Periódico Eletrônico
Fórum Ambiental da Alta Paulista
ISSN 1980-0827 – Volume 19, número 1, 2023

Composite Index for Assessment of Sanitation and Environmental Health in Municipalities of the Baixo Pardo/Grande Watershed

Karina Shibasaki
Master's Degree Student, PPGEU/UFSCar, Brazil
kashibasaki@gmail.com

Katia Sakihama Ventura
PhD Professor, PPGEU/UFSCar, Brazil
katiasv@ufscar.br

Danilo Rezende
Doctoral student, PPGEU/UFSCar, Brazil
danilorezende@estudante.ufscar.br

SUMMARY

The management of services for environmental health can be achieved through the use of indicators as a practice to improve urban infrastructure. The goal was to analyze the sanitary and environmental conditions in 14 municipalities in the Baixo Pardo/Grande watershed. The following steps were carried out: i) identification of indicators, ii) structuring of an evaluation model on a scale from 0 (zero) to 100, iii) consultation with specialists using the Analytic Hierarchy Process (AHP) method, iv) elaboration of the index in georeferenced maps in QGIS, version 3.22. The model generated 18 sub-indicators grouped into 7 indicators. The index ranged from 21.55 to 66.72%, with 8 municipalities deemed medium health level, 5 deemed low and 1 unhealthy. In most municipalities, solid waste indicators stood out with high condition, while vegetation cover and urban drainage reached the lowest values. It is essential to establish measures and public policies to guarantee the evolution of these indicators in the basin.

KEYWORDS: Indicator. Environmental health. Public administration.

1 INTRODUCTION

The advancement of population and technology does not keep up pace with environmental development, resulting in an imbalance between them. In this way, urban sustainability can improve the quality of life associated with environmental conservation. Thus, environmental and sanitary conditions can guarantee such aspect in the municipality, which, according to Aravechia Júnior (2010), is considered healthy when it presents the water supply system, sanitary sewage, cleaning and management of solid waste and urban drainage, in addition to efficient health and education systems, operate equitably in the urban environment.

In this way, the concept of basic sanitation appears with the National Sanitation Plan (PLANASA) from 1971 to 1986, and later with Law No. 11,445 of 2007, updated through Law No. 14,026 of 2020, the services of drinking water supply, collection and treatment of sanitary sewage, drainage and management of rainwater and urban cleaning (BRASIL, 2007; BRASIL, 2020). Environmental sanitation is a set of socioeconomic actions taken in order to protect and improve living conditions (FUNASA, 2015). Heller (2005) highlights the need for management integration actions to enhance service quality and maximize benefits.

To make sustainability viable, it is necessary to use assessment tools (indicators), according to Van Bellen (2006), and to measure sustainability addressing social, economic or environmental issues (HAK et al., 2007). These are essential instruments to guide actions, and support the monitoring and evaluation of the progress achieved (IBGE, 2015), in which the use by public managers is relevant to present the necessary interventions in order to correct problems, enabling development in a way that achieves effective sustainability (REZENDE E FAGUNDES, 2017).

It should be noted that indicators and indices capture the complex reality (HAK et al., 2007), and the indicator provides information about a particular phenomenon (OECD, 1993), while an index presents the state of the system or phenomenon (SHELDFS et. al, 2002). There are a variety of Indicator Systems that are scarce for more specific geographic spaces, such as for municipalities (MARTINS AND CÂNDIDO, 2012). The Sustainable Development Indicator (SDI) translates information related to the various dimensions of sustainable development: economic, social, environmental and institutional, according to NBR 14031 (ABNT, 2004).

Thus, in order to achieve sustainable development, it is important that public management acts in an integrated manner in urban systems, being able to diagnose and analyze situations to correct problems with quick, efficient and effective decision-making. In this sense, the mapping of qualitative information can support the investment of resources in urban infrastructure and contribute to this analysis.

The main scientific contribution of this research was to develop a useful tool for the administrators of sanitation services that allows the monitoring of public health aspects, as well as being useful for the temporal analysis of services performed on a municipal or regional scale.

2 OBJECTIVES

The objective was to analyze the sanitary and environmental conditions in 14 municipalities of the Baixo Pardo / Grande Watershed (UGRHI 12). Thus, the specific objectives were:

- Identify and analyze indicator models for analyzing basic sanitation, the environment and the population's quality of life;
- Select indicators and structure the evaluation model;
- Develop georeferenced maps to support the analysis.

3 METHODOLOGY

The methodology commenced by identifying studies on indicators of environmental health and sustainable development, their methodological design and adaptations to the model.

The model conceived established the following aspects as information: name of the indicator, index, purpose, calculation method or scale, source of data to be obtained and identification of researchers. The selection criteria of the indicators were adopted (Table 1) and its nomenclature was called Composite Index of Sanitation and Environmental Health Assessment (ISSA).

Chart 1: Indicator selection criteria

Criteria		Definition
C1	Be useful	It must be useful and relevant from the research point of view and the purpose for which it will be used;
C2	be easy to understand	It must be simple and clear, its meaning must be easy to understand (also by non-experts)
C3	be viable	Availability of relevant datasets needed to quantify them
C4	be measurable	It must be possible to be compared in different situations and able to be applied

Source: SUQUISAQUI and VENTURA, 2020.

To evaluate the indicators and weights proposed in the designed model, experts were consulted using the Analytic Hierarchy Process (AHP) method, devised by Saaty (1977), using an electronic spreadsheet for multi-criteria judgment (Chart 2) prepared by Suquisaqui and Ventura (2020) and Ventura (2009). The AHP spreadsheet was obtained online, prepared by Goepel (2018) by the “Business Performance Management Singapore” program, in excel format (.xls).

Chart 2: Rating scale for use by experts

Value	Judgment	Goal
1	Equal Importance	Both indicators are equally important to the analysis
3	Moderate Importance	One of the indicators is slightly higher than another indicator
5	Strong Importance	One of the indicators is strongly superior to another indicator
7	Extremely important	One of the indicators is extremely relevant in relation to another indicator

Source: Adapted from VENTURA, 2009 and SUQUISAQUI and VENTURA, 2020.

The submission and approval of this research were carried out before consulting the experts, the Ethics Committee for Research on Human Beings (CEP). The profile of the specialists considered: a) professional, researcher, consultants who perform activities related to management and management in the urban sanitation and/or environmental health sector on a municipal scale; b) existence of publications in the last 5 years, relating public health, sanitation and urban infrastructure, indicators and salubrity; c) researcher or employee of a company that manages sanitation services and/or who has participated in academic/professional events relevant to the topic. There were 13 specialists submitted to the consultation.

The composite index (ISSA) was analyzed in 14 municipalities of the Water Resources Management Unit (UGRHI) 12, whose color scale was based on the study by Batista e Silva

(2006), as shown in Chart 3. To support the analysis, thematic maps were made using QGIS software, free version 3.22.5 for all seven indicators in the 14 municipalities of the basin.

Chart 3: Conditions and color scale for indicators and ISSA

Punctuation	Condition	ISSA Result	Color Scale
0 a 25,50	Bad	Insalubrity	
25,51 a 50,50	Regular	Low Salubrity	
50,51 a 75,50	Good	Average Salubrity	
75,51 a 100	Excellent	Salubrity	

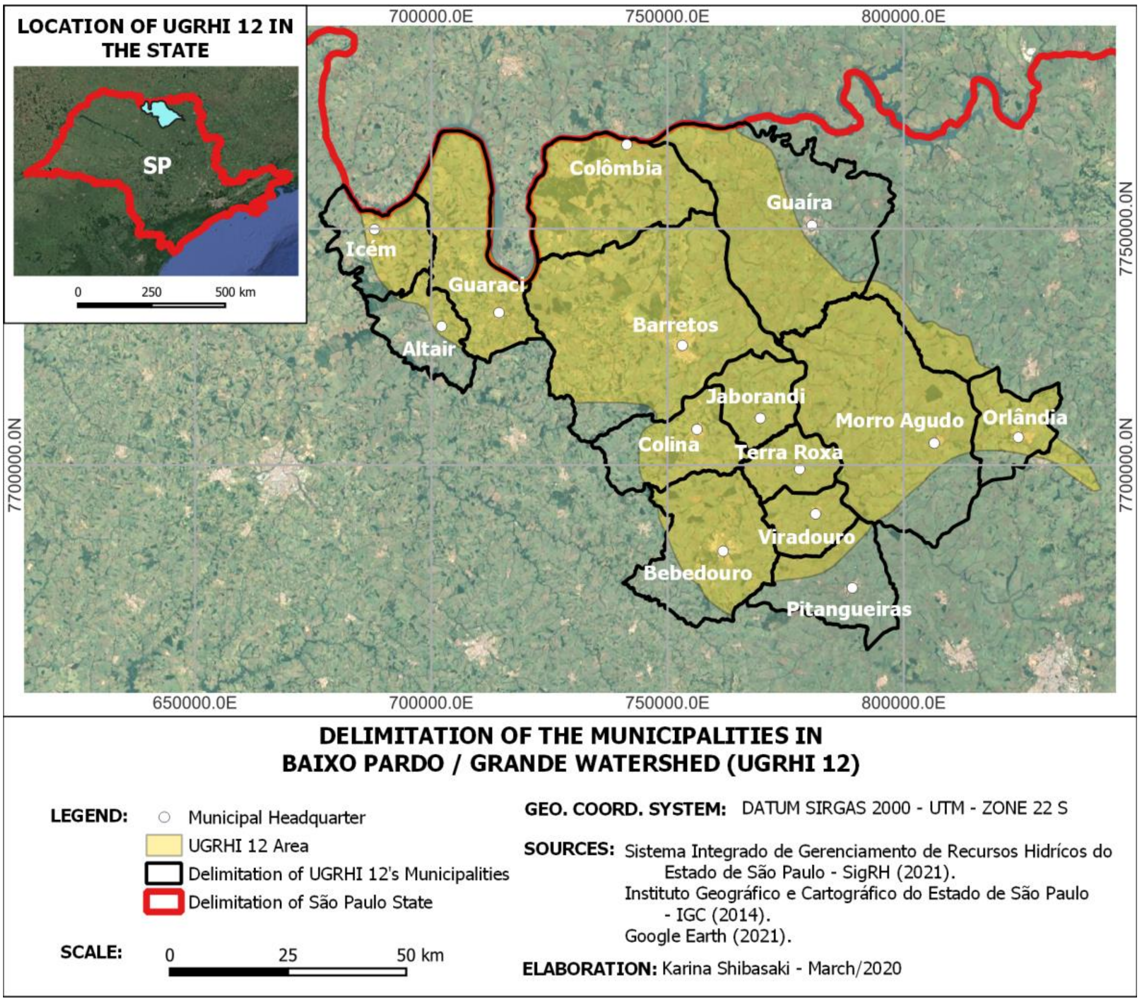
Source: Adapted from BATISTA and SILVA, 2006.

The study area comprises the Baixo Pardo/Grande watershed, called UGRHI 12 (Figure 1) is located in the north-central region of the State of São Paulo, with a total extension of 11,803.87 km², consisting of the Tietê, Jacaré-Guaçu rivers and Jacaré Pipira. There are 12 municipalities with headquarters in the UGRHI itself, and 2 more municipalities with headquarters outside which participate as representatives in the Baixo Pardo/Grande Hydrographic Basin Committee (CBH - BPG).

The digital databases, consulted online, to search for indicators and data for mapping were obtained from IBGE, SNIS, DATASUS and CETESB.

The research was carried out during the Covid-19 pandemic, which made it impossible to technically visit the prefectures/municipalities and obtain data by email or telephone contact, due to the reduction of the work team in these locations.

Figure 1: Delimitation of UGRHI 12's Municipalities



Source: AUTHORS, 2021

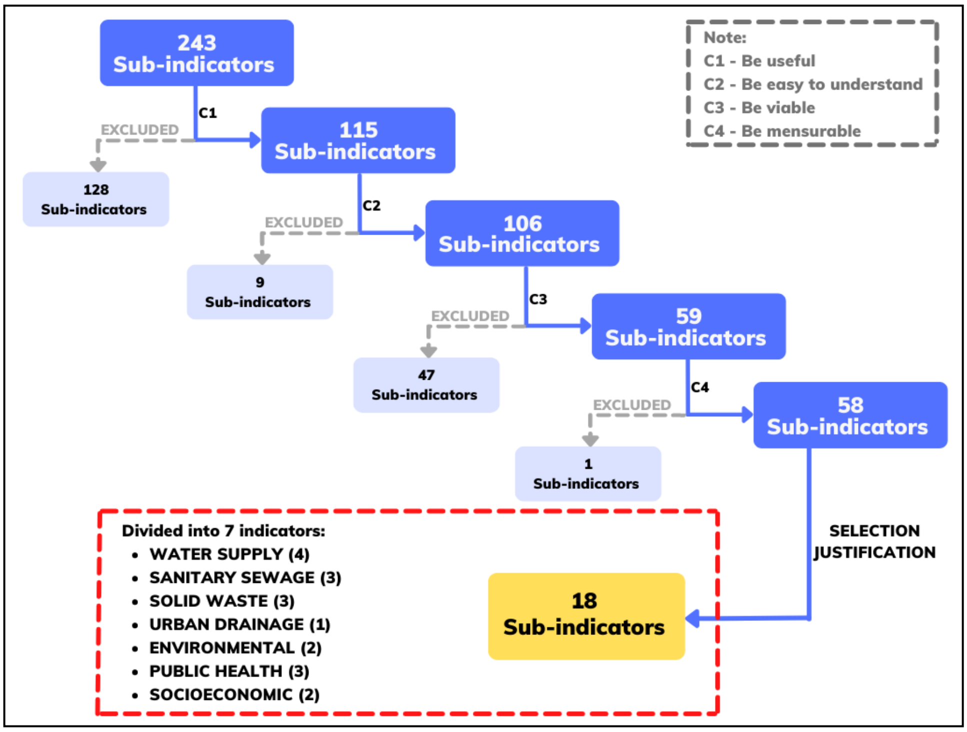
4 RESULTS AND DISCUSSIONS

The results are presented according to the methodological step.

4.1 Selection of Indicators and Sub-Indicators

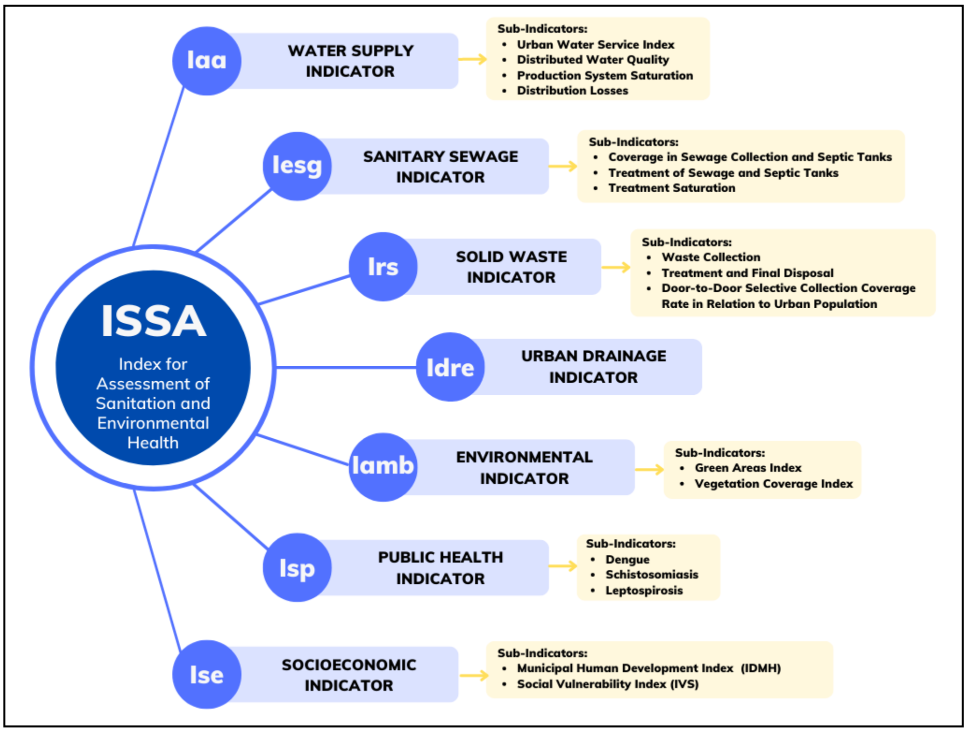
With the analysis of the surveys raised by the literature review and selection criteria, Figure 2 illustrates the result of the indicators and sub-indicators in the design of the composite index. Figure 3 illustrates the sub-indicators that met the selection criteria.

Figure 2: Number of indicators resulting from the selection criteria by thematic axis



Source: AUTHORS, 2022

Figure 3: Conceptual Model of the Composite Sanitation and Environmental Health Assessment Index (ISSA)



Source: AUTHORS, 2022.

Charts 4 to 10 illustrate the indicators selected and adapted, based on expert consultation. These tables are presented as a result, as some sub-indicators were inserted or changed in relation to the pioneer model of Piza (1999).

Chart 4: Sub-Indicators Selected to the Water Supply Indicator

Sub-Indicators	Finalidade	Calculation / Scale	Data Source
Urban Water Service Index (Iatend.ag.)	Quantify the households served	IN023 Index (Urban Water Service Index) of the SNIS that considers the urban population served with water supply, urban population residing in the municipality with water supply and urban population of the municipality in the reference year.	SNIS
Distributed Water Quality (Iqualid.ag.)	Monitor Water Quality	$Iqa\ (\%) = K \times (Naa/Nar) \times 100$ • K: no. samples taken/min. of samples; • Naa: number of samples considered to be drinking water relative to colimetry, chlorine and turbidity (year); • Nar: number of samples performed (year). Calculated using data from: $K = \frac{(QD006 + QD008 + QD026)}{(QD020 + QD019 + QD08)}$ $Naa = (QD006 - QD007) + (QD008 - QD009) + (QD026 - QD027)$ $Nar = QD006 + QD008 + QD026$ Calculated using data from: ✓ QD006 Index: Samples for Analysis of Residual Chlorine Analyzed ✓ QD007 Index: Non-standard Results for Residual Chlorine Analysis ✓ QD008 Index: Samples for Analyzed Turbidity Analysis ✓ QD009 Index: Non-Standard Results for Turbidity Analysis ✓ QD019 Index: Mandatory Turbidity Analysis Samples ✓ QD020 Index: Mandatory Residual Chlorine Analysis Samples ✓ QD026 Index: Samples for Analysis of Fecal Coliforms Analyzed ✓ QD027 Index: Non-standard Results for Fecal Coliform Analysis ✓ QD028 Index: Samples for Obligatory Fecal Coliform Analysis	SNIS
Production System Saturation (Isat.prod.ag.)	Compare water supply and demand, program new systems and/or expansions and loss reduction controls	n={log [CP/(VP(K2/K1))}/[log(1+t)] • n: years in which the system will be saturated; • CP: Volume of water produced; • VP: Produced Water; • K2: expected loss for 5 years (1.50); • K1: current loss (1.20); • t: average annual growth rate Calculated using data from: ✓ CP e VP: AG 006 Index (NIS volume of water produced; ✓ t: SEADE annual growth rate ➢ Up to 50 thousand inhab.: 100 points (N>=2); Interpolate (2>n>0); 0 points (n<=0); ➢ Of 50 thousand inhab. to 200 thousand inhab.: 100 points (N>=3); Interpolate (3>n>0); 0 points (n<=0); ➢ More than 200 thousand inhab.: 100 points (N>=5); Interpolate (5>n>0); 0 points (n<=0);	SNIS and SEADE
Distribution Losses (Iperda.ag.)	Indicate the Percentage of Water Lost in Water Distribution	Ipd =100 - % physical loss in distribution Calculated using data from: % physical losses in distribution: SNIS index IN049, which considers the volume of water produced, volume of water consumed, volume of treated water imported and volume of service.	SNIS

Source: AUTHORS, 2022

Chart 5: Sub-indicators Selected to the Urban Drainage Indicator

Sub-indicator	Goal	Calculation / Scale	Data Source
Urban Drainage (Irede.dre.)	Measure the relationship between the length of public urban roads with underground stormwater networks or channels in the urban area and the total length of urban roads.	IN021 Index (Coverage rate of public roads with underground rainwater networks or channels in the urban area) of the SNIS, which considers the total length of urban public roads in the municipality and the total length of urban public roads with underground rainwater network or channels.	SNIS

Source: AUTHORS, 2022

Chart 6: Selected Sub-Indicators to the Sanitary Sewage Indicator

Sub-indicator	Goal	Calculation / Scale	Data Source
Coverage in Sewage Collection and Septic Tanks (Icol.esg.)	Quantify households served by sewage collection network and septic tanks	IN015 Index (Sewage Collection Index) of the SNIS that considers the volume of water consumed, the volume of treated water exported and the volume of sewage collected	SNIS
Treatment of Sewage and Septic Tanks (Itrat.esg.)	Quantify the households served by sewage treatment and septic tanks	Ite (%) = Ice x (VT / VC) x 100 • Ice: Collection Coverage; • VC: collected volume; • VT: treated volume. Calculated using data from: ✓ IN015 Index: SNIS Sewage Collection Index; ✓ ES005 Index: Volume of sewage collected from the SNIS; ✓ ES006 Index: Volume of treated sewage.	SNIS
Treatment Saturation (Isat.trat.esg.)	Compare the supply and demand of existing facilities and schedule new facilities or expansions	n = [log (CT / VC)] / [log (1 + t)] ✓ n: years in which the system will be saturated; ✓ CT: treatment capacity; ✓ t = average annual growth rate of growth. Calculated using data from: ✓ ES005 Index: Volume of sewage collected from the SNIS; ✓ ES006 Index: SNIS treated sewage volume; ✓ t: SEADE annual growth rate ➢ Up to 50 thousand inhab.: 100 points (N>=2); Interpolate (2>n>0); 0 points (n<=0); ➢ Of 50 thousand inhab. to 200 thousand inhab.: 100 points (N>=3); Interpolate (3>n>0); 0 points (n<=0); ➢ More than 200 thousand inhab.: 100 points (N>=5); Interpolate (5>n>0); 0 points (n<=0);	SNIS and SEADE

Source: AUTHORS, 2022

Chart 7: Sub-indicators Selected to the Environmental Indicator

Sub-indicator	Goal	Calculation / Scale	Data Source
Green Areas Index (Ia.verde.amb.)	Check the relationship between the area of green spaces for public use and the number of inhabitants of the municipality	Iav = sum of Areas with green spaces within the urban perimeter (m²) / Urban population (inhabitant) 0:if 0<=Iav<=9.0 Bad conditions 50: if 9.0<Iav<=16.0 Regular condition 100: if Iav>16.0 Good condition	Secretary of the Environment
Vegetation Coverage Index (Icob.veg.amb.)	Check the relationship between the area covered by vegetation and the total area of the municipality	Icv = sum of the Area with vegetation cover / Total area of the municipality	Secretary of the Environment

Source: AUTHORS, 2022

Chart 8: Sub-indicators Selected to the Solid Waste Indicator

Sub-indicator	Goal	Calculation / Scale	Data Source
Waste Collection (Icol.rs.)	Quantify the households served by waste collection	IN016 Index (RDO Collection Coverage Rate in Relation to Urban Population) of the SNIS, which considers the urban population served in the municipality and the urban population of the municipality.	SNIS
Treatment and Final Disposal (Itrat.disp.rs.)	Qualify the final disposal situation of household solid waste	CETESB Household Solid Waste Landfill Quality Index ➢ 0: if 0<=Iqr<=6.0 inadequate conditions ➢ Interpolate: if 6.0<Iqr<=8.0 intermediate conditions ➢ 100: if 8<Iqr<10.0 suitable condition	CETESB
Door-to-Door Selective Collection Coverage Rate in Relation to Urban Population (Icol.selet.rs.)	Indicate the Percentage of the Population Served by the Selective Collection	IN030 Index (Coverage rate of the door-to-door selective collection service in relation to the urban population of the municipality) of the SNIS that considers Urban population of the municipality served with door-to-door selective collection performed by the City Hall (or SLU) and Population urban of the municipality	SNIS

Source: AUTHORS, 2022

Chart 9: Sub-indicators Selected to the Public Health Indicator

Sub-indicator	Goal	Calculation / Scale	Data Source
Dengue (Ideng.sp.)	Indicate the need for corrective and preventive programs to eliminate transmitters and hosts	Scale: ➢ 100 – No Aedes Aegypti infestation in the last 12 months; ➢ 50 – With Aedes Aegypti infestation and no transmission of dengue in the last year; ➢ 25 – With dengue transmission in the last year; ➢ 0 – With occurrence of dengue hemorrhagic fever in the last year.	DATASUS
Schistosomiasis (Iesquist.sp.)	Indicate the need for corrective and preventive programs to eliminate transmitters and hosts	Scale ➢ 100 – No cases in the last year ➢ 50 – With annual incidence < 1 in the last year ➢ 25 – With annual incidence <= 1 and < 5 in the last year ➢ 0 – With annual incidence greater than 5 in the last year	DATASUS
leptospirosis (Ilept.sp.)	Indicate the need for corrective and preventive programs to eliminate transmitters and hosts	Scale: ➢ 100 – No floods and no cases in the last 12 months ➢ 50 – With floods and no cases in the last 12 months ➢ 25 – No floods and cases in the last 12 months ➢ 0 – With floods and with cases in the last 12 months	DATASUS e SINAN

Source: AUTHORS, 2022

Chart 10: Sub-Indicators Selected to the Socioeconomic Indicator

Sub-indicator	Goal	Calculation / Scale	Data Source
Municipal Human Development Index (IDMH)	Assess the degree of basic human development in each municipality in the education, longevity and income sectors	Arithmetic Mean of Longevity, Education and Income Indexes	PNUD
Social Vulnerability Index (IVS)	Assess the absence or insufficiency of sets of assets that determine the well-being conditions of the population	Arithmetic mean of the sub-indices: IVS Urban Infrastructure, IVS Human Capital and IVS Income and Work Iivs = 100 - (100 * Ivs)	IPEA

Source: AUTHORS, 2022

4.2 Proposition of the Composite Sanitation and Environmental Health Index (ISSA)

The model designed for the ISSA is shown in Equation 1.

$$ISSA = A * I_{aa} + B * I_{esg} + C * I_{rs} + D * I_{dre} + E * I_{amb} + F * I_{sp} + G * I_{se} \quad \text{[Equation 1]}$$

Being that:

ISSA: Composite Sanitation and Environmental Health Assessment Index;
Iaa: Water Supply Indicator;
Iesg: Sanitary Sewer Indicator;
Irs: Solid Waste Indicator;
Idre: Urban Drainage Indicator;
Iamb: Environmental Indicator;
Isp: Public Health Indicator;
Ise: Socioeconomic Indicator.

Equations 2 to 8 define the 18 sub-indicators:

$$I_{aa} = H * I_{atend.ag.} + I * I_{qualid.ag.} + J * I_{sat.prod.ag} + K * I_{perda.ag} \quad \text{[Equation 2]}$$
$$I_{esg} = L * I_{col.esg.} + M * I_{trat.esg.} + N * I_{sat.trat.eg} \quad \text{[Equation 3]}$$
$$I_{rs} = O * I_{col.rs.} + P * I_{trat.disp.rs.} + Q * I_{col.selet.rs} \quad \text{[Equation 4]}$$
$$I_{dre} = R * I_{rede.dre.} \quad \text{[Equation 5]}$$
$$I_{amb} = S * I_{a.verde.amb.} + T * I_{cob.veg.amb.} \quad \text{[Equation 6]}$$
$$I_{sp} = U * I_{deng.sp.} + V * I_{esquist.sp.} + W * I_{lept.sp.} \quad \text{[Equation 7]}$$
$$I_{se} = X * I_{idhm.se.} + Y * I_{ivs.se.} \quad \text{[Equation 8]}$$

Being that:

I attend.ag. : Urban Water Service Sub-indicator;
I qualid.ag. : Distributed Water Quality Sub-Indicator;
I sat.prod.ag. : Production System Saturation Sub-Indicator;
I loss.ag. : Distribution Losses Sub-Indicator;
I col.esg. : Coverage Sub-Indicator in Sewage Collection and Septic Tanks;
I treat.esg.: Sewage and Septic Tank Treatment Sub-indicator;
I sat.trat.esg. : Treatment Saturation Sub-Indicator;
I col.rs. : Waste Collection Sub-Indicator;
I trat.disp.rs. : Treatment and Final Disposal Sub-indicator;
I col.selet.rs. : Door-to-door Selective Collection Coverage Rate Sub-Indicator to the Urban Population;
I rede.dre. : Urban Drainage Sub-Indicator;
I a.green.amb. : Green Areas Index Sub-Indicator;
I cob.veg.amb. : Vegetation Coverage Index Sub-indicator;
I deng.sp. : Dengue sub-indicator;
I eskist.sp. : Schistosomiasis sub-indicator;
I lept.sp. : Leptospirosis sub-indicator;
I ivs.se.: Social Vulnerability Index Sub-Indicator;
I idhm.se. : Municipal Human Development Index sub-indicator.

4.3 Consultation with Experts

The indicators which were pointed out by specialists the most are Water Supply and Sanitary Sewage, the same ones pointed out by the Piza model (1999). As for the sub-indicators, the highest weights by thematic axis (indicator) were Distributed Water Quality (53.0%), Coverage in Sewage Collection and Septic Tanks (51.4%); Solid Waste Collection (54.1%), Coverage rate of public roads with rainwater networks or channels (100%), Vegetation Coverage Index (79.5%), Dengue (60.8%) and Social Vulnerability Index (81.5%). Table 1 illustrates the weights indicated by the specialists, according to the AHP method.

Table 1: Indicators, Sub-Indicators and Weights

Indicator	$Weight_I$	Sub-indicator	$Weight_{SI}$
Water supply	0,201	Urban Water Service	0,213
		Distributed Water Quality	0,530
		Production System Saturation	0,140
		Distribution Losses	0,117
Sanitary sewage	0,199	Coverage in Sewage Collection and Septic Tanks	0,514
		Treatment of Sewage and Septic Tanks	0,327
		Treatment Saturation	0,158
Solid Waste	0,132	Solid Waste Collection	0,541
		Treatment and Final Disposal	0,308
		Door-to-Door Selective Collection Coverage Rate in relation to Urban Population	0,151
Urban Drainage	0,112	Coverage rate of public roads with rainwater networks or channels	1,000
Environmental	0,118	Green Areas Index	0,205
		Vegetation Coverage Index	0,795
Public health	0,107	Dengue	0,608
		schistosomiasis	0,129
		leptospirosis	0,263
Socioeconomic	0,131	Social Vulnerability Index	0,815
		Municipal Human Development Index	0,185

Source: AUTHORS, 2022

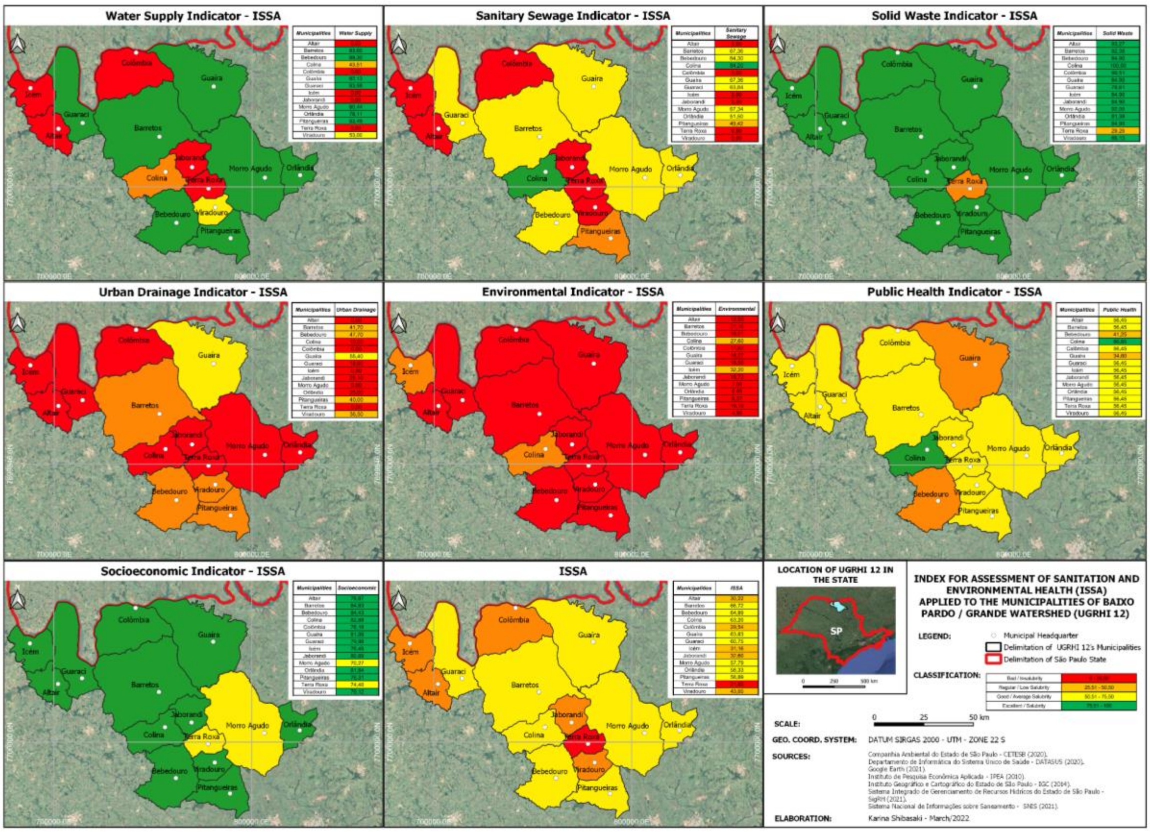
It is noteworthy that the sub-indicators of losses in water distribution, Door-to-Door Selective Collection Coverage Rate in relation to Urban Population, Coverage rate of public roads with networks or rainwater channels, Green Areas Index, Vegetation Coverage Index , Social Vulnerability Index (SVI) and the Municipal Human Development Index (IDHM) were included in the composite index, in relation to the Piza model (1999), due to population dynamics, physical characteristics of municipalities, changes in human activities, importance for environmental management, valorization of sustainable development as observed in a literature review.

4.4 Analysis of the ISSA in the Municipalities of the Baixo Pardo/Grande Watershed

The generated map illustrates the result of the indicators (thematic axis) for each municipality (Figure 4). Piza's model (1999) points out indicators that must be made available by the service manager so that simulations and monitoring can be carried out and, thus, allow the temporal analysis of the evolution of indicators and sub-indicators. This same premise was adopted in the composite index.

Periódico Eletrônico
Fórum Ambiental da Alta Paulista
ISSN 1980-0827 – Volume 19, número 1, 2023

Figure 4: ISSA for each municipality by indicator (thematic axis)



Source: AUTHORS, 2022

It can be seen from Figure 4 that the Solid Waste and Socioeconomic indicators are the ones with the best results, with at least 86% of the municipalities exhibiting optimal health conditions (above 75.51%). This fact is due to the availability of data, as well as the high values in the sub-indicators with greater weight.

It is noteworthy that the Social Vulnerability Index and Human Development Index are compositions which consider the income, education and infrastructure of the municipalities, and presented values above 69.20%. The indicators with low to medium health levels are Sanitary Sewage, Public Health and Water Supply, respectively. Water Supply and Sanitary Sewage Indicators showed 42% of the municipalities with null values of sub-indicator, caused by the non-provision of data in the National Sanitation Information System (SNIS) in the analyzed year.

High losses were observed in the water distribution and the limit of the production system capacity. In addition, there is saturation of the effluent treatment system, in which only the municipality of Bebedouro showed treatment capacity with urban expansion The need for in-depth diagnosis is evident, as well as planning and actions, in order to avoid saturation in the water and sewage systems.

In the Public Health indicator, 11 (eleven) municipalities have obtained the same result, as they are contained in the same epidemiological scope group, in addition to the lack of data update on online platforms, such as DATASUS.

The indicators which have obtained the lowest rates were those of Urban and Environmental Drainage (Green Areas and Vegetation Coverage), with 65% and 86% of the municipalities, respectively, showing poor to unhealthy levels (below 25.50%). The Urban Drainage indicator depends on parameters such as the extension of networks or channels, assessment of the real need for the system, device maintenance, high investment values, which may not be continuously monitored and/or present difficulty in obtaining data due to the uniqueness of each municipality.

In this context, it is important to develop mechanisms to conserve and encourage structural (sustainable drainage projects) and non-structural (socio-educational actions, reforestation, legal instruments, among others) improvements in the basin.

The municipality of Terra Roxa, was the only one with an unhealthy result for the ISSA (21.55%), had unsanitary in the indicators Water Supply (0%), Sanitary Sewage (0%) and Urban Drainage (0%) and Environmental (16.15%). It resulted in low health for Solid Waste (29.26%), and average for Public Health (56.45%) and Socioeconomic (74.40%).

The results of the municipalities of Altair, Colombia, Icém and Jaborandi behaved in the same way. It is observed that the indicators Solid Waste (93.27%; 90.51%; 84.90%; 84.90%,) and Socioeconomic (78.97%; 78.19%; 76.49%; 80, 69%) reached healthy levels, contrary to indicators with unhealthy conditions, which did not present data, such as: Water Supply (0%), Sanitary Sewage (0%), Urban Drainage (0%; 0%; 0.80% ; 25.10%) and Environmental (12.93%; 11.07%; 32.20%; 16.72%). The Public Health indicator (56.45%) reached average salubrity, which resulted in the low salubrity index (ISSA=30.22%; 29.54%; 31.16%; 32.60%).

In the municipality of Viradouro, the healthy levels were in the indicators Solid Waste (86.13%) and Socioeconomic (79.12%), with unhealthy levels in Sanitary Sewer (0%) and Environmental (4.56%). The Urban Drainage indicator (36.50%) reached low salubrity; in addition to the Water Supply (53%) and Public Health (56.45%) indicators that resulted in average salubrity, resulting in low salubrity index (ISSA=43.05%).

In the municipality of Viradouro, the healthy levels were in the indicators Solid Waste (86.13%) and Socioeconomic (79.12%), with unhealthy levels in Sanitary Sewer (0%) and Environmental (4.56%). The Urban Drainage indicator (36.50%) reached low salubrity; in addition to the Water Supply (53%) and Public Health (56.45%) indicators that resulted in average

salubrity, resulting in low salubrity index (ISSA=43.05%).

The results of the cities of Guaraci and Orlândia had the same behavior, with indicators with unhealthy levels were: Urban Drainage (18.90%; 25%) and Environmental (18.98%; 6.65%). The ones with average salubrity were: Sanitary Sewer (63.84%; 51.50%) and Public Health (56.45%); those with salubrious conditions were: Water Supply (83.58%; 78.11%), Solid Waste (78.61%; 91.39%) and Socioeconomic (79.98%; 81.64%), which resulted in in the average salubrity index (ISSA=60.75%; 58.33%).

The municipality of Barretos resulted in the ISSA (66.72%) - average health. The unhealthy indicator was Environmental (21.16%), the low health indicator was Urban Drainage (41.70%), the average ones were Sanitary Sewage (67.36%) and Public Health (56.45%), and the ones at healthy level were Water Supply (83.60%), Solid Waste (92.38%) and Socioeconomic (84.83%).

In the municipality of Bebedouro, healthy levels are also observed in the Water Supply (89.30%), Solid Waste (84.90%) and Socioeconomic (84.43%) indicators, contrary to the Environmental indicator (18.01%). The indicators Urban Drainage (47.70%) and Public Health (41.25%) reached low salubrity, and Sanitary Sewage (64.30%) reached average salubrity, which resulted in average salubrity for the index (ISSA= 64.89 %).

The municipality of Colina, obtained ISSA (63.20%) average salubrity, as it obtained unsanitary in the Urban Drainage indicator (10%). Still, it resulted in low salubrity for Water Supply (43.51%) and Environmental (27.60%), and salubrity for Sanitary Sewage (84.20%), Solid Waste (100%), Public Health (86.85 %) and Socioeconomic (82.69%).

The municipality of Guaíra resulted in the ISSA (63.83%) with average health. Its unhealthy indicator was Environmental (18.27%), the low health indicator was Public Health (34.80%), the medium health indicators were Sanitary Sewage (67.36%) and Urban Drainage (55.40%), and finally, the healthy indicators were Water Supply (82.13%), Solid Waste (84.90%) and Socioeconomic (81.09%).

In the municipality of Morro Agudo, healthy levels are also observed in the Water Supply (80.44%) and Solid Waste (92%) indicators, contrary to the Urban Drainage (0%) and Environmental (7.06%) indicators. The indicators Sanitary Sewage (67.34%), Public Health (56.45%) and Socioeconomic (70.27%), have reached average healthiness, which resulted in average healthiness for the index (ISSA= 57.79%).

The municipality of Pitangueiras resulted in the ISSA (58.89%) with average health. Since the unhealthy indicator was Environmental (6.37%), the ones with low health were

Sanitary Sewage (49.42%) and Urban Drainage (40.00%), the medium health indicator was Public Health (56.45%), and the salubrious ones were Water Supply (82.49%), Solid Waste (84.90%) and Socioeconomic (76.31%).

The municipality of Pitangueiras resulted in the ISSA (58.89%) with average health. Since the unhealthy indicator was Environmental (6.37%), the ones with low health were Sanitary Sewage (49.42%) and Urban Drainage (40.00%), the medium health indicator was Public Health (56.45%), and the salubrious ones were Water Supply (82.49%), Solid Waste (84.90%) and Socioeconomic (76.31%).

In general, the composite index may have been obtained by not reporting on the SNIS or by the low value indicated in the sub-indicators, which illustrates the importance of the service manager disclosing the information in the national base. It is possible that the values of the sub-indicators are in the possession of the public power, however, they were not obtained in digital media, during the Covid-19 pandemic.

5 CONCLUSION

The pioneering model established conditions to evaluate the most relevant aspects of sanitation and public health, allowing their arrangement, according to the need pertinent to the new reality and the demand for infrastructure. In this way, the composite index (ISSA) expanded the concept initially proposed by meeting the Urban and Environmental Drainage indicators (Green Areas and Vegetation Coverage).

The composite index met three of the United Nations Sustainable Development Goals (SDGs), namely:

- Health and Well-being (SDG 3): the index contains public health sub-indicators, to achieve SDG item 3.3: combating waterborne and vector-borne diseases;
- Drinking Water and Sanitation (SDG 6): the index includes sub-indicators of urban drainage and the environment, not used in the pioneering version of the ISA, and these themes help to compose the aspects of sanitation
- Sustainable Cities and Communities (SDG 11): all indicators used in the index help to achieve environmental impact reduction, sustainable urbanization, ensuring access to basic services, and supporting economic and social relationships.

Consultation with experts was a relevant step in the process of designing the composite index. However, it is worth evaluating, in future research, the use of the same weight distribution for the sub-indicators and, thus, simulating the model with equal weight. In this way, one can also consider the least regarded or few monitored among the others, especially those with improvements implemented.

Of the 14 municipalities studied, 8 (eight) reached medium health levels (Barretos, Bebedouro, Colina, Guaíra, Guaraci, Morro Agudo, Orlândia and Pitangueiras), 5 (five) with low health levels (Altair, Colombia, Icém, Jaborandi and Viradouro), and the municipality of Terra Roxa with an unsanitary level.

This demonstrates the need to achieve infrastructural improvements in the less favored axes with projects and resources in the medium and long term and seeking funding from institutions in this sector. On the other hand, the challenge remains to ensure providing existing services at satisfactory levels on an ongoing basis.

According to the result of the composite index, the indicators that deserve attention in the watershed are Urban and Environmental Drainage, since they have presented unsanitary conditions, and because they are subjects debated in the current scenario of the municipalities, which directly interfere in the well-being of the population. population.

The composite index represents an alternative for municipalities and watershed committees to manage sanitation, water resources and land occupation on a regional and municipal scale. In addition, it allows the elaboration of thematic maps to illustrate the condition of sanitary, environmental and sustainable aspects and, consequently, support decision-making.

BIBLIOGRAPHICAL REFERENCES

ARAVÉCHIA JÚNIOR, J. C. **Indicador de Salubridade Ambiental (ISA) para a região Centro-Oeste: Um estudo de caso no Estado de Goiás**. Masters dissertation. Programa de Pós-Graduação em Planejamento e Gestão Ambiental. Universidade Católica de Brasília. Brasília – DF, 2010

BATISTA, M. E. M.; SILVA, T. C. da**. O modelo ISA/JP – indicador de performance para diagnóstico do saneamento ambiental urbano**. Engenharia Sanitária e Ambiental. Rio de Janeiro, jan./mar. 2006.

BRAZIL. **Federal Law No. 11,445, 2007**. Establishes national guidelines for basic sanitation; amends Laws 6,766, of December 19, 1979, 8,036, of May 11, 1990, 8,666, of June 21, 1993, 8,987, of February 13, 1995; repeals Law No. 6,528, of May 11, 1978; and takes other measures. DOU, 2007.

BRAZIL. **Federal Law No. 14,026, 2020**. Updates the legal framework for sanitation and provides other measures. DOU, 2020.

FUNASA - Fundação Nacional de Saúde. **Manual de Saneamento**. 5th ed. Brasília, 2019. 545 p.

HAK T., MOLDAN B., DAHL A.L. **Sustainability indicator: a scientific assessment Island Press**, Washington, 2007.

HELLER, L. **Política pública e gestão dos serviços de saneamento a partir de uma visão de saúde pública.** Encuentro por una Nueva Cultura del Agua en America Latina, 2005, Fortaleza. Zaragoza: Fundación Nueva Cultura del Agua, 2005

IBGE. Instituto Brasileiro de Geografia e Estatística. **Indicadores de Desenvolvimento Sustentável**. Brazil: 2015.

Coordenação de Recursos Naturais e Estudos Ambientais [e] Coordenação de Geografia. Rio de Janeiro: IBGE, 2015.

OECD. Organisation for Economic Co-operation and Development. **Core Set of Indicators for Environmental Performance Reviews** (Environmental Monograph 83), Paris, France. 1993.

PIZA. F. J. T. SÃO PAULO. **ISA – Indicador de Salubridade Ambiental.** Manual Básico. São Paulo – SP: Secretaria de Recursos Hídricos, Saneamento e Obras, 1999.

REZENDE, G. B. de M.; FAGUNDES, E. A. A.. Í**ndice de Desenvolvimento Sustentável de Primavera do Lestes - MT, Baseado no Modelo de Martins e Cândido (2008)**. Revista Estudos e Pesquisas em Administração - REPAD. v.1, n. 1. 2017.

SAATY, Thomas L. **A scaling method for priorities in hierarchical structures**. Journal of mathematical psychology, v. 15, n. 3, p. 234-281, 1977.

SHIELDS, D.; SOLAR, S.; MARTIN, W. **The role of values and objectives in communicating indicators of sustainability. Ecological Indicato**r, v. 2, n. 1-2, p. 149-160, nov. 2002.

SUQUISAQUI, A. B. V.; VENTURA, Katia Sakihama. **Ferramenta para avaliação da gestão de resíduos sólidos urbanos**. V!RUS, São Carlos, n. 20, 2020.

VAN BELLEN, H. M. **Indicadores de Sustentabilidade: Uma Análise Comparativa**, FGV Publisher, 2nd Edition. 129p. 2006.

VENTURA, Katia Sakihama. **Modelo de avaliação do gerenciamento de resíduos de serviços de saúde (RSS) com uso de indicadores de desempenho: estudo de caso - Santa Casa de São Carlos-SP**. 2009. PhD Thesis. Universidade de São Paulo.