Healthy Sustainable Cities and the COVID-19 Pandemic: A Sustainable Development Goals Perspective

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Abstract The world is experiencing a pandemic caused by the SARS-CoV-2 virus, which develops the disease COVID-19. Taking care of yourself and others are attitudes considered more than a norm or suggestion, it is an attitude governed by common sense and also, an act of love. A new reality for many: work at home or with protective equipment; home studies; limitations when leaving home (use of mask, alcohol gel, and temperature measurement in different environments); excessive hygiene; numerous surveys (products, services, medicines, vaccines); hospital products and equipment. The importance and benefits of living in a sustainable city have become even more evident. Investments and emergency aid, water management, waste management, home education, health, are old needs, even more evident in a new reality. A sustainable city aims to develop responsibly, taking into account the triple bottom (economic, social, environmental). Based on this context, the objective of this research is: How the concept of sustainable cities can contribute in a pandemic context. This research aims to contribute theoretically, by addressing a series of measures and actions, foreseen in a sustainable city and that can positively help the population, when they find themselves in a pandemic. Still, there is a practical and social contribution, as the research contributes to the management of cities, aiming for smart, healthy and sustainable cities, focusing on education, security, and public health.

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1 Introduction

There are several transformations and changes underway in the world, of varied nature: socioeconomic, environmental, technological, and cultural change are accompanied by intense urbanization and a strong feeling that there are crises in governance and values, as well as a lack of a forward-looking vision that is capable to meet the new challenges that appear in such a fast environment (GPS 2013).

With an analysis of the information found in the "Guia da Gestão Pública Sustentável" (GPS), which stands for a Guide for Sustainable Public Management, Brazil fits that picture perfectly: one of the most challenging questions this country faces today is how to balance economic development, environmental sustainability and social justice through transparent, and democratic governance.

The GPS Guide addresses this question systemically and horizontally. There is no way to solve these problems separately, or to abandon one issue momentarily and come back to it later: the socioeconomic crisis needs to be solved within the natural limits imposed by the planet, reverting tendencies such as extreme climate change and the depletion of natural resources, while not overlooking the importance of solving social inequalities. Such solutions need to take into account that there is urgency in the temporal dimension, and there is no time to lose.

The GPS Guide is based on the sustainable development goals (SDGs) created by the United Nations (UN) in 2015 with the approval of its 192 countries to guide policy-makers into creating a more sustainable planet for future generations. The 17 goals set up by this Agenda are composed of 169 indicators and cover social, environmental, and economic development.

One of these goals is SDG 11: "make cities and human settlements inclusive, safe, resilient, and sustainable" [52]. This goal cannot be reached on its own, since several factors need to be considered, and issues such as energy, water, health, and environmental protection connect SDG 11 to the other SDGs.

To use transparent and participatory processes to achieve SDG 11 in Brazil, the GPS [23] has presented a sustainable cities program. This program is to be constantly under construction, but its starting point is the assumption that a new paradigm of development is possible, necessary, and urgent. The sustainable cities program seeks to attach the idea of change to ongoing experiences and opportunities that can be useful in the building of a new development model.

Sustainability is a broad concept, and its definition demands holistic, and multidisciplinary views. In order to measure how sustainable or unsustainable something is, a series of indicators, criteria, and goals are generally used. This logic also applies to sustainable cities: such a city needs to have sustainability as the premise of its many actions, operations, services, and infrastructure.

In the effort to reach sustainable cities, specific terminology has emerged, bringing innovative concepts: a "compact city", emphasizing density; "eco-city", highlighting cultural and ecological diversity; "neotraditional development", seeking sustainable transport and land use; "urban contention", striving for containing urban expansion; "smart city", stressing cities that use technological innovation to create efficiency, sustainability, and quality of life; "healthy city", a concept crafted by the World Health Organization (WHO) underscoring human health; and "sustainable city", which provides a global view of operations and services in a city [8]. In this research, we will use the terms smart cities, sustainable cities, and healthy cities.

The GPS [23] recommends that modern urban planning must have a sustainability-based framework that encompasses areas such as economic, cultural, social, ecological, technological, demographic, and tributary. Such a framework could provide for an integrated view of issues and connect local policy-making.

The strategic planning proposed by GPS [23] focuses on a systemic and participatory view, considering short, medium, and long-term projects—so that continuity will be assured, especially in infrastructure projects, which normally take longer. The planning also suggests that observable target are set, so that the public can transparently follow progress.

All of these problems already existed in early 2020, when the SARS-CoV-2 was identified in China. The COVID-19 pandemic that followed has had profound impacts on cities, by bringing the economy and social interactions to a halt, threatening livelihoods and jobs, made transport more difficult and crowded hospitals [38].

The COVID-19 pandemic spread swiftly around the world, creating broad and multidimensional repercussions on national and international dynamics, and posing a series of implications for human relations [42]. People and firms were forced to innovate and look for new ways of going about their activities, especially with more people working from home, which demanded adaptations in home infrastructures and improvements in hygiene.

Cities were promptly exposed and saw themselves in danger. For a long time, cities have been looking for resilient and sustainable solutions to a series of problems, ranging from fighting for urban spaces or political, financial, geographical, or environmental calamities, all, while managing their visible asymmetries and disparities [38]. The author adds that the fast-paced rhythm of change felt in the cities needs to be reversed in order to find new solutions and languages to create changes in cities.

Many of the adaptations that need to be made, presented in the concepts of healthy, smart, and sustainable cities, are a consensus among urban dwellers: the creation of green areas for sports and leisure, investments in hospital bed and support for health professionals, lower emission of pollutants, clean energy, access to quality housing, development of new technologies of information and better governance.

This chapter has as its proposal to draw a parallel between the needs imposed by the COVID-19 pandemic and the characteristics of sustainable cities to determine how a sustainable city could be effective in the context of a pandemic.

2 Literature Review

The literature review is divided into three themes: (2.1) The COVID-19 pandemic; (2.2) Healthy smart sustainable cities and their characteristics; and (2.3) the COVID-19 pandemic and the healthy smart sustainable cities.

2.1 The COVID-19 Pandemic

The Brazilian Ministry of Health [10] highlights that the coronaviruses are a known family of viruses observed in several animals, such as cattle, camels, cats, and bats. On rare occasions, viruses of this family have infected humans, but the MERS-Cov and the SARS-CoV were two examples. In December 2019, a new virus appeared: the SARS-CoV-2 was identified in China and provoked a disease that spread quickly, the COVID-19.

People infected with COVID-19 have presented different clinical pictures, ranging from asymptomatic infections to serious conditions. The World Health Organization (WHO) affirms that most of the patients (around 80%) will face few or no symptoms, and the other 20% of the patients will need to be admitted to the hospital facing symptoms such as breathing difficulty. The Brazilian Health Ministry [10] adds that the most common symptoms are similar to those observed in a common cold: coughing, fever, sore throat, breathing difficulty, temporary losses in the senses of taste and smell, and tiredness.

The SARS-CoV-2 is transmitted through respiratory droplets and is capable to lodge in several surfaces such as tables, chairs, walls, floors, and even medical equipment. In facing this pandemic, such surfaces must be cleaned regularly, especially in environments where the presence of the virus is known, such as hospitals [59]. When there is large-scale community transmission, there is a need to monitor hygiene in every environment.

The WHO [59] states that "contact transmission occurs when contaminated hands touch the mucosa of the mouth, nose, or eyes; the virus can also be transferred from one surface to another by contaminated hands, which facilitates indirect contact transmission". The transmission of the virus was associated with physical contact between individuals in closed environments—such as houses, health clinics, workplaces, schools, and others—so the recommendations for stopping the spread are to practice social distancing, using masks, washing hands frequently, and using alcohol gel.

The WHO [59] (p 1) further recommended to its member-states improvements in hygiene and "providing universal access to public hand hygiene stations and making their use obligatory on entering and leaving any public or private commercial building and any public transport facility", while "improving access to hand hygiene facilities and practices in health care facilities". The problem is that many cities, especially

in low-income countries, find trouble in making hygiene products available for their citizens.

Such protocols and technical recommendations were widely shared among governments and populations alike, and different sectors of society have organized themselves to produce further information about how people can protect themselves. The sustainable cities program has suggested practices such as urban strategies; social assistance; employment and wages; public health; transparency and communication; and webs of support.

2.2 Healthy Smart Sustainable Cities and Its Characteristics

Cities play a crucial role in the global sustainable development agenda: more than 54% of the world's population live in cities, and it is expected that at least 60% of the world will be urban dwellers by 2030. The idea of urban sustainability is widely discussed in the literature and among international institutions, in order to help cities to overcome social, economic, and environmental challenges and provide quality of life for their citizens, while considering the concerns of future generations [7].

Fabris et al [20] understand cities as living organisms: they are in constant transformation under the influence of geographic, environmental, cultural, social, demographic, political, institutional, and economic shifts. It is hard to compare urban spaces in space and time since each city has specific challenges in their urbanization.

The term "sustainable city" has emerged in the 1990s, right after the first conceptualizations of "sustainability". At the time, environmentalists, economists, and activists around the world criticized the process of economic development and the living standards in developed countries, considering that those activities led to high levels of consumption and an exaggerated waste of natural resources, creating social imbalances and pollution on water and air [7].

Sustainable cities, as defined by Fabris et al [20], are the cities that prioritize the implementation of a set of practices and infrastructure that allows them to meet the goals set by the Brundtland Report—a reference on the meaning of sustainability—and the 2030 Agenda, which set the SDGs. These cities emphasize social and individual rights and are referred to, in literature, by several names: green cities, digital cities, smart cities, information cities, knowledge cities, resilient cities, low-carbon cities, eco-cities, and omnipresent cities.

Ferreira et al [20] classify sustainable cities as those which preserve their green areas, maintaining their original ecosystems in an urban setting. The authors highlight that greener cities provide their citizens with a better quality of life, since they preserve the quality of air and climate, also facilitating the recovery of water systems.

In this scenario, quality of life and socioenvironmental balance are extremely important for sustainable cities to develop [19]. For that reason, a culture that prioritizes the environmental questions and the preservation of species must be developed.

Reference [9] claims that there is no such thing as a sustainable city, but cities that seek for sustainability. Thus, sustainable cities are a progressive process of implementation of sustainability criteria, and this process demands a series of values, attitudes, and principles—in public and private spheres.

Sustainable cities are also connected with smart cities: [3] argue that a smart city needs to be efficient and sustainable, combining a high quality of life with an optimization of resources. The authors further claim that sustainability must be one of the focuses of smart cities.

Reference [17] claims that the concept of smart cities must consider concepts such as sustainability and quality of life—but also taking into account technological and informational components.

Smart cities are those that show clean transportation, the use of alternative energies, and intense use of technology [45]. Smart cities use information and communications technology (ICT) and other technologies to make their actions more effective and improving the quality of services (QoS) [8, 44, 62].

Reference [44] defends that the smartness or intelligence of a city is a desire to perfect it based on the sustainability triple-bottom-line of social, environmental, and economic realities. The authors believe that smart cities are based upon four pillars: institutional infrastructure, physical infrastructure, social infrastructure, and economic infrastructure.

The third world cities, as [9] calls them, tend to pollute, urbanize and destroy systematically their own fundamental environmental support. Such attitudes also worsen existing housing crises and slums sometimes appear in ecological sanctuaries and vital river basins.

The search for a sustainable city entails challenges to make the local economy dynamic, creative and sustainable, by finding alternatives to traditional economic growth that will reflect on the quality of life and welfare for the population [19].

Bento et al. [20] add that sustainable cities demand the conservation and maintenance of natural resources, considering the importance of developing territorial planning that fits the need of each town. Cities, while they are not natural ecosystems, are linked in a systemic and interdependent process, and this system needs new urban governance to solve its conflicts.

To complement this discussion, Table 1 presents the 12 thematic axes in the sustainable cities program, each with its description.

The sustainable cities program has as its goal the promote sustainability and welfare of societies. To measure the environmental impacts of a city, [9] proposes using “ecological footprint”, a term first used by Willian Rees. This method focuses on calculating the amount of productive land that is used, in hectares. The calculation shows that many cities and countries demand a much larger area than they actually use, while also considering the transfer of costs and impacts to other regions in the country.

Another way to measure the efficiency and efficacy of sustainable policies and practices is suggested by [57]: using environmental and economic indicators. Urban sustainable development must act on the premise that its principles and applications need to be constantly updated, as societies and contexts are also always changing.

Table 1 The axes of the sustainable cities program

Axes	Description
Governance	Strengthening decision-making processes by promoting participatory democracy instruments
Common natural resources	Taking full responsibility to protect, preserve, and warrant balanced access to common natural resources
Equity, social justice, and culture of peace	Promoting inclusive and solidary communities
Local management for sustainability	Implementing efficient management that covers planning, execution, and evaluation
Urban planning and design	Recognizing the strategic role played by urban planning and design in dealing with environmental, social, economic, cultural, and health problems, for the benefit of all
Culture for sustainability	Developing cultural policies that respect and value cultural diversity, pluralism, and natural, built and immaterial heritage—while promoting memory preservation and the transmission of natural, cultural, and artistic heritage
Education for sustainability and quality of life	Integrate, in formal and informal education alike, values and abilities for a sustainable and healthy life
Dynamic, creative, and sustainable local economy	Supporting and creating conditions for a dynamic and creative local economy, ensuring access to employment while considering environmental concerns
Responsible consumption and lifestyle options	Adopting and providing a responsible and efficient use of resources, while incentivizing sustainable patterns of consumption and production
Better mobility and less traffic	Promoting sustainable mobility, recognizing the existing interdependence between transports, health, environment, and cities
Local action for health	Promoting and protecting health and welfare for all citizens
From local to global	Assuming global responsibilities for peace, justice, equity, sustainable development, environmental protection, and biodiversity

Adapted from Fabris et al. [19]

The sustainable cities program (2021) presents good practices that when applied can produce concrete results and inspire other cities. As an example, the city of Fortaleza, in northeastern Brazil, was able to reduce the time that citizens spend in traffic and public transportation by analyzing a large amount of data regarding displacement of people and vehicles. The city later became known as a reference in urban mobility by the mobilization of the civil society and managers on behalf of

data transparency, reaching third place in the Brazilian rankings of smart cities in 2019.

Boston, in the United States, is another example mentioned by the program. The city has launched a program called Imagine Boston 2030 to draw a pathway for urban growth, considering inequalities, and climate change. The planning began with a survey of two years, with 15.000 Bostonians responding about demographic and economic changes in that region. The plan encompasses actions in the areas of housing, health, safety, security, education, economy, energy, open spaces, environment, transportation, technology, art, and culture.

2.3 The COVID-19 Pandemic and the Healthy Smart Sustainable Cities

This chapter aims to understand how the needs imposed by the COVID-19 pandemic can be met by the concept of sustainable cities. Table 2 presents analyses and proposals from actors of private social investment, philanthropy, and other sectors of civil society, as proposed by the association of social investors in Brazil [22]. These proposals refer specifically to 2021, a year in which the pandemic is ongoing, and touch areas such as citizenship, economy, education, generation of jobs and incomes, public management, housing, infancy, urban mobility, climate change, SDGs, sanitation, and health.

The COVID-19 pandemic has caused countless changes in the life of billions of people, as exemplified in Table 2. Lockdown policies, the suspension of classes in schools, and incentives to working from home have interrupted or modified daily commutes. In this context, several impacts on urban mobility, whether social, economic, or environmental, were observed [16].

Couto et al. [16] have further observed that Brazil has not developed significant actions in urban mobility based on the lessons that were obtained during the pandemic period, thus harming several sectors, one of which is transportation. It is noteworthy that as in other places, active mobility is gaining space among the Brazilian population, which can be observed in the increase in the sale of bicycles. However, this way of moving about stumbles upon the lack of basic infrastructure to consolidate itself in the Brazilian scenario.

The sustainable cities portal (2021) prepared a list of good practices carried out in Brazil and in some other countries during the pandemic, as an example: (1) considering libraries as fundamental services and encouraging reading for adults and children; (2) Kerala, in India, focused on social assistance, access to basic services, financial support and health management, thus achieving a good recovery rate for COVID-19; (3) The city of São Paulo organized itself in order to maintain social distance and recommence medical activities; (4) in Niterói, Rio de Janeiro, a rapid response group was created for matters related to COVID-19, working in several areas in an integrated manner; (5) in Jordan, the government provided a platform

Table 2 Sustainable Cities and the COVID-19 Pandemic

Axes	Goals	Contributions
Citizenship	Recognizing and empowering base organizations	A solidarity network, built with the contribution of private actors, will spur attention to communities during the pandemic. Local organizations know the territories, have direct contact with populations, and can deliver help. It is also important to understand how these organizations work, to keep supporting them after the pandemic
Citizenship	Fostering and qualifying spaces for popular participation and social control	Deliberative democracy is a way for people to participate and make concrete decisions, instead of simply legitimizing processes that come from governments. And, for that technical knowledge is needed so that a public agenda is built, not tied to political conveniences because those are normally temporary
Education	Qualifying connectivity, boosting the use of technology	The pandemic caused many public school students to experience a learning delay, as they did not have adequate access to remote education due to lack of equipment or internet
Education	Supporting managers in providing the necessary conditions for resuming presential lessons	The reopening of schools will be paid for in the first days of January. The new representatives will have to promote the conditions for the resumption of classes in 2021, considering not only the logistical issues of the beginning of the school year, but also computing the effects of the pandemic on learning rates, dropout rates, and inequality between students

(continued)

Table 2 (continued)

Axes	Goals	Contributions
Generation of labor and income	Implementing entrepreneurship and income generation programs in the suburbs	Many people lost their jobs and small businesses were closed during the pandemic. For the resumption of economic growth, this theme will be of fundamental importance for the development of cities. Injecting capital into actions aimed at generating income in the suburbs can be an opportunity for private social investment and philanthropy to leave the care model that we were all forced to operate with at first
Generation of labor and income	Fostering innovative and sustainable local businesses to solve social and environmental challenges	Incubating and accelerating creative, supportive, and green ventures; low-carbon emissions; focusing on building local productive arrangements from the perspective of the sustainable city can be a pathway forward
Municipal Public Management	Support city halls to deal with fiscal impacts of the pandemic	The crisis surrounding COVID-19 generated an economic downturn with rising unemployment and decreasing revenue. In this scenario, cities will have to find solutions to this challenge, in order to stimulate the economic recovery and make the necessary fiscal adjustment
Municipal Public Management	Encouraging and supporting the design of integrated policies based on the demands of each territory	The world today shows very clearly that territory matters: each territory has its specificities. Therefore, the suburbs must be included in the design of these policies considering several factors such as health, education, environment, housing, and culture
Municipal Public Management	Encouraging collaboration between federated entities, and providing tools that can be immediately used, and that can directly affect the decision making of local managers	It is extremely necessary to start the debate on sustainability with instruments such as the Pluriannual Plan and Master Plans and Land Use Plans

(continued)

Table 2 (continued)

Axes	Goals	Contributions
Municipal Public Management	Demanding priority for master plans	The way of life of children in cities has been increasingly restricted to closed spaces, for a variety of reasons—ranging from the feeling of insecurity in the public space to the families' lack of time. Inequalities of class, race, gender, disabilities, etc. Inequalities shape the structures and organizations of Brazilian cities, generating territorial segregation and further exacerbating inequalities, including for children and their families. It is necessary to implement policies that evenly distribute access and security to green areas and public spaces in the city
Health	Promoting structured and long-term investments	Health issues should not remain an emergency issue in 2021, but some structural investment is still required
Sustainable Development	Addressing SDGS	Governments are failing to address the SDGs, and therefore, we are not seeing significant advances

(continued)

for remote education and teacher training; (6) the city of Tubarão invested in the local production of ventilators and masks with a 3D printer in partnership with technology companies and universities; (7) New York city launches educational material in 26 languages to reach immigrants, the material presents guidelines for health, hygiene, and social isolation; (8) the government of the city of Recife creates a mobile application to guide the population.

3 Methodology

The methodology of this research is divided into literature review procedures (3.1) and indicator elaboration procedures (3.2), which are qualitative stages of the research. During the analysis of the literature, it was possible to arrive at the selected indicators.

Table 2 (continued)

Axes	Goals	Contributions
Basic sanitation	Establishing greater engagement and partnerships with public authorities within the scope of the new legal framework for basic sanitation	Currently, 35 million Brazilians do not have access to water and almost 100 million do not have access to sewage collection (36 municipalities in the country's 100 largest cities have less than 60% of the population with sewage collection). The positive impacts of universal sanitation for the sustainable development of cities are notable, especially in the areas of health, education, income generation, and the environment—not to mention the promotion of dignity and citizenship of populations in a situation of social vulnerability, which will gain access to better housing and health conditions. The challenge is great and the engagement and partnerships between public authorities, companies in the sector and civil society are essential to move forward and guarantee more sustainable cities and better quality of life for the population
Climate change	Supporting the creation of solutions aimed at populations subject to the impacts of climate change in a more intense way in cities	Environmental racism leads millions of people in large cities to suffer the consequences of climatic events, such as floods and landslides. Black populations are more vulnerable and more susceptible to these issues, since the way of production of cities is structurally racist, segregating, and excluding. If cities do not face this challenge, life in big cities will be increasingly unsustainable in environmental terms, threatening to kill millions of black and poor lives
Urban mobility	Support reorganization of the territorial occupation of cities that encourage short circuits	If people do not have to travel daily for long distances to go to major centers to use public services, work, study, buy or visit a doctor, the overcrowding of public transport will be significantly reduced

Source GIFE [22]

3.1 Literature Review Procedures

A systematic review was chosen as the method to approach the literature. For the theoretical framework, articles collected in international databases are used. In the selection of the portfolio, the keywords for the research are defined as: sustainable cities; green cities; smart cities, healthy cities, and sustainable development in cities. The search used the Boolean expression: (sustainab * AND city) OR (green AND city) OR (city AND environment*) OR (smart AND city) OR (healthy AND city).

Then, the raw database was formed, so the next step is filtering the data. The first filter refers to redundancy: in this filter, all duplicate articles are excluded. The second filter refers to the title alignment: thus, all titles not aligned with the theme are excluded. The third filter is performed according to the representativeness of the article (number of citations) through Google Scholar. We chose to take into account all articles with more than one citation. In the articles without citation, only articles published in 2020 were read. The next step is to read the abstracts, in order to verify the representativeness of the articles.

After applying all the filters, the articles were read. Table 3 presents the bank of articles collected on sustainable healthy cities, in the period from 2010 to 2020. The references of these articles were also used; that is why we used is an article from the year 2000.

These selected articles will be the basis for composing the indicators. However, other articles selected in the database will compose this research and support these indicators.

3.2 Procedures for Elaborating Indicators

To elaborate our indicators, the indicators cited in the literature were identified (articles presented in the previous topic), then tabulated in an electronic spreadsheet, and the most cited works gave indicators their names.

4 Results and Analysis

An alternative for monitoring sustainability is the use of performance indicators. Sustainability indicators are used in order to monitor sustainable development. Thus, these indicators are responsible for capturing information that will compose an informative diagnosis for decision-makers, guiding the development and monitoring of policies and strategies. Sustainable performance indicators are identified in the literature and classified into ten categories: social, economic, governance, energy, environment, transport, water, green spaces, air quality, and health.

Table 3 Bank of articles collected on healthy sustainable cities

Authors	Journal
Rotmans et al. [40]	*Environmental Impact Assessment Review. vol*
Rosales [39]	*Procedia Engineering*
Bao and Toivanen [5]	*Journal of Science and Technology Policy Management*
El Ghorb and Shalay [25]	*Alexandria Engineering Journal*
Anand et al. [3]	*Energy Procedia*
Taecharungroj et al. [50]	*Journal Of Place Management And Development*
Brilhante and Klaas [11]	*Sustainability*
Giles et al. [26]	*Health Policy*
Silva et al. [17]	Revista de Gestão—REGE
Su et al. [48]	*Ecological Indicators, 9:*
Deng et al. [18]	*Cities*
Sokolov et al. [45]	*Technological Forecasting and Social Change*
Alyami [2]	*IEEE Access*
Yang et al. [61]	*Resources Policy*
Ruan et al. [41]	*Cities*
Wang and Peng [60]	*Mathematics*
Steiniger et al. [47]	*Cities*
Li and Yi [32]	*Journal of Cleaner Production*
Kourtit t al. [30]	*Science of the Total Environment*
Jing and Wang [29]	*Journal of Cleaner Production*

Source Prepared by the Authors, 2020

Table 4 presents the Strategic Map with the indicators, the description of each indicator and the authors that support these indicators.

The indicators of healthy smart sustainable cities are now related to the COVID-19 pandemic instructions and the lessons we learned from it.

Now, the social, economic, governance, energy, environment, transport, water, green spaces, air quality, and health indicators will be analyzed individually.

4.1 Social Indicator

The first analyzed indicator is the social indicator, which aims primarily at social welfare through quality food, access to housing, population density, social equity, employment structure, life expectancy, cultural identity, general employment index,

Table 4 Strategic map of indicators

Indicators for healthy smart sustainable cities		
1	Indicator	Social Indicator
Description		Investments in the social welfare of the inhabitants of the city
Authors		[3, 11, 17, 18, 25–27, 29, 31–41, 45, 47, 48, 60, 61]
2	Indicator	Economic indicator
Description		Economic development and growth of a city
Authors		[3, 11, 17, 25, 27, 29, 30, 31–41, 45, 48, 61]
3	Indicator	Governance indicator
Description		Governance level of a city
Authors		[3, 12, 25, 45, 47, 50]
4	Indicator	Energy indicator
Description		Investments and valorization of issues related to the city's energy
Authors		[2, 3, 5, 11, 12, 18, 32, 41, 45, 49–50, 58]
5	Indicator	Environment indicator
Description		Investments and valorization of issues related to the environment in a city
Authors		[2, 3, 11, 17, 18, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 48]
6	Indicator	Transport indicator
Description		Investments and accessibility in the city transport
Authors		[1– 3, 11, 18, 27, 31, 33, 45, 49, 50, 58]
7	Indicator	Water indicator
Description		Investments and valorization of issues related to water management in the city
Authors		[2, 5, 11, 12, 26, 29, 32, 34, 40–50]
8	Indicator	Green spaces indicator
Description		Investments, valorization and access to green spaces in the city
Authors		[1, 18, 29, 31, 33, 34, 40, 45]
9	Indicator	Air quality indicator
Description		Monitoring and preservation of the city's air quality

(continued)

Table 4 (continued)

Indicators for healthy smart sustainable cities		
1	Indicator	Social Indicator
Authors		[1, 3, 25, 29, 30, 31,33, 34,40, 45]
10	Indicator	Health indicator
Description		Investments, valorization and access to health services in the city
Authors		[3, 5, 26, 27, 31, 39, 47]

urban vulnerability, internet access, assistance from municipal services, general consumer price index, income level, community projects, unemployment rates, and many other issues involving the social indicator that are of concern in the pandemic [3, 11, 17, 18, 25, 26, 27, 29, 31–41, 45, 47, 48 60, 61].

The social indicator includes results on topics such as quality of life sustainability, sustainable development, and the relationship between quality of life and sustainability. The social indicator assesses the population's quality of life and well-being levels and the realization of social and human rights. It also discusses access to services, goods, and opportunities.

The pandemic has not only brought about a collapse in the health system of many cities but has also increased unemployment rates, numbers of children away from school, domestic violence, and other consequences.

Many communities lack access to quality food, according to [59]. When handling food, it is necessary to wash your hands with soap and water and also sanitize food, especially if you eat without cooking. A city that aims for health, invests in a healthy diet, and assists the population in terms of handling and consumption, according to [26] should also invest in nutritional literacy.

Hygiene is one of the main things that people should pay attention to in the context of a pandemic, not only regarding food, but also clothes, hands, and masks. [59] Stresses that cloth do not need to be cleaned with a washing machine or dryer, but the use of detergent or soap is necessary.

Access to education was hampered by the pandemic. While several cities aim for a safe return, increases in virus transmission, and a lack of hospital capacity emergency measures such as lockdowns are necessary. Furthermore, according to UM (2021) the closure of schools, lack of support network, economic limitations, and even the death of parents by COVID-19, has increased the risk of child marriage for girls.

According to [53], the closure of schools increases the likelihood of permanent school dropout. For the reopening of schools, policies for access to health and social services will be necessary.

A return to school still requires strategic planning for the safety of students and teachers. According to [59] for the protection of oneself and others, it is necessary to keep the distance of at least one meter between people, use masks when being with other people and clean the masks properly; maintain hand hygiene, among other ways to avoid infection.

According to [60], in addition to quantifiable physical standards, a sustainable city needs to improve the quality of local life, so that this improvement is perceived by residents. Agenda 21 (1992) has as its goal a healthy life, so the WHO (1997) proposed the healthy city (HC) project, intending to promote sustainable and healthy urban development. According to WHO (1998), a healthy city aims to create and continuously improve the physical and social environment, allowing people to support each other in order to develop their potential.

Reference [40] proposes integrated city planning, aiming to improve several factors that make up a city with the efficient use of resources, facilitating the creation of sectoral policies. In this way, economic, socio-cultural, and ecological areas will be

covered, in their sub-indicators such as: Resources/materials, work structure, transport infrastructure, demographic structure, knowledge structure, cultural heritage, quality and quantity of natural resources, and biodiversity.

Brito et al. [12] developed in their research a multiple criteria model aimed at assessing the sustainability of green cities using the multiple criteria decision approach (MCDA). The authors reached the following criteria: people, mobility, water, energy efficiency, biodiversity, waste, governance, and innovation.

4.2 Economic Indicator

The economic indicator corresponds to the economic development and growth of a city [3, 11, 17, 25, 27, 29, 30, 31–41, 45, 48, 61].

One possible economic indicator is the use of economic statistics, such as the unemployment rate, GDP, or inflation rates. They indicate how the economy is doing and predict how the economy will perform in future. For sustainable cities, economic indicators serve as a parameter for generating wealth and the ability to invest in sustainable actions.

The economic indicator involves the attractiveness of the market, economic development, income concentration, GDP per capita, contingent plan, the proportion of expenses with science and technology, comparison between the gain of urban families and the gain of rural families, growth rate of revenue regional, export rate, foreign investment, among other issues. Many of those have suffered the impacts of the pandemic.

According to [43], economic shutdowns had negative impacts on the urban economy. The consequences are diverse and involve other areas, including the already mentioned social issues. Also according to the authors, the pandemic impacted municipal tax revenues, population income, tourism, small and medium-sized companies, the food supply chain, migrant workers, and inequality in social and spatial distribution.

The impacts of COVID-19 are faced by social groups differently and disproportionately. Poorer people and in marginalized regions are more likely to suffer social and economic damage. Periods of recession increase unemployment, so designing and implementing programs aimed at post-pandemic recovery will be important [43].

4.3 Governance Indicator

The indicator related to governance is related to planning in sustainable cities, corruption, economy potential [3] (Brito et al. [12]), people's participation, but also, environmentally friend purchases [25]. Still, according to [47] governance in a healthy

smart sustainable city must have citizen participation in the elections, the government's openness to requests for information, transparency, and municipal budget dependency. Furthermore,

Reference [50] mention the importance of governance. In a pandemic context, it is not difficult to reflect the value of governance, because, more than ever, governments and companies need a set of practices in order to improve management. There are so many issues to manage in a city, in times of pandemic, the problems become accentuated, where risk management becomes necessary.

According to [21] the conditions for a healthier, safer, and more resilient post-pandemic society must already be under construction, allowing for better preparation and alert for future risks. Still according to [21], (p 7) returning to the normal "situation before the pandemic means to maintain the same conditions of risks and vulnerabilities that caused the global disaster by COVID-19".

Some cities have shown a disconnect between the political sphere and collective participation in planning and decision-making. Thus, the democratization of the participation of the population helps to build governance, as well as the exercise of citizenship through the social and collective appropriation of the city.

4.4 Energy Indicator

The energy indicator is related to several sectors of a city and is of special importance in a pandemic context when considering the energy demand of a hospital. Energy includes the use of renewable energy, smart housing, smart automation [3, 5, 12, 45, 50]. Still, according to [2], a sustainable city must have the monitoring of emissions, reduction of the carbon footprint, measurement of the spent energy, renewable energy potential. Subadyo et al. [49] mention the potential of solar energy and hydroelectric power in cities. [48] Mention the measurement of energy consumption by GDP. Examples of technologies that can be used to generate clean energy are the generation of photovoltaic energy, hybrid wind energy systems; hybrid solar energy systems; bioenergy; and geothermal energy [28].

The concern with alternative forms of energy generation, especially those from renewable sources, is at the base of a sustainable city. Cities that are concerned with sustainable development have sought to reduce the use of fossil fuel/thermoelectric energy and carbon emissions from their energy matrix. Cities are discovering more efficient ways of management, improving the quality of life, and creating less impact on human health through renewable energies.

4.5 Environment Indicator

The environment indicator is broad and also involves several sectors in the city. The themes related to this indicator are energy-efficient technologies, clean transport, air

pollution (including noise) [3], forestry area, wastewater capacity, use of solid waste [29], green spaces [1, 18, 29, 31, 33, 34, 40, 45].

The pandemic has had positive and negative impacts on the environment. Among the positive impacts are the decrease in air pollution, noise pollution, and greenhouse gas emissions [19].

The environment is also negatively impacted by the pandemic, as various wastes are improperly disposed of and become a threat. Reference [19] investigated the impacts of facial mask residues on the marine environment. According to the authors, many masks are made of petroleum-based polymers, which are not biodegradable.

Reference [19] highlights the importance of waste management with the sorting, collection, treatment, and safety protocol. Finally, the authors propose as an alternative to the problem of marine pollution by facial masks, the production of masks with nanotechnology or biomaterial.

References [4] and [6] also studied pollution on beaches, coasts, and seas by polymeric and antiviral textile waste. They emphasize that poor management represents an environmental problem, and therefore, waste management strategies must be studied.

As for noise pollution, a concern is its negative effects on physical and mental health since frequent exposure to noise above the recommended level causes serious damage to the body, such as heart problems, anxiety attacks, and gradual hearing loss.

Regarding the pandemic, there are several issues involved, because in lockdowns or social distancing policies, people travel less by plane, stay at home reduce the use of their own or public transport, creating a trend of reduction in pollution levels as well.

The main objective of a sustainable city is to avoid the depletion of the environment of its territory, thus guaranteeing its permanence for future generations. In this way, sustainable cities seek to reinvent themselves so that in future the next generations will have a planet more conducive to human life in order to guarantee the quality of life.

Reference [55] investigated the effects of the COVID-19 pandemic on environmental protection and legislation in Brazil. The research aimed to evaluate the main legislative actions, environmental fines, and deforestation. The results showed that 57 legislative acts during the current administration aimed to weaken environmental protection, half of which almost were created during the pandemic. The results also showed that during the pandemic there was a 72% reduction in environmental fines, although there was an increase in deforestation in the Amazon in the same period. Reference [55] also conclude that these actions can generate a loss of biodiversity, increase greenhouse gas emissions, and the likelihood of other outbreaks of zoonotic diseases.

4.6 Transport Indicator

The transport indicator corresponds to investments and accessibility in transporting a city [1–3, 11, 18, 27, 31, 33, 45, 49, 50, 58].

Sustainable transport is a form of strategic locomotion that aims to improve the lives of people in cities and to guarantee the right of citizens to come and go. Transport is a means that allows the population access to a set of needs that contribute to healthy and fulfilling lives, such as employment, markets, social interaction, and education. Examples of sustainable urban mobility are urban belts, exclusive routes for public transportation, cycle tracks, and cycle lanes, electric car-sharing network, and integration of different modes.

Reference [51] studied the impact of the pandemic on urban transport and air quality in Canada. According to the authors, due to the blockages caused by the pandemic, the demand and domestic consumption of fuel for transportation had a considerable decline. There were drops in the monthly consumption of transportation fuel in general as well, that is, diesel oil, kerosene-fuel for aircraft, and gasoline for engines. In May 2020, gasoline consumption dropped by 49.8% and diesel oil dropped by 28.4% compared to 2019. According to [51] "in week 12, the level of traffic congestion decreased by 69% and 75% in Toronto and Montreal, respectively, compared to 2019".

4.7 Water Indicator

The water indicator corresponds to the investment and valorization of water issues in the city [2, 5, 11, 12, 26,29, 32, 34, 45, 40–50].

Some actions are important to overcome water crises and ensure access to drinking water for the population, such as water reuse, desalination, reversing of pollution, river crossing, rainwater harvesting, cleaning streams, basic sanitation. In 2017, about two billion people did not have access to drinking water (WHO, 2017). For this reason, the search for solutions for the appropriate use of water resources becomes even more important.

4.8 Green Spaces Indicator

The green spaces indicator corresponds to investments, valorization, and access to green spaces in the city [1, 18, 29, 31, 33, 34, 40, 45].

The use of green spaces within the limits of a city aims to improve the urban environment. In this way, green spaces improve air quality, reduces the effects of heating paved surfaces, promote soil drainage, and, consequently, replenishes groundwater reserves, lakes, and rivers.

Reference [37] researched the benefits of contact with green spaces during COVID-19 lockdowns for mental health. The authors concluded that contact with nature mitigates the negative effect of the lockdowns on mental health. Most people understand that contact with nature helps to deal with restrictive measures in a better way. The study also demonstrates that access to green outdoor spaces with views of nature is associated with more positive emotions.

Still concerning access to green spaces during the pandemic, the research by [54] took into account the effects of the pandemic on the use and perceptions of urban green space. The results showed that the residents surveyed need accessible urban green spaces so that they can exercise, relax, take the dog for a walk and observe nature.

4.9 Air Quality Indicator

The air quality indicator corresponds to the monitoring and preservation of the city's air quality [1, 3, 25, 29, 30, 31, 33, 34, 40, 45].

Air quality management in cities aims to ensure that development takes place in a sustainable and environmentally safe manner. To this end, cities should promote actions that encourage the prevention, combat, and reduction of pollutant gas emissions and the effects of the degradation of the atmospheric environment. Air pollutants are gases and solid particles resulting from human activities and natural phenomena dispersed in atmospheric air. The main sources of pollutant emissions are motor vehicles, trains, airplanes, marine vessels, industrial chimneys, and power generation (thermoelectric). These sources must be countered by city decisions in order to improve air quality.

Reference [51] studied the impact of the pandemic on urban transport and air quality in Canada. According to a study carried out in Canada between 2018 and 2020, the transport and mobile equipment sector was responsible for generating 56% of total CO emissions. However, according to [51] "the level of CO concentration in six cities has decreased since March 2020″. The authors also conclude that the quality of urban air across the country has greatly improved during the pandemic period, but it is still unclear how the recovery will be".

4.9.1 Health Indicator

The health indicator corresponds to investments, valuation and access to health services in the city [3, 5, 26, 27, 31, 39, 47].

Today, more than half of the world's population now lives in urban centers. Therefore, cities should be concerned with promoting the search for health and quality of life, especially in the post-COVID-19 context. Parameters of health and well-being applied to urban development were created through environmental certifications Well and Fitwel.

These stamps use sustainability indicators to encourage the development of projects, practices that promote health in urban spaces. Actions such as the creation of urban farms, contemplative spaces for mental restoration, publicly accessible drinking fountains, cycling infrastructure, and encouraging walking are the basis for the health and well-being of the population. Healthy cities seek to think of urban health as a resource for the life and happiness of its inhabitants.

Around the world, governments and health professionals are experiencing severe stress. Patient care is changed according to the need of the moment. Many health professionals are also being infected and away from work. According to [24], the emotional suffering or exhaustion of health professionals was rated as high, especially for nurses. This problem is also associated with the lack of personnel or the lack of resources and communication, which is often deficient, on the part of supervisors.

Also according to [24] "the recovery from the peak pandemic situation will be better if people feel safe and connected to others during the crisis, if they have social, physical, and emotional support and feel they can help themselves and their community".

Reference [46] research focuses on food security in cities during periods of the pandemic. According to the authors, the global food supply chain operates in a balance between consumption, production, and stock. However, minor disturbances can cause instability, such as a pandemic.

The COVID-19 pandemic demonstrated how an infectious disease can lead to a food crisis, because many places have closed their borders, imposed lockdowns, and interrupted trade, resulting in a shortage of labor. These actions have caused disruptions along the food supply chain. The consequence of this process is limited access to food, especially for vulnerable groups [46].

Still, concerning food, the pandemic can modify consumer behavior, as they can buy more than they usually do, aiming at a private stock as a way to prevent scarcity, causing an increase in food prices, destabilizing the food system. Cities are even more vulnerable than rural areas, as cities depend on food imports [46].

Reference [35] presents a counterpoint concerning this problem of food scarcity during a pandemic, as they state that although the news was initially about empty shelves and the closing of schools, hotels, and restaurants have led many producers to destroy unused food products.

5 Final Considerations

The research proposed to make a parallel between the needs imposed by COVID-19 and the characteristics of healthy smart sustainable cities, analyzing how the concept of sustainable cities can contribute in a pandemic context. Sustainable performance indicators are identified in the literature and classified into ten categories: social, economic, governance, energy, environment, transport, water, green spaces, air quality, and health. After choosing these indicators, we have identified the main

characteristics of each, relating them both to the concept of healthy smart sustainable cities and research related to the COVID-19 pandemic.

The international emergency related to COVID-19, declared on January 30, 2020, by the World Health Organization (WHO), has turned the attention of the scientific community once again to the field of global health and sustainable development [56].

Buckeridge and Philippi Junior (2020) add that the COVID-19 pandemic revealed the virtues and deficiencies of cities in facing one of the strongest extreme events of the twenty-first century. On the one hand, the strength of science has helped to tackle the pandemic, advising on health issues at the peak of the disease. On the other hand, the deficiencies in public policies that are problems of the past demanded their resolution, revealing the most perverse face of the existing inequality in the city, the vulnerability to extreme events.

To complement the discussion, the authors Buckeridge and Philippi Junior [14] explain the relations between this pandemic and sustainable cities, making an analogy with ecology, in which the city can be seen as a urbsystem with a primary and a secondary structure, latter housing networks of services that determine the quality of life in the city. The generation of public policies is the main "physiological" mechanism by which cities can become more or less vulnerable to extreme events, such as climate change and pandemics.

The literature also shows that the COVID-19 pandemic highlights the importance of urban sustainability. It shows that sustainability can only be achieved through intelligence that always considers the application of public policies based, this can be done through broader communication with the scientific community.

Reference [15] highlighted the impacts of the pandemic on the social vulnerability that can be perceived as the resilience of communities when confronted by external factors that are stressful to health, such as natural or human-caused disasters, or disease epidemics. Reducing social vulnerability can decrease both human suffering and economic losses.

Thus, one of the measures applied and to seek the sustainability of cities at this time of COVID-19 pandemic, according to the recommendation of the Ministry of Health, in compliance with the National Contingency Plan for Human Infection by the novel coronavirus, should include social isolation, and other procedures such as strict hand hygiene and respiratory etiquette, as well as avoiding crowds, maintaining a minimum distance of 1.5 m between people in outdoor environments, and above all staying at home—except for those who work essential activities, such as supermarkets, pharmacies, health units, and others.

However, the authors [15] indicate emphasizes that in order to meet such measures, it is necessary to reflect on which lives in communities that do not have adequate infrastructure and basic sanitation, thus presenting difficulties about personal hygiene and the environment. Many families live in narrow rooms, in conditions that do not favor isolation if someone becomes infected with the coronavirus. The main source of family income is often derived from informal and face-to-face activities, making it impossible to work from home, among many other problems.

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