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Sustainable Smart Healthy Cities: What is the impact of governance on health, transport, green spaces, and air?

Cidades Sustentáveis, Inteligentes e Saudáveis: Qual é o impacto da governação na saúde, nos transportes, nos espaços verdes e no ar?

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ABSTRACT

Objective of the study: Our research aimed to verify the impact of the governance indicator on health, transport, green spaces, and air indicators. **Methodology/approach:** A systematic review of the literature was carried out and a portion of the population was consulted, validating the model through statistics. **Main results:** As a result, governance has a significant impact on health, transport, green spaces, and air quality in the smart city. **Theoretical/methodological contributions:** This article contributes to the theory of cities, as it demonstrates which indicators have a greater impact, according to the opinion of a part of the population, for health, transport, green spaces, and air indicators. As well as the impact of governance on these indicators. Methodologically, the model is innovative by seeking the opinion of city residents, and by using Partial Least Squares Analysis to evaluate the impact of city indicators. **Relevance/originality:** Healthy, smart, and sustainable cities result from good governance practices that involve human, social and technological capital, among other factors; therefore, governance is among the key factors for sustainable development policies. **Social/management contributions:** As a social and management contribution, it is important for city managers to understand what a priority for the population of a city is, as well as which city indicators have the greatest impact on sustainability.

Keywords: Healthy Cities; Smart Cities; Sustainable Cities; Urban governance; Urban sustainability indicators.

RESUMO

Objetivo do estudo: A nossa investigação teve como objetivo verificar o impacto do indicador de governação nos indicadores de saúde, transportes, espaços verdes e ar. **Metodologia/abordagem:** Foi realizada uma revisão sistemática da literatura e consultada uma parcela da população, validando o modelo por meio de estatística. **Principais resultados:** Como resultado, a governação tem um impacto significativo na saúde, nos transportes, nos espaços verdes e na qualidade do ar na cidade inteligente. **Contribuições teóricas/metodológicas:** Este artigo contribui para a teoria das cidades, pois demonstra quais indicadores têm maior impacto, segundo a opinião de uma parte da população, para indicadores de saúde, transportes, espaços verdes e ar. Bem como o impacto da governação nestes indicadores. Metodologicamente, o modelo é inovador ao buscar a opinião dos moradores da cidade e ao utilizar a Análise de Mínimos Quadrados Parciais para avaliar o impacto dos indicadores da cidade. **Relevância/originalidade:** Cidades saudáveis, inteligentes e sustentáveis resultam de boas práticas de governança que envolvem capital humano, social e tecnológico, entre outros fatores; portanto, a governação está entre os factores-chave para as políticas de desenvolvimento sustentável. **Contribuições sociais/de gestão:** Como contribuição social e de gestão, é importante que os gestores municipais entendam o que é prioridade para a população de uma cidade, bem como quais indicadores da cidade têm maior impacto na sustentabilidade.

Palavras-chave: Cidades Saudáveis; Cidades Inteligentes; Cidades Sustentáveis; Governança urbana; Indicadores de sustentabilidade urbana.

1 INTRODUCTION

Healthy, smart, and sustainable cities result from good governance practices involving human, social and technological capital (YIGITCANLAR *et al*., 2018). Thus, as a way of contributing and directing the actions of governments, companies, and institutions around the planet the United Nations (UN), with 192 member countries, created what was called Sustainable Development Goals (SDGs), composed of 17 goals that include 169 indicators. Out of these indicators, this investigation, although comprehensive, focused on objective 11, UN (2020): "Making cities and human settlements inclusive, safe, resilient and sustainable".

The idea of a healthy city began to take shape in 1992 when Agenda 21 suggested a healthy life for the population. This Agenda aimed to promote a sustainable urban development. Years later, the World Health Organization (WHO) proposed the Healthy City (HC) project with the aim of creating and continually improving the physical and social environment and supporting people development to their fullest potential (WHO, 1997; WHO, 1998). In these cities, the discussion includes, in addition to social development, the health of urban residents, including social health.

The concept of smart cities began developing in the 1980s with the aim of building ideal, easy-to-manage cities. Since the 2000s decade, with the use of the term by technology companies to indicate information systems for the integration of urban infrastructure, the concept of smart cities has been used to describe technological innovations focused on city planning, as well as city development and operation (Sokolov, Veselitskaya, Carabias and Yildirim, 2019).

Anand *et al*. (2017) included the concept of a sustainable city in the smart city concept. To support this concept, the authors mention the possibility of improving the quality of life through the optimized use of resources, especially energy. The study by El Ghorab and Shalaby (2016) further states that sustainable cities are cities that aim to reduce environmental impact by reducing waste and emissions, expanding recycling activities, expanding green spaces, in addition to encouraging local economy. This is an aspect that can be further enriched, through the planning of green and multifunctional infrastructure, especially in relation to water as is the case of New York City.

Governance practices in sustainable development were also studied, concluding that participatory management, based on principles of public governance with transparency and accountability, has repercussions on the civil society and on an efficient public management (Franz, Andreoli and Silva, 2021).

To manage resources efficiently, the city should have an integrated, flexible, transparent and participatory management (Franz, Andreoli and Silva, 2021). This would be developed through governance, policy formulation and implementation processes as well as through multilevel power and informal networks of authors inside and outside the government. This type of collaborative decision-making with the contribution of all the players involved allows the alignment of objectives, creation of policies and plans for health and sustainability (Crane *et al*., 2021).

Public governance contributing to sustainability must apply the SDGs to the territories and ensure the development of methods for implementing public policies that meet the issues of strategic efficiency according to the reality of each city (Lytras *et al*., 2018; Boca Santa *et al*, 2021).

In this connection, this investigation poses the following problem question: What is the impact of governance on health, transport, green spaces, and air? To answer this question, the objective of this research was: to verify the impact of the governance indicator on indicators related to health, transport, green spaces, and air.

This work is an unprecedented probing of the population of greater Florianopolis about indicators of Healthy Smart Sustainable Cities. Florianopolis is in Santa Catarina, south of Brazil. According to the Brazilian Institute of Geography and Statistics (IBGE), the city had a population of 500,973 inhabitants (2019). It is a coastal city with an economy based on information technology and tourism. Florianopolis has been considered by the UN the Brazilian capital with the best quality of life. This paper presents a methodological contribution by listing a series of indicators and sub-indicators based on the literature and subsequently applying them to the population of a given region. It also contributes to a theoretical aspect by listing papers relevant to the theme of Healthy Smart Sustainable Cities.

2 THEORETICAL BACKGROUND

2.1 Public Governance

The public sphere is a space where different social interests coexist and where its stakeholders engage in a discourse about an agenda for society and, to that effect, it requires new theories and new political and organizational practices different from the predominant organizational model, that is, more focused on transparency and efficiency and less bureaucratic (Zuiderwijk *et al*, 2021). The main players involved in public governance encompass individuals, citizens, organizations, and systems of organizations in the public, private and non-profit sectors that engage in collective decision-making (Ansell, C., and Torfing, J., 2021). Thus, we define public governance as all rules and actions related to public policies and services.

Public governance, therefore, is a government capacity and is related to leadership, mastery of competencies, readiness to act, action potential and public institutional design, and should be thought of with a focus on a) representativeness, b) effectiveness, c) transparency and d) authors´ cooperation. It is important to point out that the centralization of government bodies and their low performance can hamper good results in terms of effectiveness and cooperation (Weiss *et al*., 2021). Therefore, allowing for a more decentralized local action can be a good alternative for large cities (Mandelli, 2016).

The concept follows a tendency to resort more and more to self-management in the social, economic, and political fields, and to a new composition of management forms resulting therefrom. Likewise, they group together, in new players arrangements (networks, alliances, etc.), three different logics: that of the State (hierarchy), that of the market (competition) and that of civil society (communication and trust) and it appears in all areas: health, transport, education, public security, environment, etc. (Jann, 2003).

Thus, Public Governance proposes a new synthesis, an attempt to perceive the government as a broad, plural, and complex process of society, seeking to integrate policy and administration, management, and public policies. (Meuleman, 2021). Indeed, it presupposes the government's ability and capacity to: efficiently and responsibly develop the management of resources and public policies; make government more open, accountable, transparent and democratic; promote mechanisms that enable society to participate in the planning, decision-making and control of actions that allow achieving the common good (Mello and Slomski, 2010) Above all, public governance is a promise of a new understanding, comprehensive and integrative, inspiring best practices and results.

Given the above, the objective of Public Governance is to generate sustainable public value through quality and institutional capacity, performance, and collaboration (Martins, 2011a; 2011b). Therefore, it foresees the joint action of the government, civil society, and private organizations. Strengthening the government capacity and governing in a network makes no sense if those actions are not at the service of results and of the generation of public value, which, in turn, do not occur by chance, but demand the development of capacities and inter-institutional relationships aiming also at the efficient use of public resources and avoiding embezzlement, fraud and corruption.

2.2 Smart governance for smart cities

As climate change advances, local governments are forced to find ways to adapt to the worsening of environmental, economic and infrastructure impacts, balancing economic and political interests with adaptation actions that will require new approaches to adaptation governance (Mello and Slomski, 2010).

The governance of a smart city is complex and risky and therefore requires an appropriate governance system. To circumvent this stumbling block, a system that maximizes socio-economic development and the performance of city governance is needed (Ullah *et al*., 2021). An efficiency-oriented approach is important, that is, an instrumental approach that includes climate clear objectives and problem-oriented, political decision-making with effective goals (Hofstad *et al*., 2021).

To govern a smart city effectively, it's to consider factors such as transparency, public participation, cooperation, and open data access through digital tools. This approach enhances administrative efficiency by promoting collaboration, information sharing, service integration, and improved communication (Mazon, Rossetto, & Soares, 2018; Pinochet, Romani, Souza, & Rodríguez-Abitia, 2019).

Sustainability indicators are used to assist the measurement and evaluation of sustainable performance, whether in organizational settings or in public environments (Mazon *et al*, 2019). Recent years have witnessed the development of international indicator frameworks for assessing urban sustainability.

Citizens should engage with a focus on technology awareness, and the public sector must provide reliable infrastructure and services to support citizens' well-being within a sustainable city (Han and Kim, 2021). Additionally, ensuring credibility for decisions accepted by the population involves managing collaborative processes, inspiring technical credibility, and promoting empowerment, which are the key components of collaborative leadership in motivating collaborative policy making (Gonçalves et al., 2021).

2.2.1 The air in sustainable healthy smart cities

Vegetation preservation reduces air pollution and protects the ozone layer. Therefore, it is essential that urban spaces control air quality (Su *et al*. 2019; Li and Yi 2020). In cities where control is in place, such as New York, the risks of cancer and toxic elements in the air can create geographic patterns and help delineate risk bands to warn residents about necessary health care (Meerow, 2020).

Smart cities should provide warning systems for citizens about the condition of the air they breathe. To that effect, sensors and online platforms are needed to monitor air pollution and warn residents with the use of electronic maps, apps, and cell phone messages (Vukovic, Rzhavtsev and Shmyrev 2019).

Malang, Indonesia, for example, tests public transport and private motor vehicles gas emission. And, to mitigate the problems of air pollution and gas emissions, the city invested in urban forests. The results showed that in addition to cooling the air, pollution decreased considerably (Vukovic, Rzhavtsev and Shmyrev, 2019). Similarly, in Lisbon, Portugal, urban forests have reduced pollution and improved the urban landscape (Subadyo, Tutuko and Jato, 2019).

Thus, urban vegetation, in addition to improving people's quality of life, brings benefits to air quality such as: reducing pollution, cooling the air, and mitigating greenhouse gases. These indicators are correlated with the most economically developed cities and with sustainable production practices such as urban agriculture, which improve air quality (Brilhante and Klaas, 2018) and reduce urban noise. For this, the indicators of air decontamination, gain or loss of air moisture by region, air quality, percentage of native trees and noise pattern by area are defined (Deng, Peng, and Tang, 2019).

According to what has been presented, the first hypothesis of this investigation is H1 - There is governance influence on the air in sustainable healthy smart cities.

2.2.2 Green spaces in sustainable healthy smart cities

The focus on green spaces in urban areas is essential for sustainable urban development, emphasizing economic and political strategies (Kourtit et al., 2020). Increasing green infrastructure and urban vegetation is crucial for enhancing sustainability (Jing and Wang, 2020). Valuing green spaces should be based on five key pillars: economic growth, improved living conditions, biodiversity conservation, climate adaptability, and greenhouse gas reduction (Subadyo et al., 2019).

Urban green spaces provide shelter and food for various species, benefiting birds, small animals, and insects (Lima et al., 2019). These spaces are intentionally created to counteract the negative effects of urbanization and support ecological balance in urban environments (Bao and Toivonen, 2014).

In addition to enabling the fauna life, green areas promote improvements in the mental health of the urban population and can be correlated with lower mortality rates (Meerow, 2020; Brito *et al*., 2019). However, there is still no consensus on the best way to measure this finding. For this reason, indicators are used such as: rate of areas covered with forests, rainwater management, accessibility of green spaces, reduction of heat in the cities, improvement of air quality and visual comfort provided by the landscape (Meerow, 2020; Kourtit, Nijkamp and Soushi Suzuki, 2020).

Green areas drive the development of the territory, drive market forces; they impact political aspects and encourage communities. These, in turn, strengthen the market and promote a conscious consumption of environmental resources (Sokolov *et al.*, 2019). In Latin America, an important indicator is the accessibility of the population to green spaces. According to this indicator, people should take between five to ten minutes to reach them. In this connection, there are efforts to increase urban vegetation and develop, when necessary, fragmented green spaces (Steiniger *et al.*, 2020).

In the same way, green areas and parks provide, in addition to a visually pleasant environment, spaces for carrying out cultural activities. And these promote collective interaction, social cohesion, and the vitality of cities (Rosales, 2011). In China, in addition to green spaces per capita, there are other related indicators: noise pattern, proportion of ecological travel and access of residential areas to green areas (Deng, Peng and Tang, 2019). The safety of these places is also relevant for the promotion of quality of life (Wang and Peng, 2020).

According to what was presented, the second hypothesis of this investigation is H2 - There is governance influence on green spaces in sustainable healthy smart cities.

2.2.3 Health in sustainable healthy smart cities

Urban healthy ecosystem discussions address population well-being and social health using methods like problem-solving, ideal solution evaluation, and neural networks. Indicators like green space, unemployment, graduate students, built-up area, and income comparisons are used for assessment (Su et al., 2019). To enhance urban living standards, it's to bolster public health services, invest in infrastructure, and rebuild damaged areas. This includes providing essential services like water, electricity, schools, healthcare, and emergency access in underserved urban areas. These measures mitigate risks of endemic diseases, illiteracy, unemployment, violence, and terrorism (Su et al., 2019).

Smart migration policy must adapt the population to the location and improve health systems. Therefore, the improvement of the residents´ quality of life is related to these systems and to the guarantee of social protection provided by the cities. These rely on technologies based on electronic cards to guarantee health services that have unified records in the cities. Likewise, physicians are organized into clusters and have access to the patient database in a unified way. In addition, personalized medicines based on big data and artificial intelligence and remote health monitoring devices are developed to improve the quality of health care (Sokolov *et al.*, 2019).

It is assumed that the built urban environment has an impact on the physical, mental health, social connections, and economic development of its residents. Therefore, indicators related to the improvement of urban facilities, hospital beds and even the habits of the population should be established, such as levels of sports practice (Deng, Peng, and Tang, 2019).

In relation to basic care, indicators are proposed aimed at helping in communities, basic infrastructure, adequate transport, space for sports. Regarding well-being, the following indicators are suggested: friendly environments for women, assistance to minorities, immigration services, older citizens´ well-being and childcare. Finally, regarding development, the following is suggested: cooperation between public and private sectors, urban image, and use of technologies (Wang and Peng, 2020).

According to what was presented, the third hypothesis of this investigation is H3 - There is an influence of governance on health in sustainable healthy smart cities.

2.2.4 Transport in sustainable healthy smart cities

Smart traffic and parking are pivotal for smart city development, leveraging Big Data resources to enhance parking and bus services efficiency through artificial intelligence for predicting parking availability and bus schedules (Shamsuzzoha et al., 2021). The quality of public transport infrastructure, as indicated by mobility, is integral for urban sustainability

(Anand et al., 2017; Kourtit, Nijkamp, and Soushi Suzuki, 2020). A higher number of public transport vehicles positively impacts social security levels and urban mobility standards (Yang et al., 2019; Rosales, 2011).

In addition to public transport, it is essential that ecological transport services be developed based on eco-efficiency principles (Bao and Toivonen, 2014). Reducing fossil-based transport will reduce gas emissions and improve air quality. In addition, having options such as bike lanes and demarcated areas for pedestrians increases the value of homes and encourages a sense of responsibility and of belonging in the community (El Ghorab and Shalaby 2016).

Steiniger et al. (2020) propose using software to calculate public transport accessibility and its link to green spaces. Urban transport planning should consider access to green areas, leisure, and shared transport options. Indicators should evaluate sustainable transport, including travel time, accessibility, economic disparities, and transportation modes.

The current urban mobility model of large cities, such as Johannesburg, Shanghai, Buenos Aires, Berlin, Mexico City, Lagos, Delhi, New York, São Paulo, and London, demonstrates the predominant use of fossil fuel-based vehicles. This fact contributes to the deterioration of environmental conditions and increases the destruction of green spaces. It also reduces the quantity and quality of water, worsens urban traffic, generates traffic jams, and increases travel time (Brilhante and Klaas, 2018).

In China, the number of vehicle owners has increased, and public transport services are overloaded. Thus, the focus is the transport performance. To deal with the situation, car control policies should be implemented to reduce their quantity and circulation. In addition, street and city designs should be thought with the aim of providing adequate transport infrastructure and promote sustainability (Wang and Peng, 2020).

According to what was discussed, the fourth hypothesis of this research is H4 - There is an influence of transport governance in sustainable healthy smart cities.

Considering the objective of this investigation and the hypotheses addressed based on the indicators Air, Green Spaces, Health and Transport, Figure 1 shows the framework of our investigation.

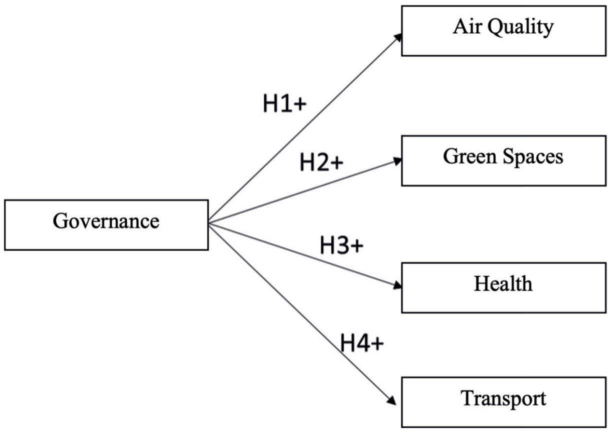


Figure 1 Investigation Framework

Source: Prepared by the authors (2021).

3 METHODOLOGY

The methodology of this research can be divided into Literature Review Procedures (3.1) and Indicator Development Procedures (3.2), which are qualitative stages of our research, where a literature review was necessary to arrive at the selected indicators and sub-indicators. The Data Analysis Procedures (3.3) employ a quantitative approach.

3.1 Literature Review Procedures

For data collection regarding the construction of the model, a systematic literature review was performed. For the theoretical framework we used articles collected in international databases. In the selection of the portfolio the research keywords were defined as follows: Sustainable cities; Green cities; Smart Cities and Cities Sustainable Development. For the search, the Boolean expression used was: (sustainab * AND city) OR (green AND city) OR (environment* AND city) OR (smart AND city) OR (healthy AND city), for the period 2010 - 2020.

This is how the raw database was formed. The next step was filtering: (1) redundancy; (2) title alignment; (3) representativeness of the article (number of citations) using the Google Scholar. We chose to consider all articles with more than one quote. Articles without a quote were only retrieved from the 2020 literature. The next step was to review the articles.

The literature of the selected articles was also reviewed which caused the retrieval of an article issued in the year 2000 that we included in the sample. These selected articles will be the basis for defining the indicators and the sub-indicators, as shown in Figure 2.

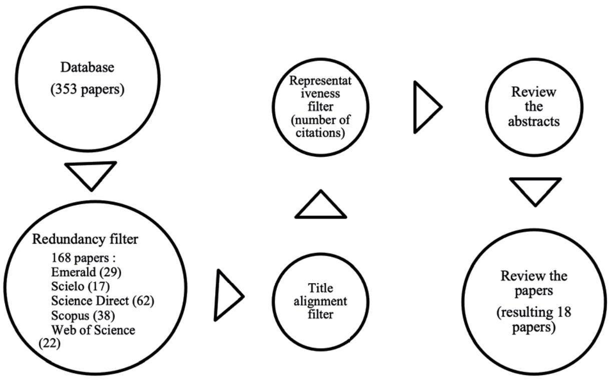


Figure 2 Database filters

Source: Prepared by the authors (2021).

3.2 Indicator Elaboration Procedures

To establish the indicators shown in Figure 3, we checked the most cited articles. Such articles allowed naming the indicators. Then, the sub-indicators were checked and tabulated according to the authors´ guidance. In the next step, the sub-indicators associated to each selected indicator were grouped, forming a set of sub-indicators for each indicator.

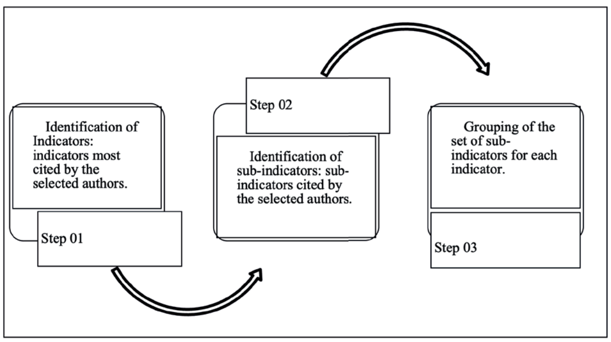


Figure 3 Indicator elaboration procedures

Source: Prepared by the authors (2021).

The indicators selected according to the methodology are as follows: (1) Governance Indicator, with 9 sub-indicators; (2) Air indicator, with 4 sub-indicators; (3) Green Space Indicator with 4 sub-indicators; (4) Health Indicator, with 15 sub-indicators; and (5) Transport indicator, with 15 sub-indicators.

3.3 Data Analysis Procedures

The research employed Google Forms for data collection and utilized descriptive statistics and the Partial Least Squares structural equation modeling technique for analysis. Following the methodology suggested by Saunders, Lewis, and Thornhill (2016), it adopted a quantitative approach involving standardized data collection and numerical data generation, allowing for hypothesis formulation, testing, and contributing to theory development. This research is conclusive, focusing on testing specific hypotheses and exploring relationships, and it is descriptive in nature, aiming to characterize a phenomenon and establish relationships between variables, like trust and perceived influence.

For the development of the collection instrument, as mentioned, models were initially sought in the literature that addressed the research topic and that had already been empirically tested. The dimensions listed in our study were identified, translated, reviewed, and adapted from existing models in the literature, aiming at obtaining compatibility with the subject and connection with the current research. Thus, the first version of the instrument had 47 questions covering the five dimensions.

Subsequently, the initial instrument underwent a pre-test. At first, a group of experts (comprising researchers, professionals in the sustainability area) reviewed the initial questionnaire and provided feedback indicating whether the instrument was easily understood and whether the sequence of items was consistent and adequate which led to some specific modifications, as recommended by Soares, Soares and Soares (2019).

Data collection took place between 06/27 and 08/18/2020, online, via Google Forms tool with release on social media and forwarding by email. In the data analysis, initially there was a verification of the completion and validation of the questionnaires received. A total of 75 questionnaires were collected and validated. Despite the non-probability sampling, this can be considered a homogeneous group, with at least one common characteristic: residents of greater Florianópolis, as recommended by Flynn, Kakibara, Schroeder, Bates, and Flynn (1990) and Hourneaux Jr, Gabriel, Gallardo- Vazquez (2018).

Then, the data collected were entered into Excel spreadsheets and analyzed using descriptive statistics and the technique of partial least square structural equation modeling, supported by the SmartPLS software, version 3.

4 DATA ANALYSIS AND RESULTS

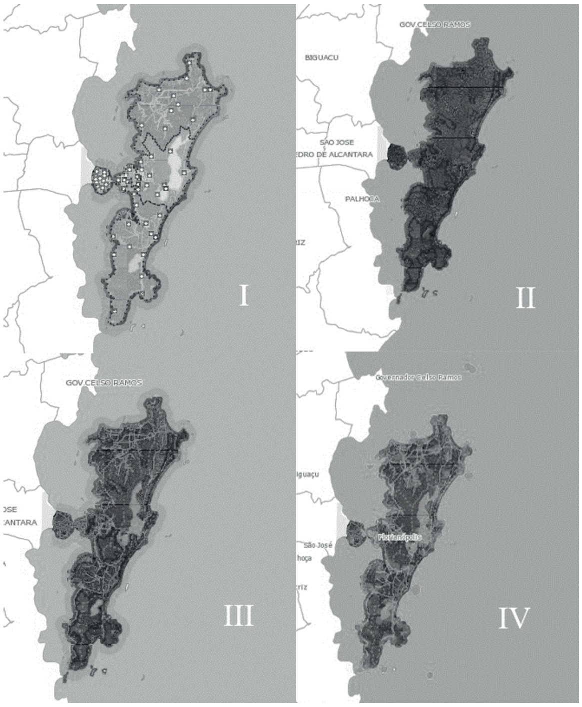
A total of 17 articles in connection with the topic addressed were reviewed during the period 2010 - 2020, according to the keywords described in the methodology. Later, an article issued in the year 2000 was included, as it is a relevant reference of one of the papers in the sample. From these articles, a strategic planning of a healthy sustainable smart city was developed with indicators on Governance, Air, Green Space, Health, and Transport. Subsequently, the PLS (Partial Least Squares) Analysis was carried out with the evaluation of the model, regarding the validity, reliability, and evaluation of the structural model.

4.1 Strategic Planning for a Sustainable Healthy City

Florianópolis is a city located in the state of Santa Catarina, Brazil. Most of city is spread on the Santa Catarina Island, which is 54 km in length. Figure 4 shows the city of Florianópolis.

Image I of Figure 4 presents the health units in 2013, considering polyclinics, health centers, headquarters, administration centers, zoonosis center and pharmacy schools. Image II presents the conservation units existing in Florianópolis; actually, the city has at least 41 conservation units including, Baleia Franca, Córrego Grande, Desterro, Dunas da Armação, Dunas da Lagoa da Conceição (natural park), Lagoa do Peri (municipal natural monument), Manguezal do Itacorubi (park), Serra do Tabuleiro (park), among others.

Figure 4 Health Units, Conservation Units, Sanitation and Archaeological Sites in Florianópolis.



Source: PMF (2021).

Image III of Figure 4 is related to sanitation in Florianópolis, where the provision of drinking water supply and sanitary sewage services is under the operational responsibility of Companhia Catarinense de Águas e Saneamento (Casan). Image IV presents in the highlighted points, the archaeological sites in Florianópolis; there are around 250 archaeological sites (FA, 2021).

The strategic planning of a sustainable healthy city is composed of 5 indicators that represent the sustainability dimensions; they include: (1) Governance; (2) Air; (3) Green Space; (4) Health; and (5) Transport.

Chart 1 presents the strategic map of the Governance Indicators, with the description of the indicator and sub-indicators, as well as the authors who established them.

Chart 1 Strategic Map for the Governance, Air, Green Space, Health and Transport indicators

Indicator		Description	Authors
Governance Indicator		Actions related to the governance of a city.	Brito, Ferreira e Pere-Gladish (2019); Sokolov et al. (2019); Anand, Rajkuma e Suganthi (2017); Pinochet, Romani, Souza e Rodríguez-Abitia (2019); Taecharungroj, Tachapattawora e Rattanapan (2018); Rosales (2011); El Ghorab e Shalaby (2016)
Sub-indicators	Environmentally preferable purchases	Purchases that benefit the environment.	El Ghorab e Shalaby (2016)
	Corruption Index	Level of illicit activities within a government.	Anand, Rajkuma e Suganthi (2017); Wang e Peng (2020)
	Municipal budget dependency	Amount used from the budget of a municipality in projects.	Steiniger et al. (2020)
	Popular participation	Presence of the population in decision-making.	Subadyo, Tutuko e Jati (2019)
	Participation in elections	Public participation in elections	Steiniger et al. (2020)
	Savings potential	Possible growth for an economy.	Anand, Rajkuma e Suganthi (2017)
	Governance indices	Calculation of the Governance Index	Rosales (2011)
	Access to government information (online)	Amount of information available about the government.	Steiniger et al. (2020)
	Effectiveness of government administration	Level of competence in government administration.	Wang e Peng (2020)
Air Quality Indicator		Air quality found in a city	El Ghorab e Shalaby (2016); Meerow (2020); Sokolov et al. (2019); Langellier et al. (2019); Mueller et al. (2020)
Sub-indicators	Temperature	Temperature found in a city	Mueller et al. (2020)
	Daily levels of particulate matter	Index of daily levels of suspended particles	Brilhante e Klaas (2018)
	Air noise level	City air noise level	El Ghorab e Shalaby (2016); Anand, Rajkuma e Suganthi (2017)
	Air quality level	Level of air quality found in the city	El Ghorab e Shalaby (2016); Meerow (2020); Anand, Rajkuma e Suganthi (2017); Sokolov et al (2019); Rotmans, Asselt e Vellinga (2000); Langellier et al. (2019); Mueller et al. (2020); Steiniger et al. (2020).

Indicator		Description	Authors
Green Spaces Indicator		Availability of green spaces for sports and leisure.	Meerow (2020); Yang et al. (2019); Subadyo, Tutuko e Jati (2019); Rotmans, Asselt e Vellinga (2000); Sokolov et al. (2019); Kourtit, Nijkamp e Suzuki (2020); Langellier et al. (2019); Mueller et al. (2020); Lowe et al. (2020); Subadyo, Tutuko e Jati (2019); Steiniger et al. (2020); Giles-Corti, Lowe e Arundel (2019)
Sub-indicators	Access to green spaces	Availability of green spaces for the population	Meerow (2020); Yang et al. (2019); Subadyo, Tutuko e Jati (2019); Rotmans, Asselt e Vellinga (2000); Sokolov et al. (2019); Kourtit, Nijkamp e Suzuki (2020); Langellier et al. (2019); Mueller et al. (2020); Lowe et al. (2020); Subadyo, Tutuko e Jati (2019); Steiniger et al. (2020); Giles-Corti, Lowe e Arundel (2019)
	Urban agriculture	Presence of agriculture in urban areas	Subadyo, Tutuko e Jati (2019)
	Public green area per capita	Amount of green area per inhabitant	Mueller et al. (2020)
	Fitness park and square	Presence of Fitness Park and Square available to the population	Jing e Wang (2020); Yang et al. (2019); Meerow (2020); Langellier et al. (2019); Giles-Corti, Lowe e Arundel (2019)
Health Indicator		Availability of resources that provide the health of the population of a city	Deng, Peng e Tang (2019); Rosales (2011); He et al. (2020); Langellier et al. (2019); Mueller et al. (2020); Steiniger et al. (2020); Jing e Wang (2020); Li e Yi (2020)
Sub-indicators	Accessibility of Health Services	Health service accessible to the population	Rosales (2011); He et al. (2020)
	Nutritional literacy	Availability of nutrition professionals.	Langellier et al. (2019)
	Health impact assessment	Impact of actions on health	Mueller et al. (2020)
	Firefighter emergency coverage	Scope of firefighter emergency coverage	Steiniger et al. (2020)
	Medical emergency coverage	Scope of emergency medical cove-rage	Su et al. (2019)
	Police emergency coverage	Scope of police emergency coverage	Steiniger et al. (2020)
	Major chronic cases: diabetes, cancer	Number of main chronic cases: diabe-tes, cancer	Giles-Corti et al. (2019)
	Number of patients due to infectious disease	Number of patients as a result of infectious disease	Giles-Corti et al. (2019)
	Number of patients due to respiratory disease	Number of patients as a result of respiratory disease	Giles-Corti et al. (2019)
	Effectiveness of health services	Competence of the health service to meet the needs of the population	Steiniger et al. (2020)
	Beds per capita	Hospital beds per inhabitant	Jing e Wang (2020); Li e Yi (2020)
	Number of doctors per popu-lation number	Number of doctors available to the population	Steiniger et al. (2020)
	Number of patients due to traffic accident	Number of injured people as a result of an accident	Steiniger et al. (2020)
	Taxation of ultra-processed foods	Taxation of ultra-processed foods to discourage consumption	Langellier et al. (2019)
	Access to food with sustainab-le and quality production	Availability of healthy food.	Bao and Toivonen (2014); Langellier et al. (2019); Anand, Rufuss, Rajkumar, and Suganthi (2017); Rosales (2011); Giles-Corti et al. (2019); He et al. (2020); Steini-ger et al. (2020).

Indicator		Description	Authors
Transport Indicator		Actions aimed at transporting a city.	Brito, Ferreira e Peres-Gladish (2019); VR512; Bao e Toivonen (2014); Pinochet et al. (2019); Taecharungroj, Tachapattawora e Rattanapan (2018); Sokolov et al. (2019); Giles-Corti, Lowe e Arundel (2019)
Sub-indicators	Destination accessibility	Ease of moving from one location to another	Giles-Corti, Lowe e Arundel (2019); Brilhante e Klaas (2018)
	Access to public transport	Ease of access to public transport in a city	Su et al. (2019); Bao e Toivonen (2014); Deng, Peng e Tang (2019); Langellier et al. (2019); Lowe et al. (2020); Giles-Corti, Lowe e Arundel (2019); Subadyo, Tutuko e Jati (2019); Alyami (2019)
	Transport Maintenance	Beware of transport maintenance	He et al. (2020)
	Road conditions	Quality found on a road	Anand, Rajkuma, Suganthi (2017)
	Travel distance (housing demographics)	Average distance traveled for population displacement	Giles-Corti, Lowe e Arundel (2019); Anand, Rajkuma, Suganthi (2017)
	Transport Diversity	Number of shipping options	Subadyo, Tutuko e Jati (2019); Anand, Rajkuma, Suganthi (2017); Sokolov et al. (2019); Lowe et al. (2020); Langellier et al. (2019); Giles-Corti, Lowe e Arundel (2019)
	Installation for pedestrians and disabled people	Transport infrastructure for pedestrians and disabled people.	Alyami (2019); Subadyo, Tutuko e Jati (2019)
	Street investments to reduce jams	Resources for streets to reduce congestion.	Langellier et al. (2019); Su et al. (2019).
	multimodal mobility	Presence of different means of displacement.	Sokolov et al (2019); Brilhante e Klaas (2018)
	Car, bicycle parks	Locations specifically intended for parking.	Alyami (2019)
	Congestion price	Money spent on transport in the presence of congestion.	Sokolov et al (2019)
	Number of buses in relation to population	Number of buses available to the population	Su et al. (2019)
	Number of Private Vehicles in relation to the population	Number of private vehicles used by the population.	Deng, Peng e Tang (2019); Giles-Corti, Lowe e Arundel (2019)
	Road traffic noise	Amount of noise pollution caused by road traffic.	Mueller et al. (2020)
	Cheap and low emission transport	Low-priced transport quantity with little emission of pollutants.	Subadyo, Tutuko e Jati (2019); Sokolov et al (2019)
	Number of Private Vehicles in relation to the population	Number of private vehicles used by the population.	Deng, Peng e Tang (2019); Giles-Corti, Lowe e Arundel (2019)
	Road traffic noise	Amount of noise pollution caused by road traffic.	Mueller et al. (2020)
	Cheap and low emission transport	Low-priced transport units with little emission of pollutants.	Subadyo, Tutuko e Jati (2019); Sokolov et al (2019)

Source: Prepared by the authors (2021)

Smart city indicators, as outlined by Pinochet, Romani, Souza, and Rodríguez-Abitia (2019), include transparency, public participation, cooperation, and open data access using digital technologies. These factors promote efficient administration through collaboration, information exchange, and service integration. Improving air quality involves promoting non-motorized transport infrastructure like bicycles and walking to reduce a city's carbon footprint (Anand et al., 2017). Overcrowding and air pollution in cities like Egypt lead to infrastructure strain and government expenses (El Ghorab and Shalaby**, 2016).**

Green spaces play an important role in the lives of people and animals and improve the quality of the urban environment. Urban vegetation areas impact the health of individuals by allowing outdoor recreation and improving air quality (Meerow, 2020). Therefore, cities based on the principle "I pollute now, I clean later" should yield to concerns with natural resources, as these constitute urban development drivers (Ruan, Yan and Wang, 2020).

Social health addresses the relationships between people and their environment. These should promote quality of life and usually depend on economic conditions that impact well-being and the availability of health services (Ruan, Yan and Wang, 2020). Its control occurs through the maintenance of indicators such as: increase in the number of hospital beds and health centers (Yang *et al*., 2019), good rates of healthy life expectancy, community maturity, and number of doctors per population group (Kourtit, Nijkamp and Soushi Suzuki, 2020).

Social integrity and social equity concern the creation of conditions for this to happen in the urban territory. Such conditions can be assessed through indicators such as: population density and growth, expenditure on education and on science and technology (Li and Yi, 2020). In Greece, for example, the analysis of social integrity and equity is developed through the provision of regional health services based on medical specialties, such as: centers for eyes, heart, cancer, among others (El Ghorab and Shalaby 2016).

In Russia, transport is based on aspects such as: alternative energy, reducing the costs of traffic jams and reducing the waiting interval in public transport. Some Russian cities are looking to adopt smart, unmanned, and collective cars as an alternative to individual cars (Sokolov *et al*., 2019).

In summary, the studies carried out on sustainable cities indicate that global movements need local actions, social participation, and public governance for the efficient application of public resources. In this connection, one of the main assumptions for effective social participation is the transparency of public acts and accounts. Thus, social participation in the public policy process allows for the sustainable development of cities based on good public governance practices. And it enables interdisciplinary and innovative solutions that take advantage of the intelligence, knowledge and skills of different players that make up the city's ecosystem.

4.2 PLS (Partial Least Squares) Analysis

In this subsection, the analysis of partial least squares will be carried out, through two stages: evaluation of the measurement model and analysis of the structural model, both of which will be further broken down.

4.3 Model evaluation - Validity and Reliability

The model evaluation began through its convergent validity, reliability, and discriminant validity, as recommended by Hair Junior *et al.* (2017). First, the cross-factor loadings were evaluated, according to the Chin (1998) criterion, which proved to be adequate, as provided in Table 1.

With values greater than 0.6, the factor loadings are adequate, and it is also verified that the factor loadings of the Observed Variables (OV) in the original Latent Variables (LV) are higher when compared to the other constructs.

Subsequently, the discriminant validity was evaluated according to the Fornell–Larcker criterion. Table 2 presents the values of the correlations between latent variables and square roots of the Advertising Value Equivalency (AVE) on the main diagonal (highlighted).

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Table 1 Values of the cross loads of the variables observed in the latent variables

Variables	Air	Governance	Green Spaces	Health	Transport
Air01	0.798	0.531	0.518	0.470	0.564
Air02	0.832	0.597	0.622	0.620	0.660
Air03	0.784	0.530	0.653	0.648	0.659
Air04	0.795	0.483	0.569	0.586	0.515
Gov01	0.447	0.744	0.464	0.470	0.441
Gov02	0.417	0.638	0.405	0.519	0.513
Gov04	0.345	0.709	0.318	0.289	0.338
Gov05	0.680	0.732	0.503	0.534	0.594
Gov06	0.530	0.774	0.430	0.450	0.483
Gov07	0.366	0.690	0.455	0.469	0.599
GSpace01	0.633	0.585	0.873	0.468	0.653
GSpace02	0.389	0.346	0.710	0.301	0.500
GSpace04	0.700	0.530	0.859	0.560	0.672
Health02	0.658	0.543	0.623	0.679	0.537
Health05	0.579	0.527	0.415	0.706	0.603
Health07	0.517	0.408	0.458	0.776	0.650
Health08	0.458	0.426	0.482	0.731	0.626
Health09	0.436	0.378	0.410	0.689	0.649
Health10	0.453	0.499	0.174	0.696	0.447
Health11	0.467	0.458	0.262	0.765	0.423
Health12	0.656	0.549	0.395	0.845	0.529
Health13	0.532	0.529	0.569	0.790	0.572
Health14	0.486	0.513	0.403	0.769	0.521
Health15	0.522	0.463	0.433	0.830	0.535
Health16	0.700	0.539	0.393	0.766	0.611
Transp02	0.560	0.664	0.636	0.551	0.768
Transp04	0.636	0.581	0.579	0.639	0.816
Transp05	0.493	0.564	0.604	0.531	0.742
Transp06	0.527	0.565	0.596	0.508	0.773
Transp07	0.585	0.553	0.539	0.627	0.756
Transp09	0.502	0.481	0.597	0.448	0.737
Transp11	0.600	0.452	0.525	0.606	0.740
Transp12	0.645	0.547	0.571	0.550	0.833
Transp13	0.588	0.490	0.461	0.589	0.740
Transp14	0.580	0.411	0.583	0.546	0.669

Source: Prepared by the authors, based on research data (SMARTPLS3®, 2021).

Table 2 Correlations values between LV and square roots of AVE values on the main diagonal (highlighted)

	Air	Governance	Green Spaces	Health	Transport
Air	0.803				
Governance	0.670	0.716			
Green Spaces	0.737	0.612	0.817		
Health	0.724	0.653	0.556	0.755	
Transport	0.751	0.709	0.752	0.736	0.759

Source: Prepared by the authors, based on research data (SMARTPLS3®, 2021).

It is verified that all the values of the correlations between the latent variables are smaller than the square roots of their AVEs; therefore, the Fornell–Larcker criterion was met.

The results of the Heterotrait-Monotrait Ratio (HTMT) criterion are presented in Table 3.

Table 3 HTMT criterion

	Air	Governance	Green Spaces	Health	Transport
Air					
Governance	0.794				
Green Spaces	0.906	0.745			
Health	0.820	0.723	0.644		
Transport	0.687	0.791	0.891	0.803	

Source: Prepared by the authors, based on research data (SMARTPLS3®, 2021).

Results below 0.90 show discriminant validity of their latent variables according to the HTMT criterion.

Finally, internal consistency values were evaluated using Cronbach's Alpha and composite reliability. Table 4 shows these values, together with the values related to AVE.

Table 4 Values related to the internal consistency of the model and AVE

Dimension	Cronbach's Alpha	Composite Reliability	AVE
Air	0.816	0.879	0.644
Governance	0.810	0.863	0.512
Green Spaces	0.755	0.857	0.668
Health	0.931	0.941	0.570
Transport	0.918	0.931	0.676

Source: Prepared by the authors, based on research data (SMARTPLS3®, 2021).

AVE values greater than 0.6, indicate compliance with the convergent validity of the latent variables. It can also be seen in Table 4 that the constructs´ Cronbach's alpha are greater than 0.70. Also, the reliability criterion was met, through the composite reliability indices, which were higher than 0.8.

To meet the statistical prerequisites for the validity of the variables, indicators were excluded from the model. Thus, the model has convergent and divergent validity of its observed variables and latent variables, as well as internal consistency.

Therefore, upon validation of the measurement model, based on the criteria described above, the next subsection will deal specifically with the analysis of the structural model.

4.4 Evaluation of the structural model

The first evaluation carried out consisted of the collinearity analysis, using the Variance Inflation Factor (VIF). Consideration should be given to removing indicators if the level of collinearity is too high, as indicated by a VIF value of ten or greater. Table 5 shows these values.

As all values are less than seven, it was decided to keep all variables. Subsequently, Pearson's coefficients of determination (R^2) were evaluated. The R^2 function is to evaluate the portion of the variance of the dependent variables, which is explained by the structural model. Figure 5 presents the structure of the measurement model, with R^2 values and path coefficients.

The dependent variables present R^2 above 0.26, indicating a high degree of explanation, according to the classifications by Cohen (1988) and Hair Junior *et al*. (2017). The model explained a substantial part of the variation in transport (50.3%), green spaces (37.4%), Air Quality (44.9%) and health (42.6%).

Table 5 Values related to the Variance Inflation Factor (VIF).

Air01	1.787	**Health10**	3.131
Air02	1.887	**Health11**	4.806
Air03	1.745	**Health12**	4.468
Air04	1.841	**Health13**	3.525
GSpace01	1.656	**Health14**	4.742
GSpace02	1.363	**Health15**	6.650
GSpace04	1.679	**Health16**	3.243
Gov01	1.691	**Transp02**	2.144
Gov02	1.389	**Transp04**	2.612
Gov04	2.092	**Transp05**	3.968
Gov05	1.535	**Transp06**	4.241
Gov06	2.194	**Transp07**	2.063
Gov07	1.466	**Transp09**	2.161
Health02	2.107	**Transp11**	2.603
Health05	1.990	**Transp12**	3.202
Health07	4.541	**Transp13**	3.471
Health08	4.444	**Transp14**	2.000
Health09	3.926		

Source: Prepared by the authors, based on research data (SMARTPLS3®, 2021).

To test the significance of the identified relationships, the bootstrapping technique was used. Thus, a bootstrapping resampling procedure and analysis was performed with 5,000 bootstrap samples per group. As can be seen in Chart 2, all hypotheses are above the reference value (1.96) in the T Statistics, supporting the hypotheses at p value 1%. In this case, the H_0 were rejected, and it can be said that the correlations and regression coefficients are significant, providing support for this part of the proposed model.

Chart 2 Hypothesis Test

Hypothesis	Path	T Statistics	P Values	Results
H1	Governance ➡ Air	8.082	0.000	Supported
H2	Governance ➡ Green Spaces	4.691	0.000	Supported
H3	Governance ➡ Health	6.592	0.000	Supported
H4	Governance ➡ Transport	6.962	0.000	Supported

Source: prepared by the authors (2021).

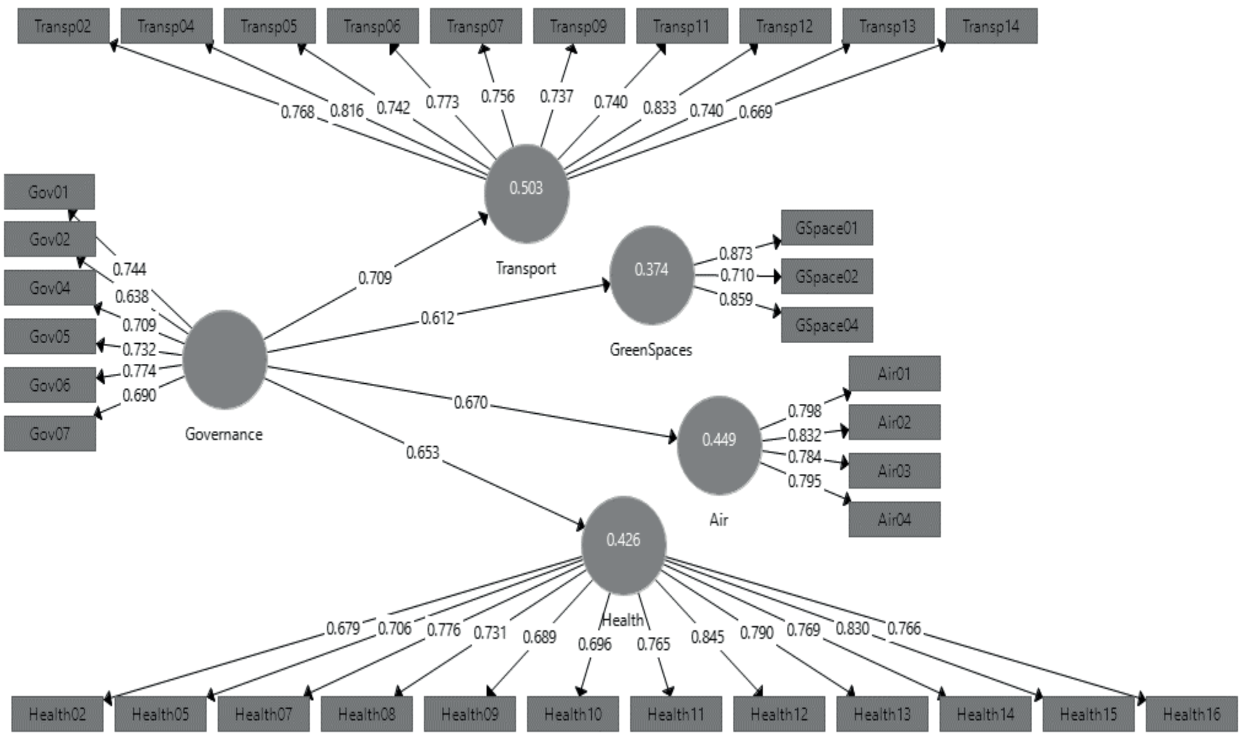

Figure 5 Proposed model, R^2 and path coefficients

Source: SmartPLS3® (2021).

The result found indicates that the consulted sample of the Florianópolis population believes that Governance has an impact on the indicators of Air, Green Spaces, Health, and Transport giving emphasis, though, to the indicator air (8,082) as being the most relevant and to green spaces (4,691) as the least relevant. This result may be due to the numerous natural green areas that the city has and environmental preservation, which already supports the green areas. Florianópolis, being an island, is surrounded by natural spaces and therefore, the population may be less concerned about green areas, since many of its inhabitants can choose to perform physical activities on one of its several beaches.

Boca Santa et al. (2023), when analyzing social, environmental, and economic indicators in the city of Florianopolis, identified that the population prioritizes investments in education, sanitation, and urban quality of life. This research, even though it examines different indicators, corroborates with Boca Santa et al. (2023) as it identifies the priorities for the city of Florianopolis from the perspective of a portion of the population.

The governance indicator with the highest R-squared value was 6, related to the possibility of economic growth, which demonstrates a concern with economic-related indicators as well. Regarding air quality, there is a concern about daily levels of suspended particles. This concern is surprising for a coastal city, largely situated on an island, with extensive environmental preservation and no industries.

Access to green spaces also considered important for the population. Florianopolis has many parks and beaches. As for healthcare, the number of doctors per population was considered more relevant. Finally, the number of buses in relation to the population was considered significant.

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5 CONCLUSION

This research aimed to verify the existence of the governance impact on the indicators associated with health, transport, green spaces, and air. According to the analysis carried out, it was possible to draw the strategic map of the indicators in question through qualitative research and through statistical analysis. This allows us to conclude that the governance indicator has a direct impact on health, transport, green spaces, and air indicators.

This research aims to contribute to the literature, since it presents a literature framework on the theme of smart, healthy, and sustainable cities and management indicators. It further contributes to academic purposes as it presents an efficient methodology for the elaboration of a strategic map and statistical model. Finally, the research contributes to practical purposes, as it offers city managers a model capable of assisting in the management and monitoring of governance in relation to transport, green spaces and air pollution indicators.

This work is original when questioning the population of the Greater Florianopolis about indicators of sustainable healthy smart cities in relation to governance. The city of Florianopolis is the capital of the state of Santa Catarina, in southern Brazil. It is a coastal city with an economy based mainly on information technology and tourism. The work presents a methodological contribution by listing a series of indicators and sub-indicators based on the literature. In addition, the theoretical contribution by listing a literature framework relevant to the investigation subject.

The study is limited to the case of Florianopolis and to the methodology adopted since only a portion of the population was analyzed for the research. Future works are already being carried out aiming at the continuity of the model containing 10 indicators. We suggest the application of these indicators in other cities to verify the impact of governance in other indicators and other connections.

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