on sustainable transportation (Khanna *et al.*, 1985; Batur and Koç, 2017).

Based on this discussion, the following research problem is identified: how to seek and identify information about the use of SD in the development and implementation of urban policies focused on sustainable transportation? Thus, the objective of this paper is to carry out a Systematic Literature Review (SLR) to verify the current situation of scientific research on the application of SD in the analysis of sustainable transportation policies.

In addition to this introductory section, this paper is organized as it follows: section 2 presents the methodology used in this study; section 3 shows the results of SLR and a critical analysis. Finally, the authors' main conclusions and recommendations for future research are presented in Section 4.

Scientific Contributions

Previous research has demonstrated the efficiency of SD in analyzing the implementation of urban policies. The present work was developed to identify the variety of sustainable transportation policies

analyzed by the SD, as well as the motivation for carrying out those studies. This research presents bibliometric indicators about the papers published on the theme. The results demonstrate the behavior and trends in the literature. Therefore, this study aims to present the gaps in the literature, contributing to the development of new studies and, consequently, increasing the variety of models on the subject.

Methodology

A Systematic Literature Review (SLR) is essential to verify the state of a particular research field (Manivannan and Sanjeevi, 2012). The SLR not only allows to integrate quantitative data between studies, but it also summarizes the findings of a given field (Michie and Williams, 2003). Therefore, this method is not just a review of existing writings because it assesses existing contributions and identifies gaps in the literature that can be explored in future studies (Thomé et al., 2016).

There are several approaches in the literature to perform the SLR. Kitchenham et al. (2009) and Thomé et al. (2016) perform the SLR through eight-step procedures. In a similar way, Connolly et al. (2012) applied a procedure composed of ten steps. Regardless of the number of steps, the SLR is composed of three phases: planning the review; conducting a review; and the report and dissemination of results (Tranfield et al., 2003).

The reasons for doing the SLR are identified in the planning phase. In addition, the objective and the steps of the research are defined at this stage (Oliveira et al., 2017). According to Brereton et al. (2007), the papers related to the theme are identified and evaluated in the second phase (conducting review). In addition, data collection and synthesis are carried out at this stage. Finally, the report, presenting the results obtained in the research, is developed in the third phase (Thomé et al., 2016).

In order to achieve the objective of this paper, we adopted the procedure for systematic literature review proposed by Brereton et al. (2007), as illustrated in Fig. 1. The results obtained in the SLR are presented in the next section.

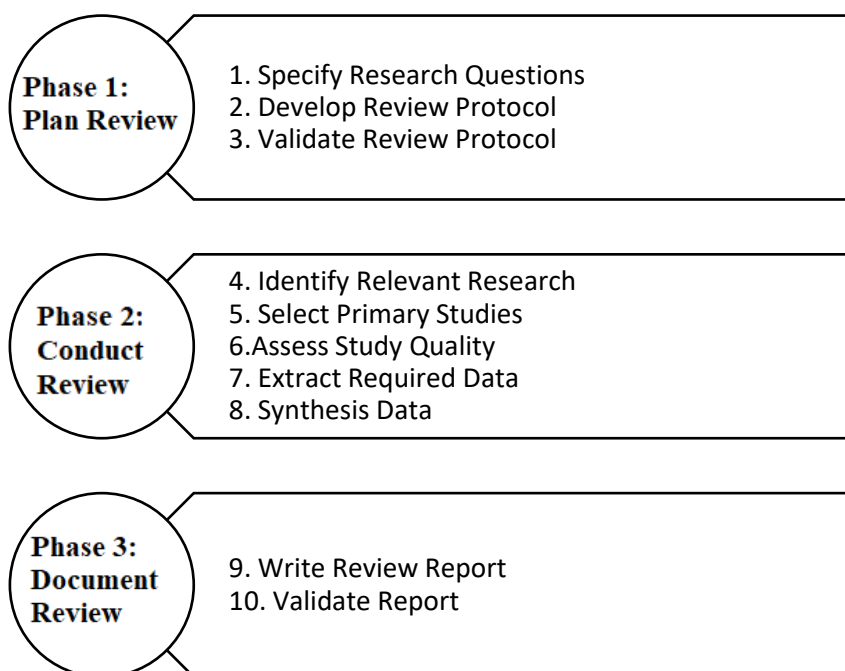


Figure 1 - Systematic literature process. Source: Brereton et al. (2007).

Systematic Literature Review

In addition to determining the research objective, we established in Phase 1 the set of terms to be used in the search for papers. For this, we conducted an analysis of the keywords of five papers on the topic. Thus, to identify studies that assessed, through SD, the impact of urban policies focused in sustainable transportation, we chose the following combination of keywords: (urban policy AND sustainable transportation AND system dynamics) OR (urban policy AND urban mobility AND system dynamics). The logical operators “or” and “and” were applied to facilitate the combination of keywords and the selection of papers. Finally, the search engines used the words in the title, abstract and keywords to find papers.

In the review plan, the delimitation of the search was also determined. We opted to restrict the search to papers published in international journals indexed and peer-reviewed in order to ensure the quality of the studies, as recommended by Shepherd (2014). Seeking to identify the maximum number of SD applications in the analysis of sustainable transportation policies, we did not set any restrictions about the year of publication. In addition, due to the importance of sustainable transportation for the development of any country, we did not adopt a specific geographical delimitation.

Bramer et al. (2017) recommend to use multiple databases in order to obtain relevant references and, consequently, good results in an SLR. In this study, we searched for papers in five bases: Web of Science, Compendex, Scopus, Directory of Open Access Journals (DOAJ) and EBSCO. As a result, 347 papers were identified.

After searching for papers in each database, we:

- I. Eliminate duplicated papers;
- II. Read the title and the abstract of each paper to select those aligned with the research theme; and
- III. Include the selected papers in the bibliographic portfolio.

In order to select the papers, first, we checked if the study analyzed an urban policy using SD. Then, we analyzed the policy presented in the study. Thus, we selected the studies that presented the analysis of an existing urban policy focused on sustainable transportation or an analysis of alternative policies or measures to be implemented in urban transportation systems. These policies took into account, in some way, at least one of the following aspects: social, environmental, economic, traffic and land use factors.

To include papers in the bibliographic portfolio, from the second database on, it was verified if the selected papers had not already been included in the bibliographic portfolio as a result of the search in a previous database. If so, the paper was not included. Therefore, 23 studies were included for the development of the SLR, as can be seen in Table 1.

Table 1 - Identification, selection and inclusion of papers

Database	Identified	Duplicates	Selected	Included
Web of Science	100	1	15	15
Compendex	99	1	15	6
Scopus	144	0	18	2
DOAJ	1	0	0	0
EBSCO	3	0	3	0
Total	347	2	51	23

Source: Authors (2020).

Besides the search and selection of papers, Phase 2 performers a synthesis data. This synthesis and the analysis of the research results (Phase 3) are presented below.

Synthesis data

To perform the synthesis data, we use Microsoft Excel in this study. We also used VOSviewer for constructing and viewing bibliometric maps. This bibliometric software allows users to visualize patterns and trends in the literature by building maps based on data in the papers (Eck et al., 2010).

Among the included papers in the bibliographic portfolio, the first paper that used SD as a tool for analyzing sustainable transportation policies was published in 2008. As can be seen in Fig. 2, the number of publications on this topic began to grow in 2014. It is worth mentioning that the search for papers was carried out in the last week of January 2020, so our base line is 2019. Thus, it is observed that in the first month of 2020 alone, it was published almost the same number of studies published in 2019. This information shows that SD is being used increasingly to evaluate and define sustainable transportation policies.

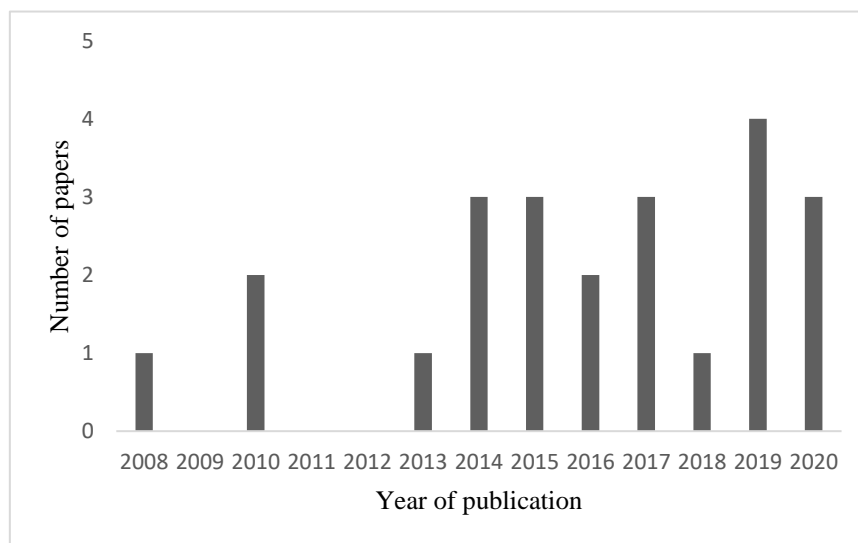


Figure 2 - Distribution of papers based on the year of publication. Source: Authors (2020).

The study developed by Wang et al. (2008) is one of the most relevant papers in the bibliographic portfolio, with 173 citations. This value may be associated with the fact that it was the first published paper. The study developed by Haghshenas et al. (2015) is also one of the prominent papers. Even though it was published in 2015, the paper has 90 citations, i.e., an average of 22.50 citations per year. After analyzing the total number of citations and the average number of citations per year, we selected the five most outstanding papers, which are shown in Table 2.

Table 2 - Included papers with the highest number of citations

Authors	Title	Year	Total number of citations	Number of citations per year
Wang <i>et al.</i>	System Dynamics Model of Urban Transportation System and Its Application	2008	173	15.73
Armah <i>et al.</i>	A systems dynamics approach to explore traffic congestion and air pollution link in the city of Accra, Ghana	2010	100	11.11
Haghshenas <i>et al.</i>	Evaluation of sustainable policy in urban transportation using system dynamics and world cities data: A case study in Isfahan	2015	90	22.50
Cheng <i>et al.</i>	Urban transportation energy and carbon dioxide emission reduction strategies	2015	66	16.50
Ercan <i>et al.</i>	Investigating carbon footprint reduction potential of public transportation in United States: A system dynamics approach	2016	53	17.67

Source: Authors (2020).

The papers included in the bibliographic portfolio are distributed in 19 scientific journals. Among them, *Sustainability* stands out with the highest concentration of papers (three publications). As can be seen in Table 3, the *Journal of Cleaner Production* and the *Journal of Simulation* also stand out with two papers each. The other journals have only one publication about the subject. In the references of the included papers, it is observed that the cited papers are from 596 journals. In this list, *Transport Policy* and *Energy Policy* stand out with more than 30 cited papers.

Table 3 - Journals with the highest number of publications

Journal	# Papers	JCR
<i>Sustainability</i>	3	4.624
<i>Journal of Cleaner Production</i>	2	6.395
<i>Journal of Simulation</i>	2	1.533

Source: Authors (2020).

The papers included in the bibliographic portfolio have 64 authors. Regarding the nationality of these authors, China is the country with the largest number of publications, followed by Brazil and the United States, as shown in Fig. 3.

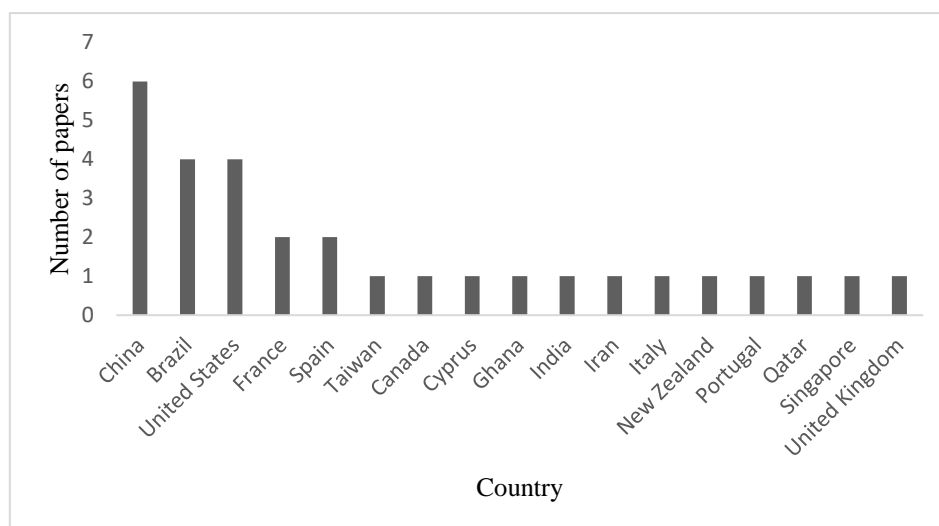


Figure 3 - Geographical distribution of included papers. Source: Authors (2020).

Finally, we analyzed the keywords used in the included papers. There were identified 70 keywords in the bibliographic portfolio. Fig. 4 presents the keywords network in which each node represents a keyword. The size of each node reflects the number of keyword occurrences in the portfolio. In addition, Fig. 4 presents how the keywords are connected, i.e., it lists the keywords that are used together. As can be seen, the most used keywords are system dynamics, sustainable transportation and CO₂ emissions.

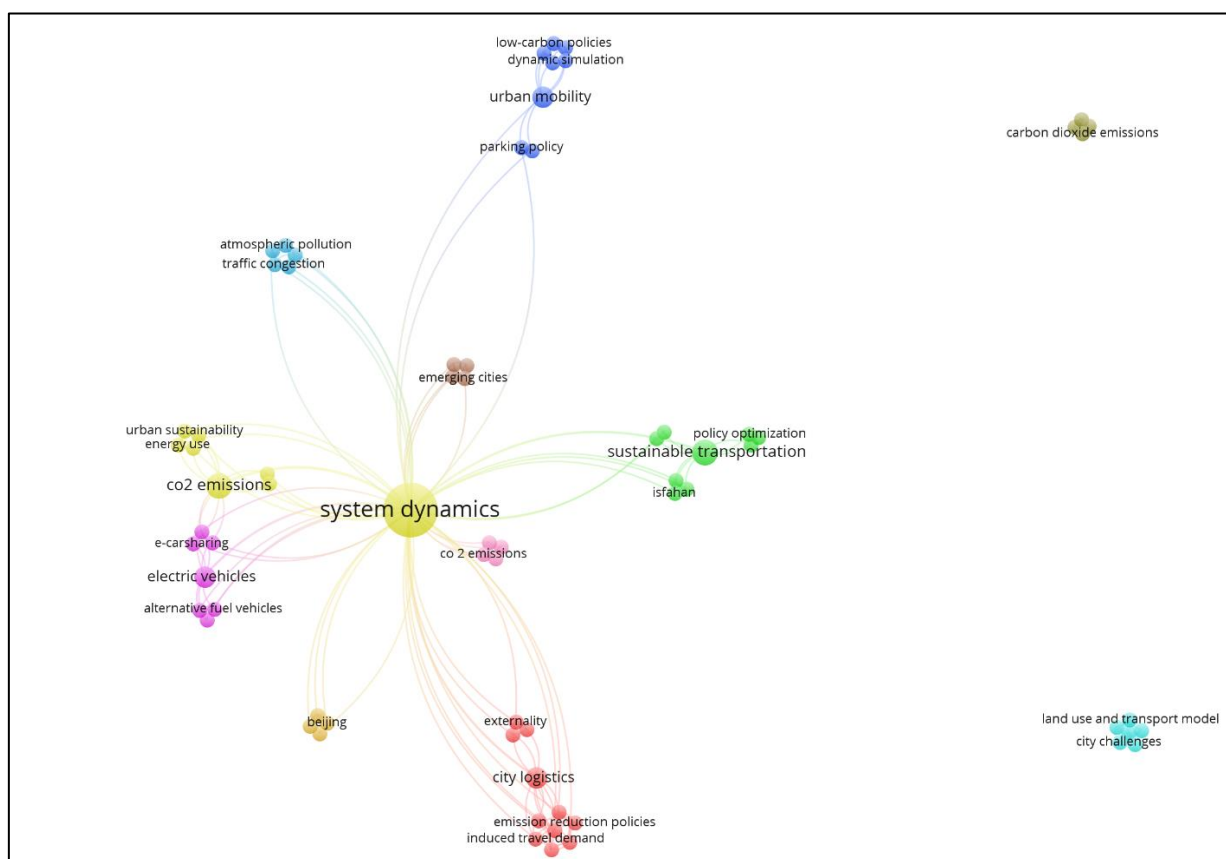


Figure 4 - Keywords network. Source: Authors (2020).

It is worth mentioning that VOSviewer groups the keywords according to the way they are typed. Therefore, if a term is typed in different ways, it will be shown more than once in the keywords network. For example, “CO₂” and “carbon dioxide emissions” are the same term, but they are shown separately in the Figure 4. However, we counted them as one keyword.

Another interesting factor in the keywords network is that the terms "land use and transport model" and "city challenges" are isolated. This is because these terms were presented as keywords only in one study focused in land use. Since they are not used together with other keywords, they have no connections in the keywords network.

Table 4 presents the synthesis of SLR with all the sustainable transportation policies that were analyzed through the SD and the main results. In addition, Table 3 also present the modes of transport (non-motorized and motorized), the sub-models (Economy, Environmental, Land Use, Social and Traffic Congestion) and the simulation time of each model. Thus, the analysis of the SLR results is presented in the next section.

Table 4 - Synthesis of SLR

Authors	Policies	Mode of Transport*	Sub-models**	Simulation Time	Main Results
Wang et al. (2008)	Vehicle development	M	ECO, ENV, and TC	50 years	The authors suggest restrain the use and the ownership of private vehicles.
Armah et al. (2010)	Government policy and planning; Travel demand management; and Supply management	M	ECO, ENV, SOC, and TC	Not performed	Proposed measures: development of a public transport system, road network expanding and enhancing, and travel demand management alternatives.

(to be continued)

Table 4 - Synthesis of SLR

Authors	Policies	Mode of Transport*	Sub-models**	Simulation Time	Main Results
Liu et al. (2010)	Clean transportation; Bus priority; Subway priority; and Car trip restriction	NM and M	ECO, ENV, and LU	15 years	Pollutants, energy consumption and land demand for roads will exceed the capacity of Beijing in 2020, if nothing changes. The four policies have positive results, but the integration of the four measures shows better results.
Bernardino and Van der Hoofd (2013)	Parking policy	M	ECO, LU, and TC	Unavailable data	The parking policy regulates the scarcity of parking and the traffic congestion. Thus, the system performs better, increasing the average speed in the network by up to 35%.
Bisen et al. (2014)	Provision of pedestrian lane; User defined vehicle occupancy; Impact of telecommunication application; and Change in land use characteristics	NM and M	ECO, ENV, LU, and TC	20 years	Reduction of pollutant emissions and traffic congestion and increase of the average speed in the network.
Guzman et al. (2014)	Road charge pricing policy	M	ECO, ENV, LU, and TC	30 years	Change in the modal split in radial trips. Speed increases and, consequently, the number of accidents also increases. Car travel has changed its destination pattern. Fuel consumption and pollutant emissions decreases.
Li et al. (2014)	Land use management	M	ECO, ENV, LU, and SOC	5 years	The model has a good accuracy and can be used as the macro-scale model for estimating the aggregated urban land use demand.
Cheng et al. (2015)	Fuel tax; Motorcycle parking management; and Free bus service	M	ECO, ENV, SOC, and TC	30 years	Fuel tax and motorcycle parking management policies are more efficient to restrict the growth of the number of cars, the fuel consumption, and CO ₂ emissions. However, fuel tax policy seems to be the most effective cost.
Haghshenas et al. (2015)	Increase in private infrastructure; Control of urban sprawl; Replacement of vehicles; Car sharing and carpooling; Travel demand management; Providing more mixed land use; and a set of policies to improve public and non-motorized transport	NM and M	ECO, ENV, LU, and SOC	13 years	Policy makers should prioritize the development of policies related to public and non-motorized transport infrastructure. In addition, they must prioritize the integration of modes with effective prices and control the use of cars.
Wen et al. (2015)	Low-carbon policies	M	ECO and ENV	13 years	Increasing the utilization of Liquefied Natural Gas vehicle (LNG) considerably reduces pollutant emissions. Vehicle quantity control helps improve the sustainability of the transportation system.

(to be continued)

Table 4 - Synthesis of SLR

Authors	Policies	Mode of Transport*	Sub-models**	Simulation Time	Main Results
Ercan et al. (2016)	Public transportation policies; Alternative fuel options (public and private transport)	M	ECO, ENV, and TC	60 years	The public policies must be supported by measures that are more aggressive. The prioritization of public transport and the improvements in the energy consumption of cars has the potential to reduce or even partially eliminate the current growth in CO ₂ emissions.
Macmillan et al. (2016)	Pro-cycling policies	NM and M	SOC	20 years	The model helps identify effective policy levers to achieve sustained growth in cycling.
Alonso et al. (2017)	Cordon toll accompanied by public transport improvements; Teleworking; and Re-densification	M	ECO, ENV, LU, SOC, and TC	19 years	The three policies increase the efficiency of the system. However, teleworking is the most effective measure. Analyzing only energy consumption and pollution, re-densification showed better results.
Menezes et al. (2017)	Low-carbon policies	M	ENV	30 years	Policies that promote the use of biofuels have the greatest potential to reduce pollutant emissions. The prioritization of public transport also stands out in reducing emissions.
Procter et al. (2017)	Implementation of the Light Rail Transit (LRT)	M	ECO, ENV, LU, and TC	40 years	The implementation of the LRT will reduce emissions. Government targets on energy consumption will not be met without implementation.
Shen et al. (2018)	Strengthening urban road construction; Strengthening the public transport system; Limiting private cars	M	ECO and TC	10 years	The three policies are effective, but the authors emphasize the importance of implementing them simultaneously.
Batur et al. (2019)	Supply management measures; Travel demand management (TDM) policies	M	ECO, ENV, and LU	10 years	Travel demand management based scenarios outperform supply management measures based scenarios.
Fontoura et al. (2019a)	Brazilian Urban Mobility Policy (BUMP)	M	ECO, ENV, and TC	30 years	The BUMP implementation improves the share of public transit and reduces the pollutant emissions and traffic congestion. Besides that, the results show the importance of rideshare.
Fontoura et al. (2019b)	Brazilian Urban Mobility Policy (BUMP)	NM and M	ECO, ENV, and TC	32 years	The BUMP implementation reduces the negative externalities and, consequently, increases the efficiency of the urban transport system.
Papageorgiou and Demetriou (2019)	Public awareness of the sustainable habits	NM	SOC	10 years	Social learning and motivation to change behaviors are effective in promoting sustainable active mobility. The introduction of Information and Communication Technology accelerates the shaping and diffusion of a walking mindset.
Hu et al. (2020)	Urban passenger rail transit network (URFT) development	M	EC, ENV, and TC	28 years	URFT schemes with higher funding and capacity reduces traffic congestion, pollutant emissions and the number of accidents.

(to be continued)

Table 4 - Synthesis of SLR

(conclusion)

Authors	Policies	Mode of Transport*	Sub-models**	Simulation Time	Main Results
Keith et al. (2020)	Alternative fuel vehicles; Hybrid-electric vehicles; and Battery electric vehicles	M	ENV	30 years	In order to obtain a low carbon transportation sector, it is necessary to integrate long-term policies, considering the different vehicles fuels, as well as vehicle platforms and their interactions.
Luna et al. (2020)	E-carsharing growth policy; and Retirement policy for conventional vehicles	M	ECO and ENV	40 years	E-carsharing reduces emissions and increases awareness of electric vehicles. The combination of the two policies presents the best results for reducing emissions and increasing electric vehicle adoption.

*NM = Non-motorized; M = motorized. **ECO= Economy; ENV = Environmental; LU = Land Use; SOC = Social; TC = Traffic Congestion. Source: Authors (2020).

Analysis

The problems of urban mobility become more evident in large urban centers and, therefore, the policy makers in these regions have been striving to meet urban sustainability standards (Poiani and Stead, 2015). Thus, the number of studies to solve such problems in those areas is increasing. All papers analyzed urban areas with more than two million inhabitants. However, it is worth mentioning that three studies did not assess the impact of policies in a city, but in a specific region. Fontoura et al. (2019a), Procter et al. (2017) and Keith et al. (2020) analyzed the Metropolitan Region of São Paulo (Brazil), the Research Triangle (North Carolina, USA) and the USA, respectively.

All papers assess the implementation of at least one policy. However, in almost all papers, the authors proposed the policies and measures analyzed in the studies. Considering the 23 papers, only five of them consider some policy or goal set by the government. Fontoura (2019a) and Fontoura (2019b) analyze the impact of the Brazilian Urban Mobility Policy implementation, being the only study that exclusively evaluates the impact of a public policy. Procter et al. (2017) proposed sustainable transportation policies and compared them with the goals set by the government. Finally, Liu et al. (2010) and Ercan et al. (2016) adjusted existing public policies, simulating ambitious scenarios.

Increasing the public transportation ridership and limiting private vehicles are the two most analyzed measures, present in 43% and 52% of the studies, respectively. When these measures are not adopted, studies generally assess policies related to alternative fuels (mainly for private vehicles). The incentive for non-motorized transport, is explored in few studies, being addressed in only 26% of the papers. Thus, it is observed that the major focus in these studies is to reduce the impact of private vehicles.

When it comes to sustainable transportation, two of the main concerns are the air pollutant emissions and the energy consumption. Therefore, these two factors are widely used to calculate sustainable transportation indicators (Cheng et al. 2015; Litman, 2019). In this context, approximately 87% of the models have the environment sub-model. In addition, of the 23 papers, nine studies aim to analyze policies focused on reducing emissions and/or energy consumption in transport systems. Among the measures analyzed, priority public transportation, alternative fuel options and fuel tax are highlighted.

After the Environmental sub-model, the Economy is the sub-model most present in the papers (78%). This is justified since the economy directly affects travel demand and, consequently, the other

sub-models (Fontoura et al., 2019b). Traffic Congestion is also one of the main negative externalities of the transportation system, becoming a big challenge for urban planners and policy-makers (Albalade and Fageda, 2019). Measures to solve this problem are presented in 65% of the studies from the bibliographic portfolio.

The Social and Land Use are the least analyzed sub-models in the studies, being represented in only 35% and 39% of the papers, respectively. Although the Social sub-model is not widely explored, two studies present a model that exclusively evaluate the social aspect of it. Macmillan et al. (2016) analyze how news about bicycle accidents affect the population and, consequently, the demand for this mode. After understanding the society, the culture and the human behavior, the authors propose pro-cycling policies, and Papageorgiou and Demetriou (2019) analyze the effects of public awareness of the sustainable habits.

According to Zolfagharian et al. (2018), SD scholars are increasingly drawing to multi-method approaches to overcome the limitations of this approach. Therefore, they combine SD with one or more research methods to analyze complex problems and develop deeper solutions than a single-method study can do. Liu et al. (2010) developed an integrated optimization model for urban transportation-environmental system, using a system dynamic model and a linear optimization model.

In order to examine the urbanization process of Daqing City, Li et al. (2014) developed two models: an integrated system dynamic (SD) and CLUE-S model (SD-CLUES), and an integrated SD and stochastic cellular automata model (SD-CA). The first model clusters new urban developments in the downtown area or close to the main transportation networks. On the other hand, the second model allocates new urban cells in a scattered way across the study area. The authors compare the results of the two multi-level models and conclude that the SD-CA is closer to reality, presenting better results.

It is worth mentioning that some authors used existing models in the literature. Guzman et al. (2014) and Alonso et al. (2017) used the Metropolitan Activity Relocation Simulator (MARS), a strategic and dynamic Land-Use and Transport Interaction (LUTI) model created by Pfaffenbichler (2003).

The effects of implementing a new policy are not immediate, because there is a period of adaptation (Dupuis and Knoepfel, 2013). Policy-makers must take into account this period when formulating and analyzing new policies. So, regarding the simulation time, we noted that there is not a standard to analyze the impacts of sustainable transportation policies. Among the papers, the simulation time varied between 5 and 60 years, presenting an average of approximately 25 years.

Despite the analysis of several policies, we did not find in the literature a study that analyzed all modes of transport (motorized and non-motorized) and the five sub-models (Economy, Environment, Land Use, Social and Traffic Congestion) at the same time. Therefore, there is an opportunity for future research to develop a model that assesses the impact of sustainable transport policies considering all these factors.

Final Considerations

This paper aimed to verify the development of scientific research on System Dynamics (SD) applied to the analysis of sustainable transportation policies using a Systematic Literature Review (SLR) methodology. Thus, it was possible to investigate the occurrence and map the studies on this topic. In addition, the behavior of the scientific community on this subject was identified and analyzed.

From the SLR, it was possible to analyze the development of studies on the subject. We identified the outstanding papers, the most used keywords and the most analyzed policies. Besides, it was observed that China is the country with the largest number of publications about the subject, followed by Brazil and the United States.

The SLR analysis shows that SD is a useful tool in analyzing the implementation of sustainable transport policies. This method allows to find the best measures and prioritize them. It is observed that most studies focus on reducing the negative externalities of transport, highlighting the search for reducing air pollutant emissions and traffic congestion. For this, the focus is still on private vehicles.

One of the results of this study was the identification of a gap in the literature. So, we suggested for future studies to develop a model that analyzes the effects of sustainable transportation policies, addressing at the same time non-motorized modes, motorized modes and the sub-models Economy, Environment, Land Use, Social and Traffic congestion.

Despite the use of multiple database to conduct this paper, there may be studies on the theme not present in these databases, so our analysis is open to improvements. In addition, there may be studies that were not found due to the terms used in the search for papers. For this reason, we also suggest performing the SLR using more databases and more keywords. This paper was relevant due to the increasing use of SD in the analysis of sustainable transport policies. Besides highlighting the gaps in the literature, this paper contributes to further research since the results assist researchers in finding information on the subject.

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Editor: Fábio Duarte

Received on 15 Jul. 2020

Approved on 10 Oct. 2020