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Analysis of environmental health and sustainability of Brazilian municipalities in the Baixo Pardo/Grande River Basin

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SUMMARY

Population growth, the lack of urban planning and poor sanitation infrastructure have persisted in the management of urban space when the core issue is environmental health and the sustainability of municipalities. This paper aimed to evaluate the environmental health and sustainability of the 12 Brazilian municipalities in the Baixo Pardo/Grande (SP) river basin. The exploratory approach and the case study guided the comparative analysis of sustainability through the Sustainable Cities Development Index (100 indicators) and the Brazilian Environmental Health Index (18 indicators) to obtain an integrated classification of these indices on a municipal scale. The analyses highlighted that 100% of studied municipalities reached medium level (score: 51-75) out for health and sustainability, especially to Altair and Orlândia results Bebedouro, Viradouro and Colina require careful monitoring of the following indicators sanitary sewage and vector control, water and socioeconomic resources, and water and socioeconomic resources, respectively. The basic sanitation, health diseases and infant mortality pillars relating to these indices identified seven similar indicators, that is, they measure the same aspects of the analyzes. Then, they were excluded to avoid duplication of data. The least promising results of Sustainable Development Goals (SDGs) were Gender equality (SDG 5), Industry, innovation and infrastructure (SDG 9), Protect life on Earth (SDG 15) and Partnerships and means of implementation (SDG 17). Finally, the great challenges of the Baixo Pardo Grande River Basin pointed out social, technological and connectivity issues between interinstitutional sectors from a regional perspective.

KEYWORDS: Environmental health. Sustainable development. River basin.

1. INTRODUCTION

The population increase, inadequate urban planning and the demand for infrastructure (water, sewage, electricity, public lighting, garbage collection, asphalt and paving in the streets, public transport, parks, squares, schools) and services, as well as the use of natural resources based on an economic development model in disassociation with environmental conservation compromises the quality of life of the population and, consequently, environmental health and sustainability of municipalities.

Investments in urban equipment do not follow, to the same extent, urbanization and urban expansion and, therefore, equal access and social exclusion make the urban environment incompatible with the concept of quality of life (Araújo; Cândido, 2017).

Quality of life is defined as the presence of a healthy and safe environment, quality health and well-being, a balanced and preserved environment, basic sanitation for the entire population, quality and, in some cases, free education. For example: green areas (Soares *et al*., 2019), public spaces open to leisure (Oliveira; Mascaró, 2007), regional distribution of employment and income opportunities (Mendonça, 2006).

Environmental health represents the state of health in which the population lives in relation to the ability to inhibit or prevent the occurrence of diseases and the potential to promote the improvement of conditions favorable to the full enjoyment of health and well-being (Funasa, 2019). In this sense, in 1999, the Environmental Health Indicator (ISA) was developed by the State Sanitation Council (CONESAN) of the State of São Paulo (CONESAN, 1999) and aimed to evaluate sanitation and environmental conditions, and can be used on municipal or regional scale (watershed).

Indexes and indicators are often used interchangeably, but they have differences. An indicator is a tool capable of obtaining and producing information on a given subject (Mitchell, 1996). It can be understood as a public-private management control instrument that shows

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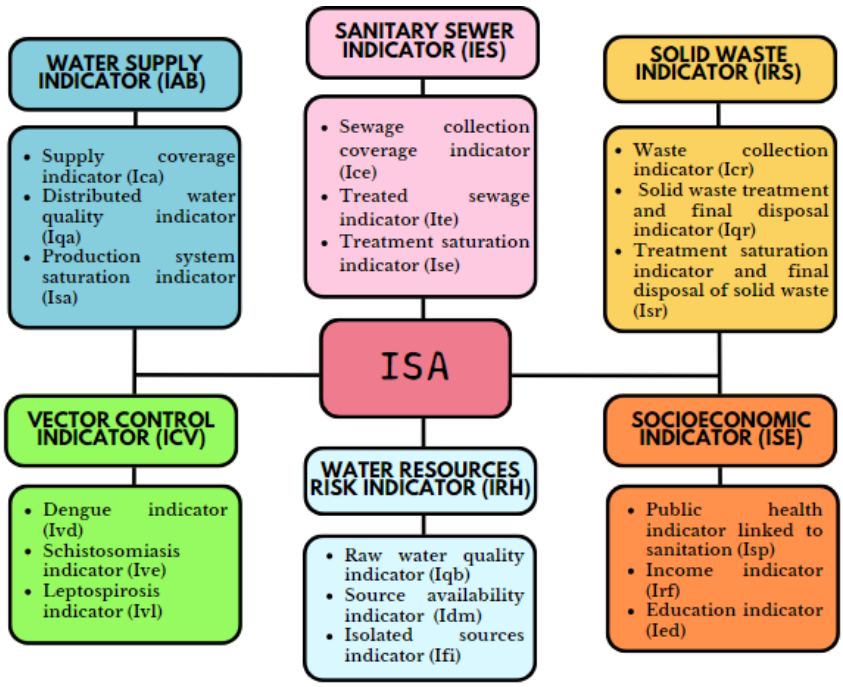
management transparency and allows dialogue between the different groups involved in an organization (Machado, 2004). The indexes are created by aggregating two or more simple indicators, referring to the same dimension, or different dimensions, of reality (Jannuzzi, 2004 cited by Sobral *et al*, 2011)**.** Given these definitions, the ISA and IDSC have an index function, as they are indicators related to basic sanitation, public health and social and environmental conditions.

The ISA is made up of components selected from the areas of environmental, socioeconomic, public health and water resources sanitation (Piza, 1999) and each one contains three sub-indicators (Figure 1).

Figure 1 – Composition of the environmental health indicator



Source: Organized by the authors based on Piza (1999).

Some authors used this method to understand the situation of sanitation and the local environment, as observed by Montenegro *et al*. (2001), Dias *et al*. (2004), Batista (2005), Lins *et al*. (2017), Lupepsa *et al*. (2018), Damaceno; Cruvinel (2018), Rocha (2019), Lima (2019), Kobren *et al*. (2019), Alvares (2020), Ferro *et al*. (2020), Rezende (2020), Duarte, Bezerra; Gonçalves (2021), Scolari, Medeiros; Passini (2023).

Most authors have applied the indicators in just one municipality, unlike Damaceno as Cruvinel (2018) used them in Brazilian capitals, Lima (2019) evaluated 21 cities in the state of Goiás and Alvares (2020); Rezende (2020) analyzed Northwest of the Rio Pardo River Basin in the State of São Paulo. Table 1 presents the research identified at the national level from 2000 to 2023.

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Since 2021, Brazil has Sustainable Cities Development Index (IDSC), which covers 100 indicators (Brazil, 2023) and has been organized into 17 Sustainable Development Goals (SDGs) (Table 2).

Table 1 – National researches related to ISA from 2000 to 2023

Author, year	Conceptual Model	Coverage area	Observed results
Dias *et al.*, 2004	ISA/OE = 0,20.Iaa + 0,20.Ies + 0,15.Irs + 0,10.Idu + 0,15.Icm + 0,10.Ise + 0,10.Isa	Spontaneous Occupation Areas in Salvador, Bahia	Baixa do Arraial do Retiro and Baixa do Camarajipe (two areas): unhealthy situation. Bom Juá (one area): low healthy situation. Nova Divinéia, Antônio Balbino, Santa Mônica, Boa Vista de São Caetano and Jardim Caiçara (five areas): average healthy situation and Sertanejo (one area): healthy situation.
Batista, 2005	ISA/JP = 0,25.Iab + 0,20.Ies + 0,20.Irs + 0,10.Icv + 0,10.Irh + 0,10.Idu + 0,05.Ise	João Pessoa, Paraíba	Aeroclube and Altiplano Cabo Branco (two neighborhoods): médium healthy situation. Bessa, Jardim Oceania, Manaira, Tambaú, Cabo Branco, Penha and Seixas (seven neighborhoods): healthy situation.
Albuquerque, 2013	ISA = 0,10.Iab + 0,25.Ies + 0,15.Irs + 0,10.Isp + 0,15.Icm + 0,05.Isme + 0,15.Iepc + 0,05.Ise	Community of Saramém em Brejo Grande, Sergipe	The ISA was an important instrument for measuring the efficiency of sanitation infrastructure in the community. From the study it was possible to verify that environmental sanitation services were classified as unsatisfactory, and, therefore, as a low healthy level.
Lins *et al.*, 2017	ISA = 0,30.Iab + 0,30.Ies + 0,25.Irs + 0,15.Icv	Guaíra, Paraná	The municipality obtained a score of 80,15, therefore, healthy.
Lupepsa *et al.*, 2018	ISA = (Iaa x 0,20) + (Ies x 0,20) + (Irs x 0,20) + (Idu x 0,10) + (Iqu x 0,15) + (Ise x 0,15)	Umuarama, Paraná	The municipality obtained a score of 0,9207, therefore, healthy.
Damaceno e Cruvinel, 2018	ISA = 0,275.Iab + 0,275.Ies + 0,275.Irs + 0,125.Icv + 0,05.Isec	Capitals of Brazil (26 capitals + Distrito Federal)	Cuiabá, Aracaju, Fortaleza, São Luís, Teresina, Belém, Macapá e Porto Velho foram classificados como baixa salubridade. Brasília, Campo Grande, Goiânia, João Pessoa, Maceió, Natal, Recife, Salvador, Boa Vista, Manaus, Palmas, Rio Branco, Belo Horizonte, Rio de Janeiro, São Paulo, Vitória and Florianópolis, as average healthy and only Curitiba and Porto Alegre as healthy.
Rocha *et al.*, 2019	ISA/CG = Iab + Ies + Irs + Idu + 0,05.Ise	Campina Grande, Paraíba	The indicators were analyzed separately. Iab: the municipality presented, in general, values between 0,60 and 0,80. Ies: central areas had better coverage than peripheral neighbordoohs. Irs: one sector presented a value of 0,75 and the other sectors presented values lower than 0,50. Idu: it was the indicator with the best values for all sectors (reaching 0,95 in one of them). Ise: most of the sectors analyzed presented values below 0,50.
Lima *et al.*, 2019	ISA = 0,275.Iab + 0,275.Ies + 0,275.Irs + 0,125.Icv + 0,05.Isec	21 municipalities of Goiás	The results were: 9,5% of the municipalities studied were considered healthy, 28,6% had average healthiness and 61,9% had low healthiness.
Kobren *et al.*, 2019	ISA = 0,30.Iab + 0,20.Ies + 0,20.Irs + 0,10.Icv + 0,10.Irh + 0,10.Ise	Porto Rico, Paraná	The indicator was applied in the municipality of Porto Rico and was classified as healthy (score = 80,18). The author concluded that the method is excellent because it addresses the needs of the location.
Alvares, 2020	ISA = 0,25.Iab + 0,25.Ies + 0,25.Irs + 0,10.Icv + 0,10.Irh + 0,05.Ise	Bacia Hidrográfica do Baixo Pardo/Grande (SP)	The ISA was applied in the 12 municipalities of the Basin River, of the 12 municipalities, 4 (Altair, Colômbia, Jaborandi and Orlândia) presented a healthy result. The others presented average healthy results.
Ferro *et al.*, 2020	ISA = 0,25.Iab + 0,25.Ies + 0,25.Irs + 0,10.Icv + 0,10.Irh + 0,05.Ise	Rio Claro, São Paulo	The indicators were evaluated separately: Iab: 96,30, Ies: 66,70, Irs: 100,00, Icv: 31,25, Irs: 60,00 e Ise: 80,30. The municipality presented ISA: 78,14, being classified as healthy.
Rezende, 2020	ISA = 0,25.Iab + 0,25.Ies + 025.Irs + 0,10.Icv + 0,10.Irh + 0,05.Ise	Porção Noroeste da Bacia do Rio Pardo (SP)	The ISA was applied in 6 municipalities: Altinópolis, Brodowski, Cravinhos, Jardinópolis, Ribeirão Preto and Serrana. The results obtained were: Altinópolis, Brodowski, Cravinhos and Ribeirão Preto were classified as medium healthiness and Jardinópolis and Serrana as low healthiness.

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Duarte, Bezerra e Gonçalves, 2021	ISA = 0,25.Iab + 0,25.Ies + 0,25.Irs + 0,10.Icv + 0,15.Ise	Caruaru, no Vale do Ipojuca, Pernambuco, Ceará	The ISA was applied in two neighborhoods in Caruaru, called A and B (the author decided to omit the names of the neighborhoods). The results obtained were: the neighborhoods A and B show low health for Iab and Irs; average healthiness for Ise and healthy for Ies and Icv.
Shibasaki, 2022	ISSA = 0,201.Iaa + 0,199.Iesg + 0,132.Irs + 0,112.Idre + 0,118.Iamb + 0,107.Isp + 0,131.Ise	Baixo Pardo/Grande River Basin (SP)	The ISSA was prepared by the author based on the selection of indicators and consultation with experts. After applying the method in the twelve municipalities, it was possible to conclude that eight municipalities had a medium health level and six had a low health level.
Framesche, Souza e Barbado, 2022	ISA = 0,25.Iab + 0,25.Ies + 0,20.Irs + 0,10.Icv + 0,20.Ise	Cianorte e Umuarama, Paraná	Both municipalities were classified as healthy, however, the indicator that requires the most attention is solid waste.
Scolari, Medeiros e Passini, 2023	ISA = 0,25.Iab + 0,25.Ies + 0,25.Irs + 0,10.Icv + 0,10.Irh + 0,05Ise	Jaboticaba, Rio Grande do Sul	The municipality of Jaboticaba reached average healthy status, requiring improvement in some sanitation sectors, mainly sewage.

Definitions:
ISSA = Index for Assessing Sanitation and Environmental Healthy, Idu = Urban Drainage Indicator, Iam = Environmental Health Index, Ism = Housing Health Index, Icm = Housing Conditions Component, Isa = Environmental Health Component, Iqu = Urban Quality Indicator, Isec = Socioeconomic Indicator, Isp = Public Health Indicator, Isme = Indicator of Satisfaction with Housing and Surroundings, Iepc = Community Public Space Indicator.
Source: Own authorship.

The term *sustainable development* emerged in 1987, at the United Nations Conference on Environment and Development, Eco-92 (Souza *et al*., 2017) and it brought about the need to rethink resources in the long term to take into account recent demands to keep society developing (UN, 1987). In this sense, IDSC aims to universally promote economic prosperity, social development and environmental protection in order to achieve sustainable development.

Table 2 – Description of the SDGs and their contribution of cities

Sustainable Development Goals	Number of indicators	Purpose of the SDG	Contribution to cities
SDG 1: No poverty	4	Acabar com a pobreza em todas as suas formas, em todos os lugares	Quality of life
SDG 2: Zero hunger	5	Acabar com a fome, alcançar a segurança alimentar e melhoria da nutrição e promover a agricultura sustentável	Quality of life
SDG 3: Good health and well-being	17	Assegurar uma vida saudável e promover o bem-estar para todas e todos, em todas as idades	Quality of life and reduction of diseases
SDG 4: Quality education	18	Assegurar a educação inclusiva e equitativa e de qualidade, e promover a oportunidade de aprendizagem ao longo da vida para todas e todos	Replacement in the job market and local economy
SDG 5: Gender equality	5	Alcançar a igualdade de gênero e empoderar todas as mulheres e meninas	Equality between men and women
SDG 6: Clean water and sanitation	5	Assegurar a disponibilidade e gestão sustentável da água e saneamento para todas e todos	Sanitation services
SDG 7: Affordable and clean energy	2	Assegurar o acesso confiável, sustentável, moderno e a preço acessível à energia para todas e todos	Local security
SDG 8: Decent work and economic growth	6	Promover o crescimento econômico sustentado, inclusivo e sustentável, emprego pleno e produtivo e trabalho decente para todos e todas	Local economy
SDG 9: Industry, innovation and infrastructure	2	Construir infraestruturas resilientes, promover a industrialização inclusive e sustentável e fomentar a inovação	Local economy

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SDG 10: Reduced inequalities	10	Reduzir as desigualdades dentre dos países e entre eles	Equality between people
SDG 11: Sustainable cities and communities	6	Tornar as cidades e os assentamento humanos inclusivos, seguros, resilientes e sustentáveis	Local security
SDG 12: Responsible consumption and production	3	Assegurar padrões de produção e de consumo sustentáveis	Local economy
SDG 13: Climate action	4	Tomar medidas urgentes para combater a mudança climática e seus impactos	Quality of life and reduction of diseases
SDG 14: Life below water	1	Conservação e uso sustentável dos oceanos, dos mares e dos recursos marinhos para o desenvolvimento sustentável	Quality of life and improvement in water supply services
SDG 15: Life on land	3	Proteger, recuperar e promover o uso sustentável dos ecossistemas terrestres, gerir de forma sustentável as florestas, combater a desertificação, deter e reverter a degradação da terra e deter a perda de biodiversidade	Quality of life
SDG 16: Peace, justice and strong institutions	7	Promover sociedades pacíficas e inclusivas para o desenvolvimento sustentável, proporcionar o acesso à justiça para todos e construir instituições eficazes, responsáveis e inclusivas em todos os níveis	Equality between people
SDG 17: Partnerships for the goals	2	Fortalecer os meios de implementação e revitalizar a parceria global para o desenvolvimento sustentável	Local economy

Source: Organized by the authors based on Brazil (2022).

The IDSC illustrates the level of compliance with the SDGs (scale from 0 to 100), whose colorimetric representation points from the highest level (dark green) to the lowest level (red), as seen in Table 3.

Table 3- Classification of ISDC

Classification		Description
0 - 39,99	Very low	Indicador reached very low or non-existent performance
40 - 49,99	Low	Indicador reached low performance
50 – 59,99	Medium	Indicador reached medium performance
60 – 79,99	High	Indicador reached high
80 - 100	Very high	Most indicators were achieved

Source: Organized by the authors based on Brazil (2022).

The core hypothesis of this paper was based on the understanding that indexes and indicators are tools that provide a diagnosis of sanitary and environmental conditions associated with other guiding axes of public policies, such as sustainable development and environmental health. Then, the key questions were: a) Can sustainable cities achieve environmental health? and b) How can the environmental health and sustainable development index improve the management of urban infrastructure and promote health for the population?

The main contribution of this study was the possibility of exploring both indexes in an integrated way on a river basin scale. Thus, the obtained results can support public policies and annual reports of River Basins by health and sustainability monitoring indicators, according to State Law 9433/1997.

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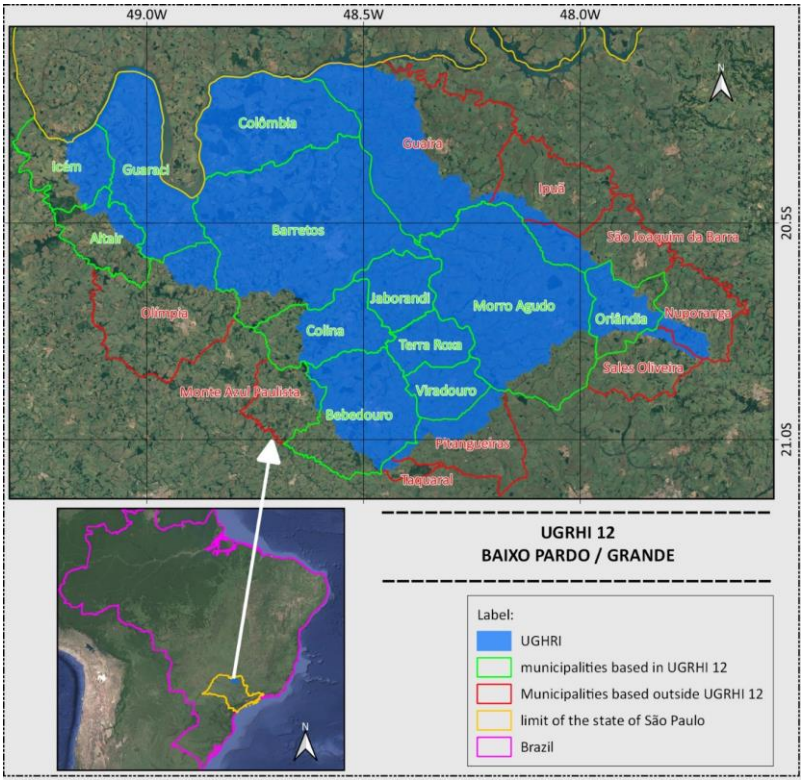
2 OBJECTIVE

The objective was to analyze the environmental health and sustainability of the 12 municipalities belonging to the Water Resources Management Unit (UGRHI) 12, known as the Baixo Pardo/Grande River Basin.

3 METHODOLOGY

The assessment of the environmental health and sustainability in both municipalities and river basins assists public administration decisions to be taken by its organs. UGRHI 12 (Figure 2) was selected due to a previous study (Alvares, 2020; Rezende *et al.,* 2021) for the 12 counties (Altair, Barretos, Bebedouro, Colina, Colombia, Guaraci, Icém, Jaborandi, Morro Agudo, Orlândia, Terra Roxa, Viradouro).

Figure2 – Municipalities of the UGRHI 12



Source: Own authorship.

The methodology was based on an exploratory analysis and case study. The exploratory analysis is based on an assessment of an unknown concrete situation, in a given location, similar or complementary in certain aspects (Marconi; Lakatos, 2003), while the case study is characterized by an in-depth study allowing broad and detailed knowledge of a certain object (Gil, 2008). In order to achieve this, three steps have been developed, which are described below.

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Analysis of the sustainability of municipalities based on IDSC data (Stage 1)

Initially, the IDSC was obtained for each of the 12 UGRHI municipalities, which were organized in a Table (17 SDGs per 12 municipalities), based on the results calculated using the Brazil method (2023). The data available for the year 2023 has been updated for ISA and IDSC. Some data remained unchanged, as the database refers to previous years (2022, 2018, 2010).

Comparative analysis between indices for UGHRI 12 (Stage 2)

A comparative analysis was accomplished with a database in an electronic spreadsheet. The objective was to identify similar indicators with identical descriptions to exclude them from the analyses to avoid the duplicate information.

Elaboration of the level of association of the indices for the object of study (Step 3)

The association between the indexes (ISA and IDSC) established the closing level among them (Rezende *et al.,* 2021). Then, the defined scale and the arithmetic average of the indicators are shown in Table 4. A dispersion diagram allowed the interpretation of the data.

Table 4 – Level of association between indexes to municipalities scale

Score	Level	Description
0 - 25	Unhealthy and Unsustainable	The municipality had a very low score for healthy and SDG indicator. The municipality is in a state of alert and needs a lot of attention.
26 - 50	Low level of healthiness and sustainability	The municipality achieved less than half of the healthy and SDG indicator scores. The municipality needs attention and improvements.
51 - 75	Medium level of healthiness and sustainability	The municipality achieved more than half of score for health indicators and the SDGs. The municipality can improve planning and infrastructure to raise a score.
76 - 100	Healthy and Sustainable	The municipality reached the healthy indicators and the SDGs.

Source: Own authorship.

4 RESULTS AND DISCUSSION

4.1 Analysis of sustainability in UGRHI 12 municipalities (Stage 1)

Table 1 presents the situation of the municipalities in relation to the SDGs that make up the sustainability index.

The municipality of **Altair** achieved a very high level of three (SDGs 6, 14 and 16) from 17 SDGs. Six goals (35% of the SDGs) are close to the maximum score (SDGs 3, 4, 7, 10, 11 and 12). The rest (47%) require improvements for values below 59.99. The municipality of **Barretos** achieved seven (41%) goals classified in the colors dark green and green (SDG 6, 7, 14, 3, 10, 11 and 13), while the others (59%) scored below 69.99.

The municipality of **Bebedouro** did not reach SDG 14. In addition, it has obtained 35% of SDGs achieved. Of all the objectives, the municipality of **Colina** achieved seven of them (41%), being SDGs 3, 6, 7, 10, 11, 12 and 14. The municipality of **Colômbia** achieved six SDGs (35%) in relation to those observed in Colina, except SDG 12. The municipalities of **Guaraci**, **Icém** and **Jaborandi** reached nine identical SDGs (53%), highlighting: 3, 6, 7, 10, 11, 12, 13, 14 and 16. These three municipalities presented similar scores for all goals.

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The municipality of **Morro Agudo** achieved seven SDGs (41%), such as 3, 6, 7, 10, 11, 13 and 14. The municipality of **Orlândia** was the only one that achieved SDG 1 (Eradication of poverty), in addition to the others with 41% (SDGs 3, 7, 10, 11, 13, 14, 16). The municipality of **Viradouro** achieved the same SDGs as Morro Agudo, with the latter reaching SDG 16. The municipality of **Terra Roxa** was also similar to Morro Agudo, in addition reached 12.

In general, 100% of municipalities achieved SDG 3 (Health and well-being), SDG 10 (Reduced inequalities) and SDG 11 (Sustainable cities and communities). However, SDG 9 (Industry, Innovation and Infrastructure), SDG 15 (Protect life on land) and SDG 17 (Partnerships and means of implementation) displayed low representation and, consequently, low scores, because they were the least prominent in the municipalities analyzed.

In this context, it is noteworthy that these SDGs and their indicators require careful consideration to develop measurements and actions towards improving the industry and technology sectors and protecting life on Earth. Beyond that, it is an opportunity for inter-institutional partnerships to leverage these goals in the medium and long term.

It is wishable that municipalities take care of sustainability as a pillar to build equalitarian cities taking into account some studied indicators such as Public investment in infrastructure per inhabitant; Share of jobs in knowledge and technology intensive activities; Rate of forested and natural areas; Protective conservation unit integral and sustainable use; Degree of maturity of environmental protection financing instruments; Public Investment and Total revenue collected.

Municipalities are on track to achieve most of the UN Goals due to the variety of results observed in Table 5. On the other hand, adjustments and political actions are necessary to meet the population demands and increase the quality of life on vulnerable and unhealthy scenarios. For instance, sustainable development in agriculture and industry, universal access to energy, access to drinking water, collection and treatment of sanitary sewage, a sustainable transport system and appropriate infrastructure have been adopted better strategies to promote this concept in society.

The municipalities of Barretos and Bebedouro are the largest cities in UGRHI 12 and, therefore, it is recommended that they mobilize actions and discussions in that River Basin, aiming towards promoting projects and programs to encourage these concepts and raise indicators in critical condition (red color) or evolving (orange and yellow colors). In this way, it can engage socio-environmental actions for access to services and urban infrastructure, in an integrated way with healthy and effective public spaces for the health and population welfare.

4.2. Comparative analysis between indexes for UGHRI 12 (Stage 2)

The analysis of the similarity identified six indicators (33% of ISA and 6% of IDSC) commons (Table 5).

Seven (7%) were compatible from the 100 sustainability indicators such as one for each axis (water supply, losses, sewage collection, dengue fever and mortality). Only the ISA “treated sewage” indicator refers to two IDSC indicators. Therefore, 6% similarity has been identified

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between such indices. This means that most sustainability indicators evaluate unobserved aspects of environmental health.

Four indicators work in the basic sanitation axis (water supply and sanitary sewage) from the seven of them: one deals with waterborne diseases and another is related to infant mortality. Then, this means that for the association of indices, only one of the methods must be considered in order to avoid duplication of calculation. The methods (ISA and IDSC) were combined in two ways: the first all indicators, and the second one excluded the similar ideas.

4.3 Elaboration of the level of association of the indexes for the object of study (Step 3)

The level of association between indexes is detailed in Chart 2, noting that all municipalities were classified as having a medium level of health and sustainability (highlighted yellow), which arithmetic average varied from 52 to 62.

Table 5 – Description of the similarities of ISA and IDSC

ISA	IDSC	Description
Urban water service index	Population served with water service	Percentage of the urban population served with potable water
Loss coefficient	Water loss	Fixed value that determines the losses incurred in the water supply network
Sewage collection index	Population served with sanitary sewage	Percentage of the urban population served by sanitary sewage services
Treated sewage	Sewage treatment index Sewage treated before reaching the sea, rivers and streams	Percentage or volume of collected sewage that receives some type of treatment
Dengue, Schistosomiasis, Leptospirosis	Diseases related to inadequate environmental sanitation	Presence of cases of waterborne diseases (for the ISA, there is a table that scores the number of cases at different levels)
Mortality indicator	Infant mortality (children under 1 year old)	Indicates the relationship between deaths and the local population

Source: Own authorship.

There was a 33.3% association between the indexes (Chart 2) for the municipalities of Altair, Colombia, Jaborandi and Orlândia, which were classified as healthy and sustainable (76-100) for the ISA. The other municipalities (Barretos, Bebedouro, Colina, Guaraci, Icém, Morro Agudo, Terra Roxa and Viradouro) were classified as medium health and sustainability (51-75), covering 57.6% association between indices (Chart 2).

The **Iab** for all municipalities was classified as average regarding health and sustainability (score between 51 and 75%) and, therefore, the networks which supply the population with drinking water require innovations in the system (Chart 2).

In relation to **Ies**, Bebedouro was the only one classified as having low health and sustainability scores (26-50). Barretos, Colina, Morro Agudo and Viradouro, were deemed medium level and requiring new installations, as the sewage collection and treatment systems are saturated. The remaining municipalities were classified as healthy (Chart 2).

The classification of **Irs** was as medium health and sustainability in 4 municipalities (Colina, Icém, Terra Roxa and Viradouro), therefore projects, programs and sustainable actions are indicated for the environmentally appropriate disposal of solid waste and/or which enable

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the creation of an inter-municipal consortium. The other 8 municipalities were classified as healthy and sustainable. For **Irh**, all of them were classified as low in health and sustainability and, due to that, they require attention in relation to the availability and quality of water resources.

Except for Barretos (unhealthy and unsustainable) and Bebedouro (low health and sustainability), the other 10 municipalities have obtained a healthy and sustainable classification for the **Icv**. Therefore, it is up to both municipalities to intensify vector control for waterborne diseases, such as diarrhea, leptospirosis, among others. The classification of **Ise**, Altair, Colina, Icém, Jaborandi and Viradouro were as having medium healthiness and sustainability scores, while the others were in the low healthiness and sustainability levels. In this case, it is recommended to expand initiatives that guarantee security and improve the socioeconomic conditions of the population in question.

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Chart 1 – SDG classification for the twelve municipalities of the Baixo Pardo/Grande River Basin (SP) in 2023

Sustainable Development Goals 2023	Altair	Barretos	Bebedouro	Colina	Colômbia	Guaraci	Icém	Jaborandi	Morro Agudo	Orlândia	Terra Roxa	Viradouro
SDG 1: No poverty	54,72	53,56	55,45	53,23	51,82	54,37	46,86	47,63	56,62	61,47	48,99	45,06
SDG 2: Zero hunger	40,30	45,77	44,80	40,31	44,62	37,99	46,42	26,36	45,58	27,81	50,00	46,69
SDG 3: Good health and well-being	75,00	70,64	70,33	77,27	63,07	67,65	64,44	60,11	67,50	64,62	70,12	64,85
SDG 4: Quality education	61,50	59,84	58,49	55,94	55,62	58,92	53,24	54,32	46,78	53,39	54,90	57,62
SDG 5: Gender equality	21,36	40,79	29,19	10,73	7,38	31,47	34,12	23,54	31,11	40,54	30,37	37,44
SDG 6: Clean water and sanitation	83,58	92,49	74,60	79,35	92,97	94,73	90,91	87,42	93,74	59,52	87,63	86,52
ODS 7: Affordable and clean energy	77,14	82,23	82,23	84,86	81,81	78,15	77,04	75,93	80,36	83,27	75,74	76,85
ODS 8: Decent work and economic growth	55,70	59,40	58,56	59,18	59,36	52,59	48,59	52,34	55,02	59,36	53,03	50,67
ODS 9: Industry, innovation and infrastructure	6,12	25,11	10,82	7,07	0,33	5,21	4,28	4,98	6,00	13,81	6,25	6,38
ODS 10: Reduced inequalities	71,78	70,99	70,50	72,17	65,39	75,62	69,38	76,91	76,19	77,52	67,48	67,37
ODS 11: Sustainable cities and communities	75,67	71,30	72,27	67,45	65,00	71,01	70,83	72,30	67,61	68,90	67,67	72,05
ODS 12: Responsible consumption and production	77,04	41,12	50,01	68,51	50,35	72,73	100,00	100,00	49,92	51,73	100,00	36,07
ODS 13: Climate action	46,87	67,01	79,87	49,07	51,13	60,09	63,18	69,52	60,62	72,83	70,49	73,75
ODS 14: Life below water	93,02	100,00	33,01	100,00	93,75	96,37	98,32	94,68	95,02	100,00	95,42	99,23
ODS 15: Life on land	15,00	26,92	26,83	27,18	29,33	14,59	14,29	14,20	20,92	33,45	13,83	13,56
ODS 16: Peace, justice and strong institutions	80,16	43,61	43,94	44,30	49,30	70,24	73,02	75,40	42,58	73,11	49,10	64,29
ODS 17: Partnerships for the goals	18,58	18,40	18,34	14,64	19,11	9,09	17,10	12,87	16,62	15,66	5,47	18,71

Source: Own authorship.

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Chart 2 – ISA and IDSC association level for UGRHI 12 municipalities after excluding indicators 2021-2023

Municipalities	Environmental Health Indicator (ISA) (%)	Sustainable Cities Development Index (IDSC) (%)	Arithmetic average ISA and IDSC
Altair	67,95	56,09	62,02
Barretos	59,59	57,01	58,30
Bebedouro	60,17	51,72	55,95
Colina	59,15	53,60	56,38
Colômbia	63,32	51,81	57,57
Guaraci	63,70	55,93	59,82
Icém	58,90	57,18	58,04
Jaborandi	64,06	55,79	59,93
Morro Agudo	67,79	53,66	60,73
Orlândia	67,17	56,28	61,73
Terra Roxa	59,90	55,68	57,79
Viradouro	59,43	53,95	56,69

Source: Own authorship.

For the **Iab**, all municipalities were classified as having a medium level of health and sustainability. In relation to **Ies**, only the municipality of Bebedouro was classified to be at a low level of health and sustainability; Barretos, Colina, Guaraci and Morro Agudo at medium level; while the others (Altair, Colombia, Icém, Jaborandi, Orlândia, Terra Roxa and Viradouro) as healthy and sustainable (Figure 3).

The municipalities of Colina, Icém, Terra Roxa and Viradouro were classified as having a medium level of health and sustainability for the **Irs**, while the others were classified as being healthy and sustainable. All municipalities were classified as healthy and sustainable for **Irh** (Figure 3).

Regarding the **Icv**, Barretos was classified as unhealthy and unsustainable, while Bebedouro was classified to be at a low level of health and sustainability. The other ten municipalities were healthy and sustainable. For **Ise**, Altair, Colina, Icém, Jaborandi and Viradouro were classified as average healthy and sustainable level municipalities, while the other municipalities were at a low level (Figure 3).

The dispersion diagram (Figure 4) identified the relationship between the two quantities. This diagram allows the analysis of the existence of a correlation between variables, with high values of one variable associated with high values of the other variable (Viali, s/d).

The evidence indicates that the municipalities of Altair and Orlândia highlighted the greatest values to health and sustainability (Chart 2). However, Bebedouro, Viradouro and Colina are in the opposite situation, with the lowest associations between the indices. Figure 4 illustrates the largest magnitudes of the 12 municipalities therefore, the River Basin was classified as a medium level of health and sustainability.

Entire municipalities of UGRHI 12 (100%) achieved an average rate in a health and sustainability lens with outcomes varied from 51 to 75 level. This level pointed out a challenging classification for those in the lowest position and, however, uncomfortable for others.

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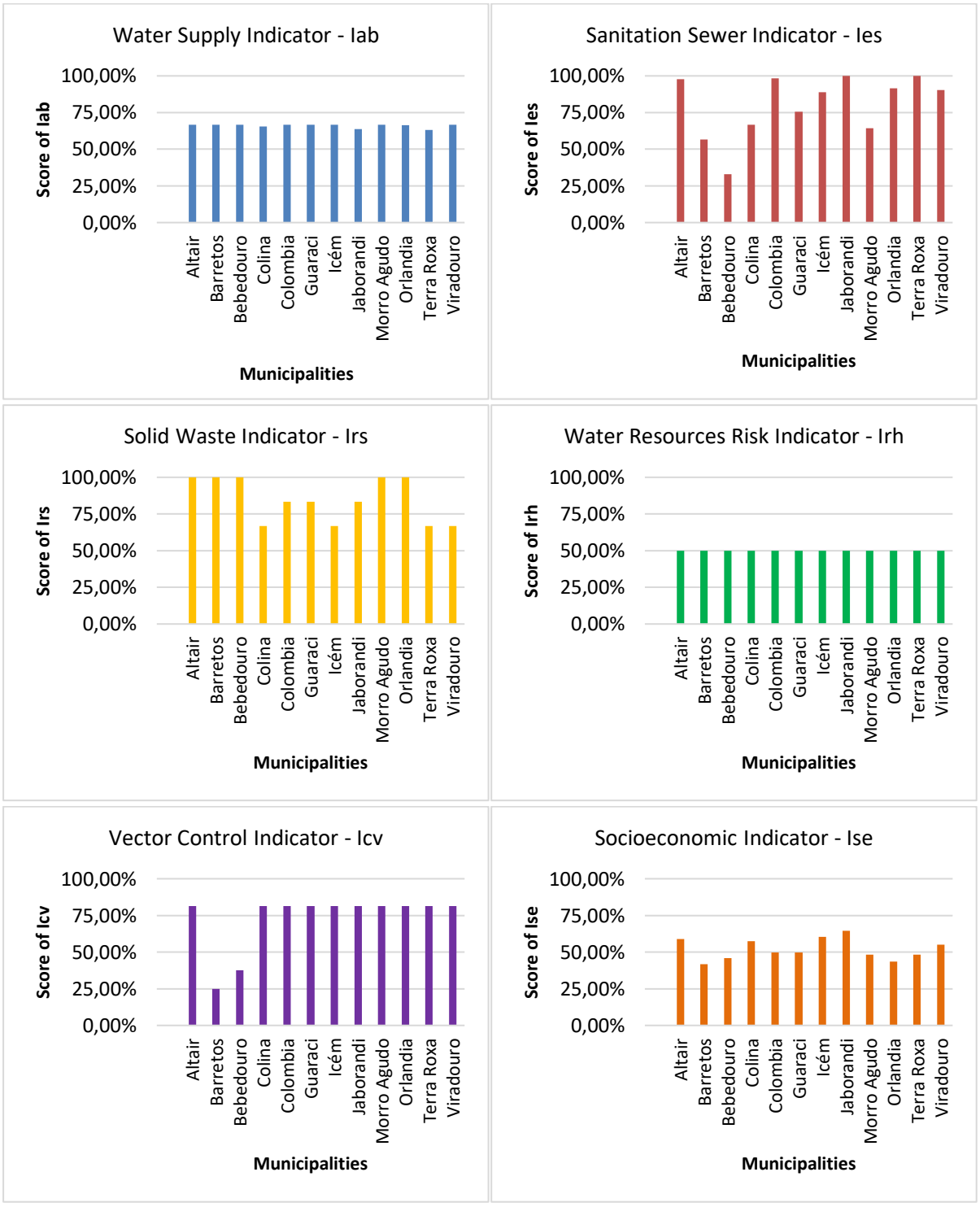
Figure 3 – ISA indicators (Iab, Ies, Irh, Irs, Icv e Ise) per municipality in the year 2023



Source: Own authorship.

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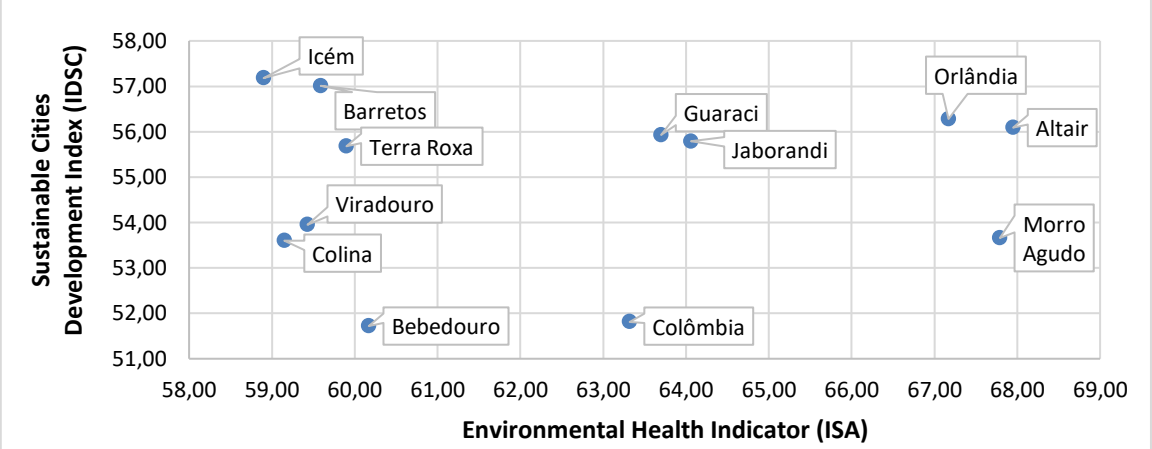
Figure 4 –Dispersion between ISA x ISDC indexes



Source: Own authorship based on Simpson *et al*. (2020) and Brazil (2023).

In the case of ISDC, the recommendation is to consider indicators with a critical situation - such as Gender equality; Industry, innovation and infrastructure; Protecting life on land and Partnerships and means of implementation- as a priority, as the majority of municipalities (100%) presented critical results for these indicators. In the case of ISA, the indicators that require carefully tackle and improvements are: **Ies** for the municipality of Bebedouro (8.3%), the **Irh** for all municipalities (100%), the **Icv** in two municipalities (16.6%) and **Ise** for seven cities (58.3%). For the IDHM, only one municipality is below 70% (8.3%).

5 CONCLUSION

The Baixo Pardo/Grande River Basin was classified at a medium level of health and sustainability (51-75), after the exclusion of duplicate indicators.

Finally, it is reinforced that the managers of UGHRI 12 search for alternatives to move forward with environmental health and sustainability perspective through universities and research bureaus' partnerships, extension activities with these indicators and urban planning as an effective tool for medium and long term.

The indexes could analyze the issues that affect urban land and the health and basic sanitation demands. Thus, actions can be prioritized by an indicator, built for a critical situation and, then, increase the general index. It responded to the first question of the hypothesis.

The main objective was achieved and the hypotheses were partially confirmed. The indicators allowed the diagnosis attainment of sanitary and environmental conditions. Nevertheless, public policies have not developed these concepts as a mandatory way of urban planning. Therefore, the hypothesis didn't match due to denying the second question in this paper.

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