

**Analysis of Brazil's second smartest city in 2024: Vitória – ES, according to the axes of urbanism, health and education**

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## **Análise da segunda cidade mais inteligente do Brasil de 2024: Vitória – ES, segundo os eixos do urbanismo, saúde e educação**

### **RESUMO**

**Objetivo** - Este artigo tem como objetivo analisar a cidade de Vitória, no estado do Espírito Santo, que foi reconhecida como a segunda cidade mais inteligente do Brasil em 2024, segundo o *Ranking Connected Smart Cities*. O estudo se concentra no contexto de seu planejamento urbano e a partir dele, a análise de alguns indicadores dos eixos de saúde e educação.

**Metodologia** - Utilizando uma abordagem quali-quantitativa, a pesquisa se baseou em dados secundários provenientes de relatórios especializados, artigos acadêmicos e documentos oficiais.

**Originalidade/relevância** - O trabalho visa preencher uma lacuna teórica ao investigar a aplicação prática do conceito de cidades inteligentes no contexto brasileiro, ressaltando a relevância de indicadores específicos para o desenvolvimento sustentável e a melhoria da qualidade de vida urbana.

**Resultados** - Os resultados revelam que Vitória se destaca pela eficiência na gestão de saúde, educação e infraestrutura urbana, implementando práticas que favorecem a inclusão social e a sustentabilidade ambiental.

**Contribuições teóricas/metodológicas** - Este trabalho contribui para um entendimento mais profundo sobre os pilares essenciais das cidades inteligentes, propondo uma análise integrada desses indicadores.

**Contribuições sociais e ambientais** - Além disso, apresenta implicações sociais e ambientais significativas que posicionam Vitória como um modelo de referência.

**PALAVRAS-CHAVE:** Cidades Inteligentes. Sustentabilidade Urbana. Vitória – ES.

## **Analysis of Brazil's second smartest city in 2024: Vitória – ES, according to the axes of urbanism, health and education**

### **ABSTRACT**

**Objective** – This article aims to analyze the city of Vitória, in the state of Espírito Santo, which was recognized as the second smartest city in Brazil in 2024, according to the Connected Smart Cities Ranking. The study focuses on the context of its urban planning and from there, the analysis of some indicators of the health and education axes.

**Methodology** – Using a qualitative-quantitative approach, the research was based of secondary data from specialized reports, academic articles, and official documents.

**Originality/Relevance** – The purpose of the work aims to fill a theoretical gap by investigating the practical application of the concept of smart cities in the Brazilian context, highlighting the relevance of specific indicators for sustainable development and improving the quality of urban life.

**Results** – The results reveal that Vitória stands out for its efficiency in managing health, urban infrastructure, and education, implementing practices that favor social inclusion and environmental sustainability.

**Theoretical/Methodological Contributions** – This work contributes to a deeper understanding of the essential pillars of smart cities, proposing an integrated analysis of these indicators.

**Social and Environmental Contributions** In addition, it presents significant social and environmental implications that position Vitória as a reference model

**KEYWORDS:** Smart Cities. Urban Sustainability. Vitória – ES.

## **Análisis de la segunda ciudad más inteligente de Brasil en 2024: Vitória – ES, según los ejes de urbanismo, salud y educación**

### **RESUMEN**

**Objetivo** – Este artículo tiene como objetivo analizar la ciudad de Vitória, en el Espírito Santo, que fue reconocida como la segunda ciudad más inteligente de Brasil en 2024, según el Ranking de Ciudades Inteligentes Conectadas. El estudio se centra en el contexto de su planificación urbana y a partir de ahí, el análisis de algunos indicadores de los ejes salud y educación.

**Metodología** – Utilizando un enfoque cualitativo-cuantitativo, la investigación se basó en fuentes secundarias provenientes de informes especializados, artículos académicos y documentos oficiales.

**Originalidad/Relevancia** – El propósito del trabajo pretende llenar un vacío teórico al investigar la aplicación práctica del concepto de ciudades inteligentes en el contexto brasileño, destacando la relevancia de indicadores específicos para el desarrollo sostenible y la mejora de la calidad de vida urbana.

**Resultados** - Los resultados revelan que Vitória se destaca por su eficiencia en la gestión de la salud, la infraestructura urbana y la educación, implementando prácticas que favorecen la inclusión social y la sostenibilidad.

**Contribuciones Teóricas/Metodológicas** – Este trabajo contribuye a una comprensión más profunda de los pilares esenciales de las ciudades inteligentes, proponiendo un análisis integrado de estos indicadores.

**Contribuciones Sociales y Ambientales** – Además, presenta importantes implicaciones sociales y ambientales que posicionan a Vitória como un modelo de referencia.

**PALABRAS CLAVE:** Ciudades Inteligentes. Sostenibilidad urbana. Victoria – ES.

## **1 INTRODUCTION**

The growing search for an understanding of smart cities reflects the need to develop urban environments that balance technological innovation, sustainability, and quality of life. As Mora and Deakin (2019) point out, the concept of a smart city has been constructed as a response to contemporary urban crises, combining public policies, digital technologies, and citizen participation to promote more efficient and equitable cities. In this context, this research explores how Vitória (Espírito Santo) stands out in the Brazilian scenario as an example of a smart city, evaluating its performance in the areas of urbanism, health, and education, according to the Connected Smart Cities 2024 Ranking. Therefore, the city was chosen as the study site because it is currently the best-positioned in the Southeast region and second in the national Ranking. The analysis of the axes of urbanism, health, and education, among the other eight axes of the Ranking, was determined by their importance in the urban context, the position of the chosen city, and the focus of the authors' research.

To this end, the research adopts a qualitative-quantitative and exploratory approach, using data analysis methods obtained from secondary sources (books, journal articles, dissertations, and theses) and primary sources such as reports and official documents available for consultation. Iconography and cartography related to the topic under study were also used. In this context, the bibliographic analysis deepened the subject, organizing existing knowledge on the topic, and establishing the state of the art. As pointed out by Kitchin (2014), the production of real-time urban data in smart cities must be accompanied by a critical reflection on their governance and public appropriation, which reinforces the importance of comparative analyses such as the one proposed in this article. Furthermore, the data analysis process uses a comparative and interpretive approach based on the Connected Smart Cities 2024 Ranking.

Therefore, this article is structured into six sections, in addition to this introduction: objectives, the concept of smart cities, the context of Vitória as a smart city: planning for the future, global challenges facing cities in the 21st century, results, discussions, and final considerations. The indicators for the Ranking's axes under analysis are presented in the subtopics of the fifth section.

## **2 OBJECTIVES**

The overall objective of this article is to analyze the city of Vitória, in the state of Espírito Santo, recognized as the second smartest city in Brazil in 2024, according to the Connected Smart Cities Ranking, within the context of its urban planning and, from this, to analyze selected indicators in the areas of health and education. The specific objectives include investigating the application of the smart city concept in Vitória's context, identifying the factors that contribute to its outstanding indicators. The research also aims to reflect on the global challenges faced by cities in the 21st century, while highlighting the innovative best practices adopted by Vitória, which can serve as a reference for other Brazilian cities committed to promoting sustainability.

### 3 CONCEPT OF SMART CITIES

The idea of a new way of thinking about cities, the Smart City, emerges from the context shaped by the influence of the Information Age on various sectors of society (Castells, 1999); the increasing concentration of people in urban areas; the pressure for the provision and efficiency of services to meet the population's demands; the interests of private capital; the competition between cities for investment; in addition to the increasingly urgent impacts of climate change (Weiss, Bernardes and Consoni, 2015; Ravache et al, 2024). In an attempt to overcome the challenges presented (Chourabi et al., 2012) according to research by YIN et al. (2015) and Arroub et al. (2016), several authors sought to conceptualize what a Smart City would be, but using Hiroki's definition (2019, p. 34), Smart Cities:

[...] are urban spaces with management focused on efficiency and innovation, the result of collaboration between public, private, and civil society initiatives. This partnership develops projects that manage the city, primarily through technology platforms, resulting in extensive production and analysis of data about the population. This promotes sustainable resource use and a resilient urban space—that is, prepared for its challenges.

Therefore, by utilizing technological resources, the public sector can become more efficient in providing services related to governance and administration, such as the management of public services. However, the proposal to transform cities into Smart Cities has been evolving over time, and has so far been categorized into three phases: the First, Second, and Third Phases. The First Phase emerged at the beginning of the 21st century, focusing on the implementation of large-scale technology projects. However, with the global economic crisis of 2008, it became clear that there were insufficient resources for such large-scale projects, marking the beginning of the Second Phase, which focused on citizen engagement. The Third Phase, which is the current one, is characterized by the use of data to develop projects that better respond to the population's demands, given the resource limitations observed during the transition from previous phases and exacerbated by the COVID-19 pandemic. Thus, it was recognized that it would be more viable to utilize existing data generated through citizens' use of digital technologies.

With the aim of classifying cities as smart, and considering the competition for urban investment resources, rankings have been created to assess the degree of city intelligence (Hiroki, 2019; Giffinger; Gudrun, 2010). Among the international rankings is the IESE Cities in Motion (prepared by the University of Navarra, Spain), which is the most widely used, along with the European Medium-Sized Cities (prepared by the European Union). In Brazil, according to Hiroki (2019), this competitive scenario was defined by the example of Curitiba, under the administration of Jaime Lerner in the 1990s, which introduced innovations in the structuring of cultural and leisure spaces, and, above all, in urban mobility, with the implementation of Bus Rapid Transit (BRT), making the city a global benchmark. This prepared the population for the new era that was announced for the 2000s, in which urban planning was oriented towards: the practical use of new technologies; quality of life as an attractive factor for investments; and actions that would make it internationally competitive. (NEC BRASIL, 2021). Regarding the

Brazilian ranking, Connected Smart Cities (prepared by the Brazilian consultancy Urban Systems), whose website description states that:

The study considers the "Concept of Connectivity" as the relationship between the various sectors analyzed. The Smart Cities concept adopted here assumes that development can only be achieved when city development agents understand the power of connectivity across all sectors. An example of this is the awareness that investments in sanitation are linked not only to environmental gains, but also to health gains, which will, in the long term, reduce expenditures in this area (basic health care) and consequently impact governance and even economic issues. (Urban Systems, 2024).

The Ranking, which has been developed since 2015, is currently in its tenth edition (2024 edition), mapping 656 municipalities with more than 50,000 inhabitants in the country. Up to 100 cities are ranked using 75 indicators distributed across 11 thematic axes: Mobility (MOB), Environment (MAM), Entrepreneurship (EMP), Education (EDU), Energy (ENE), Governance (GOV), Urbanism (URB), Technology and Innovation (TIC), Health (SAU), Security (SEG), and Economy (ECO).

According to Urban Systems (2024, p. 10), the Ranking is compiled by consulting national and international publications related to smart cities, connected cities, sustainable cities, and similar publications, such as ISO 37.120 - Sustainable development of communities - Indicators for city services and quality of life" / NBR 37123; ISO 37.122 - Sustainable cities and communities - Indicators for smart cities" / NBR 37122; and ISO 37.123 - Sustainable cities and communities - Indicators for resilient cities" / NBR 37123. To update the indicators, since 2022 an online form has been made available for two months each year for public officials to update municipal data, which is then analyzed by the Ranking developers. Based on the above, the following sections will analyze the context of Vitória, Espírito Santo, within the concept of a smart city.

#### 4 CONTEXT OF VITÓRIA AS A SMART CITY: PLANNING FOR THE FUTURE

The city of Vitória, despite being one of Brazil's oldest capitals, dating back to the 16th century, began its effective occupation during the Republican period, when the effervescence of urban reforms was evident in the discourse and actions of mayors and governors, seeking to improve urban health conditions.

Vitória, officially founded on September 8, 1551, maintained its colonial layout until the beginning of the 20th century, when major land reclamation and roadworks produced urban transformations that reshaped the city's profile. According to Daemon (1879, p. 247), the first land reclamation works in the city were only carried out in 1818 by Governor Rubim, in the areas of Porto dos Padres, Pelame, and Largo da Conceição da Praia and their surroundings. These land reclamations were carried out despite limited resources and skilled labor, and depended on the goodwill of wealthy local residents.

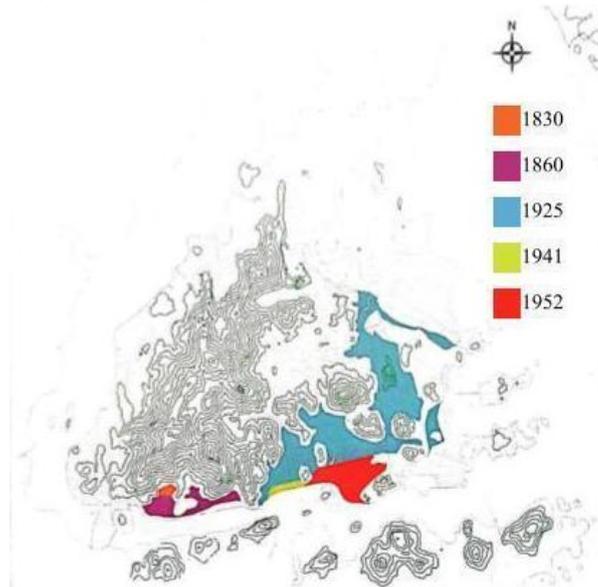
Still in the 19th century, the Torrens company was contracted by the Espírito Santo State Government to develop the Street Plan for Vila Moscoso in the downtown area known as Lapa do Mangal, Mangal do Campinho, or Campinho—a flooded area that had undergone successive landfills in the name of public health. The contract was part of the redesign of the

upper city and Largo da Conceição, a project that sought to give the Espírito Santo capital a modern feel within the framework of the new republican order and the positivist philosophy of Auguste Comte.

According to Cruz (2010, p. 131), although the landfills contributed to improving the capital's sanitary conditions, they also had a strong economic and ideological character, with a focus on transforming the city into an important commercial center.

Regarding urban morphology, the landfills present regular patterns within a grid, the result of landfilling and adaptation to the former colonial core. "The new streets and those that were rectified within the initial nucleus occupied a flatter physical site, the result of landfills where rationalist grids draw regular figures" (Klug, 2009, p.34).

Figure 1 – Mapping of landfills that occurred up to the 1950s.



Source: Klug, 2009, p.47 (adapted by the authors)

In the 1930s, inspired by French urban planner Alfred Agache, engineer Henrique de Novaes developed plans for Vitória along the lines of remodeling and beautification. His proposals focused on the island area where the mangrove landfills of the Jucutuquara region led to the creation of the city's industrial zone. This landfill also led to the implementation of the Novo Arrebalde project (designed by engineer Saturnino de Brito in 1896), solving the flooding problem. Currently, the neighborhoods of Praia do Canto, Santa Luiza, Barro Vermelho, Santa Lúcia, Santa Helena, Praia do Suá, and Horto are located in this area.

The name Praia do Canto became established in the 1970s, when the lots became highly sought after by the real estate market for building construction. With the land reclamation carried out by the Urban Development and Improvement Company (COMDUSA) in 1972, the beaches of Santa Helena, Barracão, Comprida, and Canto disappeared. Saturnino de Brito Avenue became the address of upper-middle-class families, as did the neighboring neighborhoods of Boi and Frade Islands, the former connected to the mainland by a landfill, taking on the shape of a peninsula, and the latter still retaining island characteristics and a bridge.

Saturnino de Brito Avenue became a metropolitan arterial, and although it differs from the original design due to the reclamation that made way for late, Namorados, and Desejos Squares, it still retains the ambiance of a beachfront. According to Klug (2009, p. 30), Saturnino de Brito's design incorporated the triad of classical requirements: safety, comfort, and beauty, conceiving the urban landscape as a work of art. Successive reclamation works allowed the construction of coastal roads that avoided crossing the already densely populated downtown area, while also ensuring connections with the new residential neighborhoods emerging to the east of Vitória Island: Santa Maria Island, Jucutuquara, and Praia do Canto.

However, on the north/northwest side of the island, due to the industrial expansion in Espírito Santo during the industrial boom promoted by Vargas, which enabled the establishment of the Companhia Vale do Rio Doce (1942) and the Vitória Iron and Steel Company (COFAVI), a new large land reclamation was built in the 1980s, further altering the island's profile.

The Greater Vitória Metropolitan Region (RMGV) concentrated 80% of the investments and jobs generated by the industry at the time. In 1960, the population of Greater Vitória was 209,172, and by 1991, it had grown to 1,126,638. (MATTOS, 2011).

According to Corrêa and Vasconcelos (2018, p. 67), migrants were temporarily employed in the construction of industrial plants belonging to Companhia Siderúrgica de Tubarão, Companhia Vale do Rio Doce, and Aracruz Celulose – now Arcelor Mittal, Vale, and Fibria, respectively. However, later stages of industrial plant implementation required higher levels of education than were compatible with migrants from rural areas. This resulted in unemployment and poverty that took hold in Greater Vitória and were evident in the Greater São Pedro region.

The city of Vitória, with 97.123 km<sup>2</sup> (IBGE, 2023), the smallest municipality in the Metropolitan Region, whose geography is defined by the presence of hills, islands, and mangroves, even after undergoing numerous land reclamation projects up to the 1970s, lacked sufficient land to accommodate such a large influx of immigrants. This transformed Greater São Pedro into a slum area, lacking infrastructure and services and marked by precarious housing.

The invasion processes in the region occurred on the north/northwest side of the island, in an area composed of mangroves and hills, where the city government disposed of all the municipal waste. In the following years, the invasion, which began in the mangrove swamps and gave rise to the São Pedro favela, extended for almost five kilometers, subdividing into São Pedro I, II, III, and IV. The last occupation, which occurred in 1980, represented an area more than three times larger than the first, which occurred in the region around 1977. In 1980, São Pedro was home to an average of 15,000 (fifteen thousand) favela residents (SIQUEIRA, 2010).

From another perspective, the presence of housing in the mangrove area negatively impacted it, resulting in a mix of sewage, garbage, and the mangrove flora and fauna. According to Alves (2015), an area of 760 hectares of mangroves was filled in to create lots, almost half of the current area: 1,800 hectares. However, much of this population knew little about the ecosystem in which they lived.

Freire (2004, p. 110) states that the first government actions began in 1989, and with them, land use and occupation policies. Botelho (2011, p. 133) highlights that, in 1991, Pope John Paul II came to Vitória for the documentary "The Place of All Poverty," however, the mangrove swamp was filled with municipal waste. It is worth noting that mangroves have been

disregarded throughout various urbanization projects, beginning with the sanitationist approach, which considered them a primary focus of disease and an unhealthy area.

#### 4.1 Urbanism in Vitória: from early actions to the present day

Despite these major urban transformations, Vitória's historic center preserved its urban layout in the central area, maintaining a significant cultural heritage, with heritage sites dating from the 16th to the 20th centuries, through which Espírito Santo society recalls much of its past.

However, public policies in the State of Espírito Santo recognized Vitória's downtown area as an investment destination until the 1960s. The capital of the State of Espírito Santo, which was restricted to its historic core until the beginning of the last century, expanded within the island area until the late 1960s, when it finally crossed the Camburi Channel and reached the mainland.

For Botelho (2005, p. 58), rapid population growth, combined with the perception that the central region was functionally saturated and could not meet the demand for expansion, led the municipal government to abandon the downtown area and expand the urban fabric.

The transfer of administrative activities to Enseada do Suá, as well as the shift of the wealthier population to the north of the island and the mainland, fueled by real estate speculation, transformed the city center into a traffic corridor. The importance of the city center was thus diminished by the effects of polynuclearization and decentralization.

In the downtown area, commerce became widespread, historic complexes were altered, and population decline reached a point where, in the 1980s, the municipality recognized the need for intervention. Urban planning and the development of the first Municipal Master Plan in 1984 were key drivers for improving the quality of life in the region and promoting public participation aimed at valuing historical heritage and revitalizing the downtown area (PMV, 1984). With citizen input and a focus on environmental issues, the City Hall began to guide its decisions.

The issue of urbanization in São Pedro also entered the urban planning agenda during the development of the Municipality's first Master Plan, prompting the City Hall to direct its actions with public participation and environmental considerations. The São Pedro I neighborhood urbanization project is a pioneering example of this convergence, which received funding from the National Housing Bank (BNH) and later from the Caixa Econômica Federal (CEF).

The Terra Project envisioned public participation and institutional integration, working and planning within a field of action delimited by polygons, which often correspond to ZEIS (Special Zones of Social Interest). The project's scope encompassed 30 neighborhoods, 13 communities, and approximately 85,000 inhabitants.

Freire (2004, p. 110) states that the first government actions began in 1989, and with them, land use and occupation policies. "In 1996, the City Strategic Plan, Vitória do Futuro, was developed in response to Agenda 21, which was implemented that same year. The plan diagnosed all the problems faced by the capital" (Cruz, 2010, p. 141).

"The results of the municipal initiative regarding Greater São Pedro received several awards and were included in the 2nd United Nations Conference on Human Settlements, Habitat II, held in 1996 in Istanbul, Turkey" (Bonduki, 1996).

Over the years, the Terra Project changed its name to Terra Mais Igual and was updated, expanding its partnerships. Magalhães and di Villarosa (2012, p. 66) compare the City of Rio de Janeiro, in the early years of the Favela-Bairro program, and that of Vitória, under the current administration of Terra Mais Igual, showing that both have arrangements in place to coordinate these programs with other social sectors within local governments. In 2002, the Vitória do Futuro Project was published, revising the 1996-2010 plan and proposing a scope extending to 2015.

In the downtown area, according to Botelho (2005, p. 60), by mid-2003, the results of the revitalization effort were already noticeable: cleared and restored facades, public facilities, and the renewed landscape along the steps of the Anchieta Palace and the port area. During this period, the second Master Plan (1996) had already been published, determining that the Municipality should implement legislation, public policies, and specific programs aimed at reducing social inequality (PMV, 1996), and Agenda 21, which carried out the planning from 1996 to 2010, taking into account the identification and protection of buildings of historical value through the Vitória Historic Center Revitalization Project (PMV, 2000, p. 77).

Vitória's third Master Plan (PMV, 2006) intended urban development plans to address a set of actions in an integrated manner, meeting the region's demands for urban infrastructure, solutions for at-risk areas, community facilities, leisure areas, and road and transportation systems, establishing guidelines for project development.

Recently, the municipality's Fourth Master Plan (PMV, 2018) highlights the pursuit of a sustainable, economically viable, socially just, and environmentally sound city, developing with the rational use of material and natural resources.

#### **4.2 Health in Vitória: advances in sanitation and quality of life**

Health is one of the essential indicators in smart cities, as it directly impacts the quality of life of their inhabitants. This aspect goes beyond simply providing medical services; it translates into the creation of urban environments that prioritize the well-being of citizens. Through organization and planning, these cities foster healthy lifestyles, encourage community life, and minimize health risks. Furthermore, by prioritizing functional public spaces, accessible mobility, and efficient infrastructure, the health indicator results in a balanced and inclusive urban environment. International studies reinforce this perspective by indicating that health promotion in cities must be aligned with integrated public policies that consider the social determinants of health and spatial cohesion (Barton & Grant, 2006).

A smart city understands health as a fundamental right that must be accessible with quality to all citizens, regardless of their social class, ethnicity, gender, race, or any other condition. In short, health is a universal right, without distinctions or exceptions (Tecnoit, 2022). Furthermore, the Federal District's Secretariat of Science, Technology, and Innovation emphasizes that smart cities make "efficient use of natural resources, promote environmental

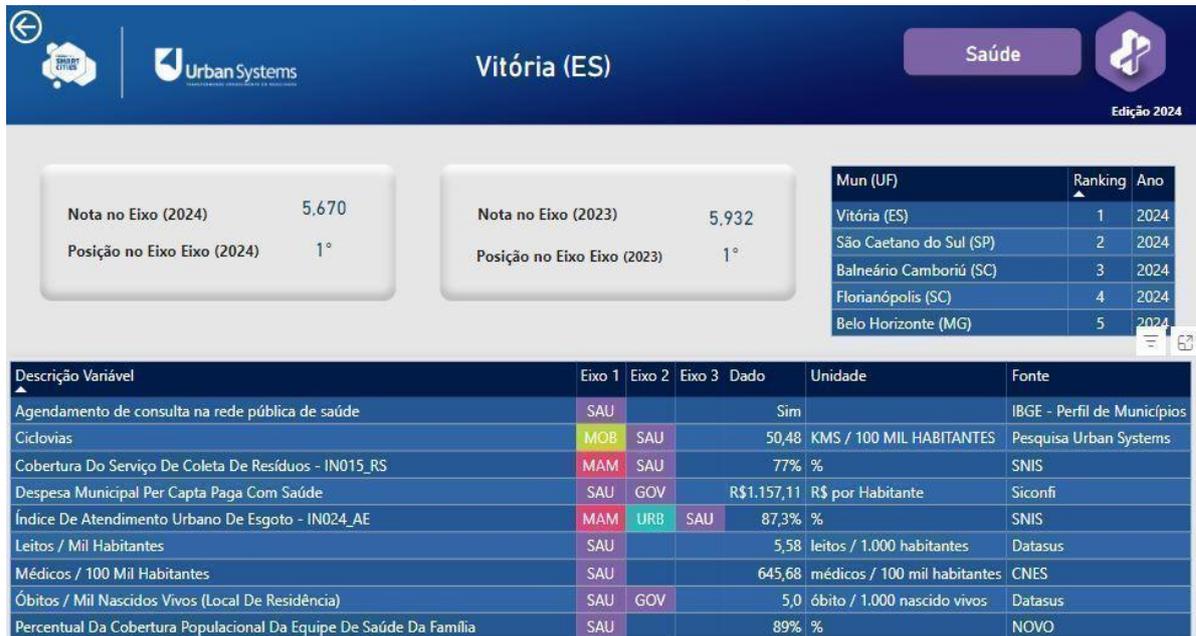
conservation, and the health and well-being of people" (SECTI, 2020). This approach is supported by international research, such as that of the Organization for Economic Cooperation and Development (OECD), which advocates for the integration of urban technologies to improve health outcomes through the use of data and smart governance (OECD, 2020).

Recent studies have explored how this indicator can help manage health crises and promote healthier urban environments. One study that speaks to this issue is the research by Müller and Silva (2021), where they analyzed urban health indicators in Passo Fundo, RS, and their relationship with COVID-19 epidemiological data. The research highlighted that cities with adequate monitoring of health indicators, combined with the development of smart city strategies, have better results in combating pandemics. Another relevant study is that of Chen (2018), who proposed a big data system for urban health based on air quality indicators through crowdsourcing and cloud computing. This system provides health guidance to urban residents, demonstrating the importance of environmental indicators in promoting health in smart cities.

In Brazil, the Connected Smart Cities Ranking places Vitória in first position for the health indicator, ahead of cities such as São Caetano do Sul (SP), Balneário Camboriú (SC), Florianópolis (SC), and Belo Horizonte (MG). This prominent ranking underscores the positive impact of local public policies and sustainable practices in the health sector, contributing to a high quality of life for its residents.

As can be seen in Figure 4, among the variables that stood out for this result are sewage, waste collection, and bike paths, essential elements for the development of sustainable cities, especially in the urban health area. According to the World Health Organization (WHO, 2022), universal access to sanitation is one of the greatest determinants of global health, serving as an indicator of sustainable development and social equity. Waste management is another essential pillar; policies that prioritize recycling and composting help reduce the volume of waste in landfills, mitigating greenhouse gas emissions and promoting a healthier and more sustainable environment (UNEP, 2020). Cycle paths, in turn, offer an active mobility solution that integrates health and sustainability. Cities that invest in accessible cycle path networks encourage residents to cycle, which improves cardiovascular health, reduces radiation problems associated with air pollution, and stimulates physical activity. Studies such as that by Nieuwenhuijsen (2021) show that the combination of active mobility and pedestrian-oriented urban planning can significantly reduce the global burden of noncommunicable diseases in cities.

Figure 4 – Health axis of the Ranking.



Source: Urban Systems (2024).

Vitória's sewage system stands out for its efficiency and covers a large part of the city, playing a crucial role in disease prevention and improving urban sanitation. The municipality has invested in a sewage network that prevents the discharge of untreated wastewater into water bodies, thereby helping to reduce outbreaks of infectious diseases.

Furthermore, solid waste management in Vitória is notable for its efficiency. Regular collection and proper disposal of waste help keep the city clean, minimizing the risk of environmental contamination. This ensures a safer urban environment for its residents, promoting the reduction of breeding grounds for mosquitoes and other disease vectors.

Mobility infrastructure is also a major highlight of the city, especially with the expansion of the bike path network. Vitória has dedicated itself to promoting sustainable transportation, offering a healthy and environmentally friendly alternative to motorized vehicles. With the presence of bike paths, the city not only contributes to the reduction of respiratory problems but also improves the cardiovascular health of the population and helps reduce air pollution. Furthermore, this initiative provides greater safety for cyclists, encouraging a more active and conscious lifestyle (Urban Systems, 2024).

Thus, it is clear that the combination of different factors is essential for the development of urban environments that promote health, and in this context, Vitória stands out as an example to be followed. With innovative initiatives and a commitment to sustainability, Vitória has established itself as a benchmark for other cities in terms of well-being.

### 4.3 Education Indicator

Given Smart Cities' focus on citizen protagonism and, to this end, the use of data to develop projects more coherent with the population's demands, Education becomes an extremely important axis, considering citizen participation not only as users of city resources

and enabling technologies but also as active agents in integrated and sustainable development, aiming for a better quality of life (Tsun et al., 2024). Because it is fundamental to the development of Smart Cities, Education has been the object of study allied to the concept of Smart Cities (Molnar, 2021; Badshah et al., 2023; Mazza, 2021; Dimitrova; Nikolov; Gospodinov, 2024; SCALA et al., 2024) and is included as an indicator in most indexes proposed to evaluate cities (Zammar et al., 2021). For example, the Education axis is included in ISO 37.122, which establishes guidelines for Smart Cities and is one of the sources for the Brazilian Ranking. "Thus, the educational development of citizens must be analyzed, as it is the main component for a city to evolve and remain smart" (Zammar et al., 2021, p. 2). In this sense, the importance of education is described in the Ranking's own report when it states: "[...] the importance of education, not only as basic indicators of service delivery and teaching quality, but also its power in shaping and reproducing the potential of each city" (Urban Systems, 2024, p. 9).

Thus, it is necessary to understand current citizens and those of future generations to assess whether they are or will be receiving the appropriate education "to live with quality, dignity, independence, and freedom in smart cities, so that they can access data and apply knowledge correctly to manage a technologically responsive, sustainable, and resilient city" (Tsun et al., 2024, p. 3-4). In this sense, they draw attention to the implications of technology implementation not only in the management and use of urban resources, but also in education, so that cities can be inclusive in terms of digital access, through improved access, quality, and efficiency of education, aiming not only at preparing for the job market, but also for civic action and an envisioned, increasingly technological future. Despite the widespread use of Information and Communication Technologies (ICTs) in the context of Smart Cities, it is important to emphasize that their use alone will not revolutionize Education, as, like any other area, it is also "[...] capable of creating social inequality [...]" (Camargo and Roma, 2023). Therefore, the implementation of ICTs must be aligned with social inclusion.

Based on the presented context, the Education Axis is included in the Connected Smart Cities Ranking, with the allocation of twelve indicators: eleven developed for this axis and one from the Technology and Innovation axis. These are: Public University Placements, Average ENEM (National Higher Education Institute) Score, Faculty with Higher Education, IDEB (Institute of Education and Innovation), Dropout Rate, Average Students per Class, Education Expenditure, Average Daily Class Hours, Computers per Student, Employed Workforce in the Education Sector, Online School Enrollment in the Public School System, and Percentage of Formal Higher Education Jobs (Technology and Innovation Axis). Each indicator is assigned one point, totaling twelve points for the Education Axis. In the current edition, the city of Vitória ranked eighth overall, with a score of 5.906, the same position as in the 2023 edition, but with a lower score (2023 score: 6.505) and as the best-rated state capital, as illustrated in Figure 8.

Figure 7 – Education axis of the Ranking.



Source: Urban Systems (2024).

Among the twelve indicators in this axis are the Basic Education Development Index (IDEB), teachers with higher education, and online enrollment in the public school system. To analyze the results of these indicators, in addition to academic papers in the field, we also consulted the Vitória State Education Plan (PMEV) for the period 2015-2025 (Law No. 10,382), in compliance with the National Education Plan (Federal Law No. 13,005/2014).

The analysis begins with the IDEB, which combines the School Performance Index (average pass rates for the assessed cycle, measured through School Census data) with Performance Averages (based on the average results from the National Basic Education Assessment System (SAEB), standardized to a scale between 0 and 10). For its score, the Federal Government considers that achieving an IDEB of 6.0 corresponds to the average level of educational quality in the member countries of the Organization for Economic Cooperation and Development - OECD (Todos pela Educação, 2017; Chirinéia; Brandão, 2015). For Silva et al. (2020), the use of IDEB is part of a "culture of assessment," serving as an outcome indicator rather than a measure of quality, since to assess quality, other variables need to be analyzed, such as pedagogical practice, school management, teacher training, among others (Chirinéia; Brandão, 2015). In the PMEV, IDEB is part of Goal 7, whose objective is to "Foster the quality of basic education at all stages and modalities, supported by educational indicators, available at national, state, and municipal levels, aiming at improving the flow and school learning" (PMV, 2017). Analyzing Vitória's IDEB (final years), which was 4.6, it is 1.4 points below the national target of 6.0 and 0.8 below the municipal target set in the PMEV, which was to reach a score of 5.4 by the end of the period (2025), with the target of 6.0 projected for 2031.

The indicator "Teachers with Higher Education," which has significant implications for the quality of education, is part of Goal 15 - Teacher Training of the PMEV. The goal is to ensure, within one year of the PMEV's implementation, the municipal policy for training and developing education professionals, so that all basic education teachers have specific higher education training obtained through a bachelor's degree program in the same field of instruction (PMV,

2017). In the first year of the PMEVA program, the percentage was already around 80%, with a target of 100% by the end of the period, for both elementary and secondary school teachers. The result covered in the Ranking is 99.90%, considering secondary school teachers. However, data from the table "Percentage of Teaching Positions with Higher Education by Municipality - 2023," developed by INEP (the same source as the Ranking), shows that the percentage of public school teachers in Vitória with higher education is 99.90% for Early Childhood Education, 100% for Elementary Education, 100% for Professional Education (state-run), and 100% for Youth and Adult Education (EJA). This means that some levels of education are 0.10 points close to the target, while others have already achieved the target, considering the 2023 data used in the 2024 Ranking.

Finally, the indicator "School Enrollment in the Online Public School System" is extremely important because it leverages ICTs to facilitate access to education, avoiding travel throughout the region for this purpose, which can have several implications for families' daily lives. This avoids the formation of traditional queues, which can generate potential social, ergonomic, and relational discomfort, situations that the lower-income population is commonly subject to. The Ranking shows that in the city of Vitória, these are conducted online, but checking the Municipal and State Government portals revealed that enrollment in municipal public schools is conducted in person. Enrollment occurs in two stages, regulated by a separate ordinance published annually in the Municipal Official Gazette between November and December. However, re-enrollment is conducted online through the city's website. Enrollment and re-enrollment in the state public school system are conducted online.

Thus, it is clear that in this axis, the city of Vitória has already made progress in improving access, quality, and the pursuit of better educational indicators. However, as its own established goal indicates, there is still work to be done to achieve higher-quality education, beyond meeting the indicators.

## **5 GLOBAL CHALLENGES OF CITIES IN THE 21ST CENTURY**

Twenty-first-century cities face complex global challenges reflecting rapid population growth, uncontrolled urbanization, and the increasingly intense effects of climate change. These factors, coupled with infrastructure problems and social inequality, increasingly pressure urban managers to seek innovative and sustainable solutions. Within this scenario, the idea of smart cities presents itself as a promising approach to mitigate the impacts of these challenges and foster sustainable growth. As Pinto (2014) argues, urban planning is an essential tool for mitigating and adapting cities to climate change, while also combating structural inequalities.

Urban population growth, one of the main factors behind contemporary transformations, has placed a considerable focus on cities. According to the United Nations (UN-Habitat, 2022), by 2050, approximately 68% of the world's population will live in urban areas, representing an increase of 2.5 billion people. This growth challenges the ability of cities to provide basic services such as health, education, sanitation, and transportation. Rapid, often disorderly, urban expansion results in urban macrocephaly, socio-spatial inequalities, and overburdened public services (Brasil Escola, 2022). In megacities such as Lagos, Nigeria, and Mumbai, India, this population expansion has resulted in the management of informal

settlements, leaving millions of individuals in precarious conditions with inadequate housing and no access to basic services (Adams, Silva, and Zucchetti, 2020).

Disorderly urbanization, often associated with population growth, intensifies problems related to urban infrastructure. In places like Jakarta, Indonesia, urban expansion without adequate planning ends up occurring in areas susceptible to flooding, coupled with an infrastructure incapable of meeting the growing demands of the population (Adams, Silva, and Zucchetti, 2020). In Brazil, the metropolis of São Paulo exemplifies this reality: while the city is home to globally important financial centers, its vast outlying areas face serious sanitation shortages and public transportation that fails to meet the population's needs (Monteiro, 2019). This disparity reinforces the need for public policies that integrate urban planning and investments in sustainable infrastructure.

Another critical challenge facing cities is the impact of climate change. Despite occupying only 3% of the Earth's surface, urban centers are responsible for more than 70% of global greenhouse gas emissions (C40 Cities, 2021). Extreme weather events, such as storms, floods, and heat waves, have become increasingly frequent and intense. In 2022, the city of Durban, South Africa, suffered severe flooding that resulted in more than 400 deaths and the destruction of thousands of homes (BBC, 2022). These events not only reveal the vulnerability of urban areas but also highlight the urgent need to invest in resilient infrastructure capable of adapting to climate change. According to Carter et al. (2015), building adaptive capacity in cities requires integrated and interdisciplinary approaches ranging from governance strategies to the reconfiguration of urban spaces.

Furthermore, social inequality remains one of the main challenges faced by contemporary cities. The unequal distribution of resources and opportunities exacerbates socio-spatial segregation, resulting in the formation of pockets of poverty in urban areas. A striking example of this disparity can be seen in Mumbai, where the presence of luxurious skyscrapers contrasts with vast slums (World Bank, 2020).

In Brazil, this inequality also manifests itself in access to technology and digital services, fundamental aspects in the context of smart cities (Silva et al., 2020). This digital divide creates barriers to populations' access to essential services, such as healthcare and education, which increasingly lack technological solutions. Furthermore, the lack of connectivity limits citizen participation in smart governance processes, reinforcing preexisting inequalities.

In this scenario, smart cities emerge as a promising alternative to mitigate the impacts of these challenges. Through technologies such as the Internet of Things (IoT), artificial intelligence, and real-time data analysis, it is possible to develop integrated solutions for transportation, resource management, and urban planning.

However, the success of smart cities depends on an approach that prioritizes both social inclusion and environmental sustainability. As Santos, Silva, and Almeida (2022) point out, it is crucial to ensure that technological innovations do not perpetuate preexisting inequalities, but rather are instruments for promoting equity and improving the quality of life for all citizens. In this sense, Höjer and Wangel (2015) emphasize that the definition of smart cities must be deeply connected to sustainability and social justice, otherwise they will become merely exclusionary technological models.

The challenges faced by cities in the 21st century require comprehensive and interdisciplinary solutions. Urban planning, inclusive public policies, and the strategic use of technologies are essential steps toward overcoming urban crises (Ravache et al., 2024). In this sense, smart cities emerge as a valuable opportunity to build a more resilient, sustainable, and just urban future.

## 6 RESULTS AND DISCUSSIONS

Vitória stands out nationally as a remarkable example of how technology and urban planning can combine to meet the challenges of the 21st century. According to the Connected Smart Cities 2024 Ranking report, Vitória (ES) performed impressively, surpassing Niterói (RJ) and solidifying its position as the highest-ranking city among mid-sized municipalities, those with a population between 100,000 and 500,000. Furthermore, Vitória ranked 2nd in the Overall Ranking, registering a significant increase of five positions compared to the previous year.

This performance is a result of the Espírito Santo capital's ongoing efforts to implement technological solutions, innovative public policies, and sustainable urban planning strategies. Thanks to these initiatives, the city has excelled in several evaluated areas, such as urban planning, healthcare, and education. Vitória not only reaffirms its leading role on the national stage but also establishes itself as an exemplary model of efficient and intelligent urban management.

Urban planning in Vitória reflects a trajectory of profound transformations, shaped by historical and contemporary urban disciplines that have reshaped the city over the centuries. Despite the challenges, it demonstrates ongoing efforts to balance development and sustainability. The capital of Espírito Santo stands out for initiatives such as the restoration of degraded areas, investments in urban mobility, and policies focused on social inclusion. Even so, the marks of past transformations remind us of the importance of structured and integrated actions to overcome existing barriers. Vitória is, therefore, an example of urban resilience, where historical lessons guide current projects, promoting more inclusive and sustainable growth aligned with the principles of smart cities.

In the field of healthcare, Vitória ranks first in the Connected Smart Cities 2024 Ranking, with a score of 5.670 points (66.70% of the total score for the area, which is 8.5 points), reflecting the positive impact of its public policies and sustainable practices on the quality of life of its residents. The efficiency of the sewage system, which covers a large part of the city, and proper solid waste management are fundamental pillars of urban health, contributing to disease prevention and environmental preservation. Furthermore, investments in bike paths promote sustainable mobility and encourage physical activity, integrating health and sustainability. These practices consolidate Vitória as a benchmark for smart cities, fostering quality of life and inclusion for all citizens.

Regarding education, it ranked 8th in the Connected Smart Cities 2024 Ranking, with a score of 5.906 (49.22% of the total score for the area, which is 12 points and 0.776 points behind the first-place city, São Caetano do Sul, São Paulo). Although it recorded a slight decrease in its score compared to the previous year, Vitória remains the highest-rated state capital in this

area, reflecting its continued efforts to provide quality education, digital inclusion, and prepare citizens for a more technological future.

Vitória's position as the second smartest city in Brazil in 2024, with a score of 37.513, just below Florianópolis, with 37.525, reinforces the importance of an integrated approach that combines technology, sustainability, and social inclusion. Although it has achieved significant progress, the challenges faced by the city demonstrate that the concept of urban intelligence needs to be constantly adapted to local realities. Vitória's case illustrates that building a smart city is not limited to the application of advanced technologies, but rather the use of these tools to promote more equitable, sustainable, and resilient urbanization. Finally, it is also important to note that the Ranking has a maximum score of 67.0 points, and no city exceeded 60% of its total score, demonstrating that despite current implementations, Brazilian cities have much room to improve in applying the smart city concept.

## 7 FINAL CONSIDERATIONS

The overall objective of this study was to analyze the city of Vitória, in the state of Espírito Santo, recognized as the second smartest city in Brazil in 2024 according to the Connected Smart Cities Ranking, in the context of its urban planning and, based on this, to analyze certain indicators in the health and education sectors. To this end, the concept of smart cities and its application in Vitória's context were investigated, identifying the factors that contribute to its outstanding indicators. The study reflected on the global challenges faced by cities in the 21st century, in addition to highlighting the innovative best practices adopted by Vitória that can serve as a reference for other Brazilian cities.

Therefore, the study contributed not only to the analysis of the city in question from the perspective of the smart city concept, but also as a reference for future research using data from the Connected Smart Cities Ranking; However, the study has a limitation due to the lack of analysis of the other indicators in the studied sectors. As a suggestion for future work, it is recommended that research focus on analyzing the remaining indicators of each axis separately and their impact on the municipality in question, in order to broaden the understanding of the impact of the Connected Smart Cities Ranking and the application of the smart city concept.

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STATEMENTS

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CONTRIBUTION OF EACH AUTHOR

- **Study Conception and Design:** Luciana Nemer Diniz.
- **Data Curation:** Luciana Nemer Diniz, Jessica Queiroz da Silva Falcão e Amanda Pereira Rodrigues Moura
- **Formal Analysis:** Jessica Queiroz da Silva Falcão e Amanda Pereira Rodrigues Moura
- **Acquisition of Financing:** There was no financing.
- **Investigation:** Luciana Nemer Diniz, Jessica Queiroz da Silva Falcão e Amanda Pereira Rodrigues Moura
- **Methodology:** Luciana Nemer Diniz, Jessica Queiroz da Silva Falcão e Amanda Pereira Rodrigues Moura
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- **Review and Final Editing:** Luciana Nemer Diniz
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DECLARATION OF CONFLICTS OF INTEREST

I/we, **Luciana Nemer Diniz, Jéssica Queiroz da Silva Falcão e Amanda Pereira Rodrigues Moura**, declare that the manuscript entitled "**Analysis of Brazil's second smartest city in 2024: Vitória – ES, according to the axes of urbanism, health and education**":

1. **Financial Ties:** Does not have/has financial ties that could influence the results or interpretation of the work.
  2. **Professional Relationships:** Does not have/has professional relationships that could impact the analysis, interpretation, or presentation of results.
  3. **Personal Conflicts:** Does not have/has no personal conflicts of interest related to the content of the manuscript.
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