Journal of Sustainable Development; Vol. 14, No. 2; 2021
ISSN 1913-9063 E-ISSN 1913-9071
Published by Canadian Center of Science and Education

Measuring the Impact of Brazilian Transport Systems on the 2030 Agenda Goals

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Received: February 1, 2021 Accepted: March 2, 2021 Online Published: March 4, 2021

doi:10.5539/jsd.v14n2p82 URL: https://doi.org/10.5539/jsd.v14n2p82

Abstract

This paper aims to propose indicators to measure Brazilian transport systems' impact on meeting the 2030 Agenda and to analyze advances of Brazilian transport systems in terms of sustainable development over the last decade. The proposed indicators were based on a literature review and data availability. Time series data (2010-2019) were obtained to analyze the situation of Brazil. From 27 proposed indicators, only 12 showed some evolution based on the before-after method, relating to improvements in cleaner transport modes, such as railways and waterways, in exclusive lanes for public transport, and in improving active transport infrastructure. This scenario presents Brazil's challenges over the next ten years to achieve the Sustainable Development Goals proposed by the 2030 Agenda. Results reinforce the importance of the transport sector to contribute to the world's sustainable development. Therefore, this paper contributes to improving the analysis hereafter of this thematic.

Keywords: 2030 Agenda, Brazilian Transport Systems, Sustainable Development Goals

1. Introduction

In 2015, all United Nations Member States adopted the 2030 Sustainable Development Agenda. It provides a shared blueprint for peace and prosperity for people and the planet (United Nation [UN, 2018). The 2030 Agenda defined 17 Sustainable Development Goals (SDGs), which guarantee all people's human rights without neglecting environmental and economic issues. Regarding the transport sector, the UN's High-Level Advisory Group on Sustainable Transport (UN, 2016) stated that advances in sustainable transport have an impact on reducing greenhouse gas emissions; food security; health care of the population; school attendance of young people; the guarantee of employment opportunities for women, independence, and dignity of people with mobility restrictions; and personal safety for all users of transport infrastructures.

Despite its importance, at the time of writing this article, few studies systematized the transport sector's role to reach the goals proposed in the 17 SDGs (Ahmad & Oliveira, 2016; Sdoukopoulos et al., 2019; Chakwizira, 2019). There were also few papers focusing on analyzing advances in the world's transport systems to measure their contribution to sustainable development (Santos & Ribeiro, 2015; Mansourianfar & Haghshenas, 2018; Farzaneh et al., 2019). This lack of research makes it even more complicated for developing countries to meet the goals of the 2030 Agenda. Although Brazil (the country selected to be studied in this paper) has the 9th world's highest GDP (World Bank, 2020), it is considered a developing country. The choice is justified because Brazil is a country of continental dimensions and seems to have many challenges in its transport systems to meet the goals of the 2030 Agenda.

Considering this scenario, we formulated the following research questions: What indicators measure Brazilian transport systems' contribution to sustainable development? What have been the advances of Brazilian transport systems over the last decade to meet the 2030 Agenda goals? Therefore, this paper aims to propose indicators that could measure and analyze Brazilian transport systems' advances to meet the United Nations' 2030 Agenda SDGs between 2010-2019. Thus, the main contribution of this article is to propose indicators that can be measured in other developing countries, using data available from public sources and that can reflect the advances in their transport systems to meet the 2030 Agenda.

The paper is organized as follows. In the next section, the background behind creating the UN's 2030 Agenda is introduced. It also presents the 17 SDGs and highlights 10 SDGs and 20 targets related to the transport sector. The research method and data sources are described in Section 2. Section 3 presents the indicators proposed to measure Brazilian transport systems' impact on meeting the 2030 Agenda. Section 4 shows the Brazilian transport sector's advance in 2010-2019, measured by the proposed indicators. Finally, conclusions are drawn in the last section.

1.1 The Role of the Transport Sector in the 2030 Agenda

In the early 1970s, the threat of natural resource depletion was already announced due to production and consumption patterns. The topic was discussed in The Limits to Growth (Meadows et al., 1972) and at the United Nations Conference on the Human Environment (known as the Stockholm Conference). Meadows et al. (1972) pointed out the risks of economic collapse in the long term, and the Stockholm Conference (June 5-16, 1972) gave rise to the Report of the United Nations Conference on The Human Environment (UN, 1973). The Stockholm Conference was the first major conference on international environmental issues organized by the United Nations, marking a turning point in global environmental politics.

Encouraged by these discussions, the Our Common Future report, known as the Brundtland Report (WCED, 1987), conceptualized Sustainable Development, referring to several urban sectors, including transportation. The expression "sustainable mobility" was introduced in the international Agenda in the Green Paper on the Impact of Transport on the Environment – EUCOM, 1992 – (Holden et al., 2019). Eight years later, the United Nations proposed the Millennium Development Goals (MDGs) (UN, 2000). During the Rio+20 Conference (1992), the need to focus on the MDGs was reinforced, and the central role of transportation for sustainable development was highlighted (UN, 2012). Based on the MDGs and the Rio+20 Conference, the United Nations adopted the 2030 Agenda in 2015. This Agenda proposed 17 Sustainable Development Goals (SDGs) and 169 related targets to meet the SDGs to end poverty, fight inequality and injustice, and tackle climate change by 2030 (UN, 2015). Therefore, 193 countries agreed to implement actions to meet the SDGs by 2016-2030.

Although seen as revolutionary and ambitious, the 2030 Agenda does not seem to highlight the impact that the transport sector has on the economy, environment, and social welfare (Magalhães et al., 2018; Meschede, 2019; You et al., 2018), apparently neglecting the negative impacts of the transport sector (Holden et al., 2019). The UN (2016, p. 3) has already observed the need to invest in sustainable transport to promote the 2030 Agenda.

The UN (2017) proposed 241 indicators to monitor the 169 targets, offering guidance that they should be refined annually. We analyzed the 241 indicators, and concluded that only eight include the transport sector as a protagonist, summarized according to the UN wording (2017): households with access to essential services (indicator 1.4.1) and close to roads (indicator 9.1.1), traffic mortality (indicator 3.6.1), passenger and freight volumes (indicator 9.1.2), migration policies (indicator 10.7.2), access to public transport (indicator 11.2.1), urban space for public use for all (indicator 11.7.1), and share of global exports (indicator 17.11.1). However, twenty-five more indicators consider the transport sector in a secondary way, mainly focused on pollutant emissions and economic issues, such as complementing global data, e.g., carbon dioxide emissions by industry (indicator 9.4.1), and fossil-fuel subsidies (indicator 12.c.1).

The transport sector directly affects seven SDGs through ten targets (UN, 2016), highlighted here with identification according to the UN (2015): SDG 2 (target 2.3), SDG 3 (targets 3.6, and 3.9), SDG 7 (target 7.3), SDG 9 (target 9.1), SDG 11 (targets 11.2 and 11.6), SDG 12 (target 12.c), and SDG 13 (targets 13.1, and 13.2). However, the transport-related indicators refer only to six SDGs (1, 3, 9, 10, 11, and 17). Comparing the results of the UN (2016; 2017), the lack of connection between them is clear.

Relating the transport sector to the 2030 Agenda, Magalhães et al. (2018) added ten other targets related to SDGs 4, 10, and 17 as being directly affected by the transport sector. Taking this into account, this paper considers that ten SDGs and twenty targets are related to the transport sector. Consequently, to answer the research questions, the transport sector's role must be understood to achieve those targets. Table 1 presents the selected targets' description linked to eight roles (i, ii, iii, …, viii) of the transport sector in terms of achieving the respective targets.

Investments in transport boost agriculture and food production (UN, 2016; Weitz et al., 2018). Moreover, investments in rural road infrastructure reduce production and storage costs (Chakwizira, 2019), and transport policies could eliminate hunger (Fiorini & Hoekman, 2017). Therefore, to meet targets 2.1, 2.3, and 12.3, a country or region needs to expand and improve logistics and transportation infrastructure (role i).

In another aspect, Moschen et al. (2019) state that transport has directly related to road traffic deaths. Traffic-accidents account for 14.34% of human deaths, second only to drowning (43.63%) and suffocation (27.57%) (Lili et al., 2017). The UN (2016) already stated the need to reduce deaths and injuries in traffic to ensure the population's health and well-being. Also, to achieve traffic safety, it is necessary to invest in transport policies (Bakker et al., 2017; Jones et al., 2019). Therefore, to meet target 3.6, a country needs to improve infrastructure, signaling, and inspection on roads (role ii).

Several studies highlight the promotion of sustainable transport systems for the sustainability of cities and the population's well-being (Gupta & Vagelin, 2016; Mundorf et al., 2018; Farzaneh et al., 2019). Accordingly, the energy matrix, control emissions, and fuel quality need to be modified, and transport has a fundamental role (Cruz & Katz-Gerro, 2016; Bakker et al., 2017; Franco & Tracey, 2019). Farzaneh et al. (2019) state that mitigating climate change in transport may be a main priority on the Political Agenda. Therefore, to meet targets 3.9, 7.2, 7.3, 11.6, and 13.1, a country needs to reduce fossil fuel consumption in the transport sector (role iii).

Cruz and Katz-Gerro (2016) highlight that the transport sector is one of the principal emitters of carbon dioxide in terms of pollution. The main impasse that these authors highlight is the economic issue, especially regarding incentives related to fuel. Also, Franco & Tracey (2019) emphasize the need to discourage fossil fuels. Therefore, to meet target 12.c, a country needs to rethink subsidies in the transport sector for oil products (role iv).

Table 1. Targets of the SDGs linked to the role of the transport sector

Target	Description*	Role**
2.1	End hunger and ensure access by all people to food	i
2.3	Double the agricultural productivity and incomes of small-scale food producers	
3.6	Halve the number of global deaths and injuries from road traffic accidents	ii
3.9	Reduce the number of deaths and illnesses from hazardous chemicals and air, water, and soil pollution and contamination	iii
4.3	Ensure equal access for all women and men to education at all levels.	v
7.2	Increase the share of renewable energy in the global energy mix	iii
7.3	Double the global rate of improvement in energy efficiency	
9.1	Develop quality, reliable, sustainable, and resilient infrastructure, including regional and transborder infrastructure	v
10.7	Facilitate orderly, safe, regular, and responsible migration and mobility of people	vi
11.1	Ensure access for all to adequate, safe, and affordable housing, to essential services, and upgrade slums	v
11.2	Provide access to safe, affordable, accessible, and sustainable transport systems for all	
11.6	Reduce the adverse per capita environmental impact of cities	iii
11.7	Provide universal access to safe, inclusive, and accessible, green, and public spaces	v
11.a	Support positive economic, social, and environmental links between urban, peri-urban, and rural areas	
12.3	Halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses	i
12.b	Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products	v
12.c	Rationalize inefficient fossil-fuel subsidies	iv
13.1	Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries	iii
13.2	Integrate climate change measures into national policies, strategies, and planning	vii
17.14	Enhance policy coherence for sustainable development	viii

**2030 Agenda text (UN, 2016) with clippings.*

***i) expand and improve logistics and transportation infrastructure; ii) improve infrastructure, signaling, and inspection on roads; iii) reduce consumption of fossil fuels in the transport sector; iv) rethinking subsidies in the transport sector for oil products; v) invest and qualify the transport infrastructure, prioritizing the public, and active transport service; vi) facilitate and order the migration of people in ports, airports, and borders; vii) develop and implement Urban Mobility Plans, and viii) invest in logistics and transport policies that promote more efficient and less polluting forms of travel.*

Sustainable transportation infrastructure improvements are essential to achieve sustainable development (Gupta & Vegelin, 2016). Therefore, it is necessary to increase the use of public transport (Porfiryev & Bobylev, 2018), and rail and waterway modes (Bere-Semeredi & Mocan, 2019), and the investment in active transportation (Ahmad & Oliveira, 2016; Vermae & Raghubanshi, 2018). The improvement of mobility has directly influenced the quality of life of elderly citizens (Cinderby et al., 2018), women and children (Jones et al., 2019), and improved educational outcomes (Fiorini & Hoekman, 2017). Therefore, to meet targets 4.3, 9.1, 11.1, 11.2, 11.7, 11.a, and 12.b, a country needs to invest and qualify the transport infrastructure, prioritizing the public and active transport service (role v).

Migration policies occur at airports, ports, and borders. Therefore, these transport infrastructures are the means to facilitate people's migration. Sá and Fernandes (2016) highlight airport connectivity analysis to understand the dynamics of migratory flows. Therefore, there is a great potential for studies in the field of international migration. A country needs to facilitate and order people's migration in ports, airports, and borders to meet target 10.7 (role vi).

An urban mobility plan aims to transform a city towards sustainable development (Mozos-Blanco et al., 2018), being crucial well-designed transport policies (Kane & Whitehead, 2017). Therefore, to meet target 13.2, a country needs to develop and implement Urban Mobility Plans (role vii). Also, a country needs to invest in logistics and transport infrastructure, promoting more efficient and less polluting ways of travel to meet target 17.4 (role viii). The next section presents the research method that leads to the proposal of indicators that could measure Brazilian transport systems' impact on meeting the United Nations 2030 Agenda SDGs and to analyze the advances 2010-2019.

2. Method

The first step was to carry out a literature review to search for indicators that could measure transport systems' impact on meeting the 2030 Agenda SDGs. The indicators' selection was based on the literature and were chosen to evaluate the evolution of the chosen targets presented in the previous section. Likewise, priority was given to data belonging to official databases. Therefore, 27 indicators were selected and proposed in line with this paper's purpose in Section 3, with their respective related literature.

The second step was to analyze Brazilian transport systems' advances over the last decade, understanding their impact on the 2030 Agenda SDGs. Thus, data between 2010 until 2019 were obtained for each indicator.

Analyzing the advances Brazilian transport systems' advances decade was based on comparing two comparison groups (time series of 2010-2015 and 2016-2020) using the before-after method. These time series were chosen since 2015 corresponds to the year in which United Nations Member States adopted the 2030 Sustainable Development Agenda. We compared the averages between 2010-2015 (before, B) and 2016-2019 (after, A) using the t-test. The t-test determines whether the means of two datasets are equal, which is suitable for small samples. If the null hypothesis is rejected (p-value <0.05), the SDGs indicators are in line with the 2030 Agenda

3. Results

A literature review was carried out to propose indicators to measure the impact transport systems (particularly in the Brazilian case) have on meeting the 2030 Agenda SDGs. Table 2 presents the indicators, their related SDGs, targets, and the support literature. Most indicators proposed are easily found in official databases of many developing countries. The next step was to search for information and consequently analyze their evolution between 2010-2019.

Table 3 summarizes the results of before-after method and highlights the indicators with advances over the last decade (i.e., rejected the null hypothesis with 5% significance). Considering the null hypothesis of the t-test, we have three situations: (i) H0: $mA = mB$, if the indicator average in 2016-2019 (after) kept the same while compared to 2010-2015 (before); (ii) H0: $mA \leq mB$, if the indicator average in 2016-2019 (after) reduced while compared to 2010-2015 (before); and (iii) H0: $mA \geq mB$, if the indicator average in 2016-2019 (after) increased while compared to 2010-2015 (before).

The situation (i) ($mA = mB$) was explicitly applied for the indicator 24 (annual average temperature in main Brazilian cities) since keeping the temperature unchanged is an action against climate change. In a longer time-analysis (more than ten years), the objective is to reduce the annual average temperature, and null hypothesis H0: $mA \leq mB$ needs to be applied. The situation (ii) ($mA \leq mB$) was considered for the indicators that need to be reduced to achieve the SDG's. For example, the annual number of accidents on Brazilian roads (indicator 11) needs to be reduced to achieve the SDG (11). Finally, the situation (iii) ($mA \geq mB$) was applied in those indicators that need to grow to achieve sustainable development. For example, to reach reduced inequalities (SDG 10) and sustainable cities and communities (SDG 11) is expected to grow in the annual number of accessible public transportation.

Table 2. Indicators to measure the impact of Brazilian transport systems on the 2030 Agenda

ID	Indicators	SDG	Target	Literature related
1	Annual energy consumption in the economy by economic sector	3; 7	3.9; 7.2; 7.3	Ma et al. (2020); Sengupta & Cohan (2017); Sun & Huang (2020)
2	Annual energy consumption, by transport mode	7; 17	7.2; 7.3; 17.14	Biresselioglu et al. (2018); Liu et al. (2016); Dalla Chiara et al. (2017)
3	Annual energy efficiency in transport	7	7.2; 7.3	Stefaniec et al. (2020); Yang et al. (2020)
4	Annual total emissions	3; 13	3.9; 13.1	Yang et al. (2019); Takashima (2017)
5	Annual emissions by transport mode	11	11.6	Carroll et al. (2019)
6	Annual growth in infrastructure by transport mode	9	9.1	Tapia et al. (2020)
7	Annual investment in transport infrastructure	9; 12	9.1; 12.3	Xu et al. (2015); Wang et al. (2020)
8	Annual investment in transport infrastructure, by mode	2; 12; 13; 17	2.1; 2.3; 12.3; 13.2; 17.4	Mariola (2008); Barilla et al. (2020); Mariola (2008); Khan et al. (2019); Havenga et al. (2019)
9	Annual number of freight trips by rail and waterways	3	3.6	Probha & Hoque (2018)
10	Snnual number of interstate passenger trips by rail and waterways	3	3.6	Probha & Hoque (2018)
11	Annual number of accidents on Brazilian roads	3	3.6	Moradi et al. (2019)
12	The annual number of deaths due to environmental pollution	3; 11	3.9; 11.6	Wang (2019); Tang et al. (2020)
13	Annual number of accessible public transport	11	11.2; 11.7	Lope & Dolgun (2020)
14	Annual number of Brazilian cities with Mobility Plan	13	13.2	Persia et al. (2016)
15	Annual number of public transport passengers	11; 12	11.1; 11.2; 11.7; 11.a; 12.b	Anciaes & Jones (2020); Guzman & Oviedo (2018); Ross et al. (2020); Arbex & Cunha (2020); Lumsdon et al. (2006)
16	Annual percentage of goods transported by transport mode	2; 9; 11; 12; 13; 17	2.1; 2.3; 9.1; 11.a; 12.3; 12.b; 12.c; 13.1; 13.2; 17.14	Gharehgozli et al. (2017); Bahadur et al. (2016); Gallo & Guevara (2019); Salvucci et al. (2019); Guan et al. (2019); Winzar et al. (1993); Tao et al. (2017); Hulkkonen et al. (2020); Valderrama et al. (2019); Astegiano et al. (2019)
17	Percentage of access to technical, professional, or higher education by income	4	4.3	Liu (2015)
18	Annual economic loss generated due to accidents on Brazilian roads	3	3.6	Probha & Hoque (2018)
19	Average price of diesel, by year	12	12.c	Ferraresi et al. (2018)
20	Annual Brazilian agricultural productivity	2	2.3	Rivera-Padilla (2020)

21	Growth annual of priority infrastructure for public transport and active transport	4; 11; 12	4.3; 11.1; 11.6; 11.7; 12.b	Kenyon (2011); Chung et al. (2014); Pathak & Shukla (2016); Abubakar & Aina (2019); OECD (2016)
22	Annual fuel subsidies	12	12.c	Solarin (2020)
23	Annual public transport tariff in main Brazilian cities	2; 4; 11	2.1; 4.3; 11.1; 11.2; 11.a	Motta et al. (2013); Zhao & Zhang (2019); Matas et al. (2020); Roy & Basu (2020); Buehler et al. (2019)
24	Annual average temperature in main Brazilian cities	13	13.1	De Troeyer et al. (2020)
25	Annual number of legally transported emigrant passengers	10	10.7	Zhang (2015)
26	Annual number of legally transported immigrant passengers	10	10.7	Zhang (2015)
27	Annual number of deported foreigners	10	10.7	Sánchez & Acosta (2018)

It is important to note that out of 27 indicators, 13 presented advances over the last decade. We highlight some indicators, such as Indicator 1 (agriculture) and Indicator 2 (railways), which reduced the annual energy consumption by 2% each. Still, it was not enough to obtain statistical significance in the t-test. Thus, the conclusion is that indicator 2, in sector railways, as an example, did not advance enough over the last decade to contribute to the 2030 Agenda.

Table 3. Summary of results for each indicator using the before-after method

ID Indicator	Subdivision	Average 2010-2015 (B)	Average 2016-2019 (A)	Null hypothesis	p-value
1	Commercial	7,807	8,444	$m_B \leq m_A$	0.950
	Public Service	3,841	4,054	$m_B \leq m_A$	0.989
	Residential	24,011	25,035	$m_B \leq m_A$	0.993
	Agriculture	10,595	10,391	$m_B \leq m_A$	0.227
	Transport	79,274	83,917	$m_B \leq m_A$	0.930
	Industrial	**87,061**	**83,204**	$\mathbf{m_B \leq m_A}$	**0.011**
2	Roads	73,299	77,123	$m_B \leq m_A$	0.821
	Rails	1,163	1,192	$m_B \geq m_A$	0.144
	Waterways	1,291	816	$m_B \geq m_A$	0.998
	Airports	**3,620**	**3,368**	$\mathbf{m_B \leq m_A}$	**0.037**
3	Private Car	153,434,860	194,213,548	$m_B \leq m_A$	0.998
	Motorcycle	30,667,097	40,683,104	$m_B \leq m_A$	0.998
	Bus	7,378,986	8,990,990	$m_B \leq m_A$	0.997
4	**CO**	**12,636,177**	**11,786,661**	$\mathbf{m_B \leq m_A}$	**0.022**
	NOx	**2,860,358**	**2,589,617**	$\mathbf{m_B \leq m_A}$	**0.001**
	CH4	17,671,292	17,874,092	$m_B \leq m_A$	0.836
	CO2	1,305,869,978	1,278,745,076	$m_B \leq m_A$	0.290
5	CO	21,269,932	25,268,387	$m_B \leq m_A$	0.999
	NOx	5,336,485	6,235,684	$m_B \leq m_A$	0.999
	CH4	2,020,343	2,374,548	$m_B \leq m_A$	0.999
	MP	276,530	317,547	$m_B \leq m_A$	0.999
	CO2	3,179,985,487	3,726,880,074	$m_B \leq m_A$	0.999

6	Roads	1,708,323	1,720,771	$m_B \geq m_A$	0.084
	Rails	**28,998**	**30,496**	$\mathbf{m_B \geq m_A}$	**0.009**
	Waterways	21,497	19,464	$m_B \geq m_A$	0.999
	Commercial Flights	151	123	$m_B \geq m_A$	0.994
	Private Airports	**2**	**11**	$\mathbf{m_B \geq m_A}$	**0.013**
7	Brazil	28,150,000,000	26,450,000,000	$m_B \geq m_A$	0.651
8	Roads	11,487,063,333	8,860,900,000	$m_B \geq m_A$	0.988
	Rails	7,055,816,667	5,668,310,000	$m_B \geq m_A$	0.852
	Waterways	1,633,146,500	845,463,333	$m_B \geq m_A$	0.907
	Airports	3,170,635,000	2,276,293,333	$m_B \geq m_A$	0.669
9	**Rails**	**458,361,833**	**537,485,000**	$\mathbf{m_B \geq m_A}$	**0.001**
	Waterways	**849,583,333**	**987,900,000**	$\mathbf{m_B \geq m_A}$	**0.002**
10	Rails	1,253,359	1,309,015	$m_B \geq m_A$	0.155
	Waterways	12,300,000	9,800,000	$m_B \geq m_A$	0.845
11	**Road Deaths**	**8,248**	**5,970**	$\mathbf{m_B \leq m_A}$	**0.001**
	Road Injuries	**69,187**	**57,635**	$\mathbf{m_B \leq m_A}$	**0.001**
12	Brazil	66,595	73,729	$m_B \leq m_A$	0.998
13	**Brazil**	**527,636**	**613,705**	$\mathbf{m_B \geq m_A}$	**0.016**
14	Brazil	19	19	$m_B \geq m_A$	0.510
15	**Bus**	**15,473,500,000**	**15,985,500,000**	$\mathbf{m_B \geq m_A}$	**0.042**
	Rail	2,399,333,333	2,423,000,000	$m_B \geq m_A$	0.391
16	Pedestrians	0.38	0.41	$m_B \geq m_A$	0.106
	Bicycle	0.03	0.03	$m_B \geq m_A$	0.782
	Public Transport	0.29	0.28	$m_B \geq m_A$	1
	Private Car	0.26	0.25	$m_B \leq m_A$	0.202
	Motorcycle	0.04	0.04	$m_B \leq m_A$	0.782
17	**25% poorer**	**0.05**	**0.08**	$\mathbf{m_B \geq m_A}$	**0.015**
	25% to 50%	**0.11**	**0.17**	$\mathbf{m_B \geq m_A}$	**0.009**
	50% to 75%	**0.20**	**0.28**	$\mathbf{m_B \geq m_A}$	**0.003**
	25% richer	**0.39**	**0.47**	$\mathbf{m_B \geq m_A}$	**0.000**
18	Public Transport	1,600,000,000	800,000,000	$m_B \leq m_A$	0.096
	Individual Transport	46,783,333,333	126,200,000,000	$m_B \leq m_A$	0.950
19	**Brazil**	**2.25**	**3.28**	$\mathbf{m_B \geq m_A}$	**0.000**
20	**Brazil**	**3,372**	**3,810**	$\mathbf{m_B \geq m_A}$	**0.001**
21	**Brazil**	**989**	**2,229**	$\mathbf{m_B \geq m_A}$	**0.006**
22	Brazil	70,975,004,982	47,000,591,415	$m_B \geq m_A$	0.872
23	Bus	2.50	3.71	$m_B \leq m_A$	1
	Subway	2.43	3.51	$m_B \leq m_A$	0.999
24	Brazil	23	24	$m_B = m_A$	0.439
25	Brazil	251,612	288,111	$m_B \geq m_A$	0.336
26	Brazil	101,501	114,115	$m_B \geq m_A$	0.148
27	Brazil	380	272	$m_B \leq m_A$	0.058

4. Discussion

For indicator 1, there was a decrease in energy consumption only in the industrial and agriculture sectors, although the last was not statistically significant. However, this reduction might not be related to technological developments or due to the use of cleaner energies. According to EPE (2018), the shift in energy consumption in the Brazilian industrial sector was lower than the evolution in total energy consumption because of the Brazilian economy's loss of dynamism in the last decade. In indicator 2, there was a decrease in annual energy consumption in the aviation sector, maybe due to Brazilian air fleet renewal, which today is one of the newest in the world (Medeiros et al., 2017). The estimated annual total emissions of CO and NOx (indicator 4) possibly decreased due to Proconve - Brazilian Motor Vehicle Air Pollution Control Program (Brazil, 2020), which requires that new vehicles emit less and fewer pollutants over the years.

There were improvements in railways and airports in indicator 6 (annual increase in infrastructure dedicated to each transport mode). This result is due to recent investments in railways (Betarelli Jr. et al., 2020) and the Brazilian airport concession program (Pereira Neto et al., 2016). Consequently, the increase in indicator 9 was observed, which is cargo transport journeys by rail and waterways (ANTT, 2020; ANTAQ, 2020). Regarding the annual number of accidents on Brazilian roads, Brazil agrees and implements actions foreseen in the World Health Organization's Global Plan for the Decade of Action for Road Safety 2011-2020 (Andrade & Antunes, 2019), maybe explain the advances in indicator 11. Regarding indicator 13, Brazil has a relatively recent accessibility law (Brazil, 2015) that requires companies to provide transport services to have accessible vehicles.

The annual number of public transport passengers (indicator 15) has possibly evolved due to investments made due to mega-events such as the FIFA World Cup 2014 and the Rio 2016 Olympics. Although Brazil spends an above-average percentage of its gross domestic product (GDP) on education, spending per student on primary to upper secondary levels is well below the OECD average (OECD, 2019). However, indicator 17 is related to the improvement of access to education, and there have been massive investments in new universities, technical and professional schools over the last decade (Almeida et al., 2020). From indicator 19, diesel is the usual fuel used in buses and trucks in Brazil, and the price has become more expensive due to the increase in the US Dollar concerning the Brazilian Real in recent years (Hillier & Loncan, 2019). As Brazilian agriculture is one of the world's most advanced sectors and the country is an active food exporter (Magalhães et al., 2020), the agricultural productivity (indicator 20) advanced year by year.

However, most of the studied indicators did not show a significant evolution over the decade. Bearing in mind that the SDGs have targets to be met by 2030, it can be inferred that almost a third of the time was lost, with little (or even none) progress being made toward sustainable development. This situation shows that the transport sector faces huge challenges over the next ten years to fulfill its role to contribute to Brazil to meet the SDG targets effectively.

5. Conclusions

This paper proposed 27 indicators to measure the contribution of Brazilian transport systems to sustainable development. Results indicated that the main advances of the Brazilian transport systems over the last decade to meet the 2030 Agenda SDGs are improvements in cleaner transport modes, such as railways and waterways, and investments in exclusive lanes for public transport, and improving active transport infrastructure. Therefore, it can be stated that the objectives proposed for this paper were achieved.

Also, the results are worthy of concern since many indicators have evolved towards SDGs' goals. This situation poses various challenges for Brazil over the next ten years. Probably, this situation is similar in other developing countries. More investments are needed to achieve the Agenda 2030 targets. However, the economic crisis due to the COVID-19 pandemic should make it even more challenging to allocate resources to transport improvements. However, the study also reinforces the transport sector's importance to contribute to the world's sustainable development.

Although data collection is not the focus of this paper, we highlight the importance of using public data for this analysis. The availability of time series of updated data, mainly on transport, is a challenge for Brazilian researchers. Thus, we proposed and aligned the indicators based on public and available data, whose analysis showed consistency in the proposed indicators to achieve the 2030 Agenda.

Notwithstanding the results, the analysis carried out in this paper has some limitations. The limited-time series is one of them. As mentioned before, the updated base is not always available. Also, older historical series are not reliable and diverge even on official grounds. Because of this, we have limited the analysis to the last decade. The updating of indicators and the study of advances in meeting the 2030 Agenda is a proposal to reduce the limitation imposed by the data series used. A systematic data collection to analyze the progress of the indicators can provide a more realistic picture of Brazil's situation.

As for recommendations for future studies, we suggest carrying out further research on the indicators that have not advanced in Brazil. We also recommend studying the same indicators in other developing countries to analyze if this lack of advances is only a Brazilian problem or a difficulty for other countries. Finally, the causality analysis of the indicators could be an interesting approach to analyze the advances in meeting the 2030 Agenda.

Acknowledgments

The authors would like to thank the Brazilian National Council for Scientific and Technological Development (CNPq) (grant number 436236/2018-4) and the Brazilian Agency for Coordination of Improvement of Higher-Level Personnel (CAPES) for financial support and encouragement in this research.

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