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Sustainability Indicators for Water Management: Analysis of Water Security in the Capibaribe River watershed

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Indicadores de Sustentabilidade para Gestão da Água: Análise da Segurança Hídrica na Bacia Hidrográfica do Rio Capibaribe

RESUMO

A segurança hídrica envolve o uso sustentável e a proteção dos mananciais, de modo a se dispor de água em quantidade e qualidade adequadas à saúde, aos meios de subsistência, aos ecossistemas e à produção, além de protegê-la contra os efeitos negativos dos eventos climáticos extremos. Internacionalmente, o conceito de segurança hídrica começou a ser discutido na década de 90, sobretudo, a partir de 2009, quando o assunto passou a ser objeto de maior número de publicações. No Brasil, a Lei Federal 9433/97, que institui a Política Nacional de Recursos Hídricos, e as leis estaduais correspondentes trazem implícito o conceito de segurança hídrica. Entretanto, somente em 2019 foi lançado o Plano Nacional de Segurança Hídrica, que passou a ser o instrumento fundamental de tomada de decisões nesse tema. O objetivo da pesquisa foi pré-selecionar indicadores para analisar a segurança hídrica dos municípios contemplados na bacia do rio Capibaribe, no âmbito da gestão sustentável da água. Para alcançar esse objetivo foi adotada a seguinte metodologia: pré-seleção de indicadores; aplicação de questionário a um painel de especialistas; estruturar um banco de dados. Sendo assim, este trabalho visa trazer subsídios de forma a contribuir para ações e políticas públicas de segurança hídrica por meio da elaboração de um banco de dados de indicadores. Além disso, essa pesquisa é uma proposta para trabalhos futuros, sendo possível definir uma equação do índice de segurança hídrica para os municípios da bacia.

PALAVRAS-CHAVE: Segurança hídrica. Saneamento básico. Recursos hídricos. Sustentabilidade.

Sustainability Indicators for Water Management: Analysis of Water Security in the Capibaribe River watershed

ABSTRACT

Water safety involves the sustainable use and protection of water sources, so that water is available in adequate quantity and quality to health, livelihoods, ecosystems and production, in addition to protecting it from the negative effects of extreme weather events. Internationally, the concept of water security began being discussed in the 1990s, and more so since 2009, when the issue became the subject of a greater number of publications. In Brazil Federal Law 9433/97, which establishes the National Water Resources Policy, and corresponding state laws implicitly provide the concept of water security. However, the National Water Safety Plan was only launched in 2019, and has became the fundamental instrument for decision-making on this issue. The objective of the research was to pre-select indicators to analyze the water safety of the municipalities contemplated in the Capibaribe river watershed, within the framework of sustainable water management. To achieve the objective, the following methodology was adopted: pre-selection of indicators; application of a questionnaire to a panel of experts; structure a database. Thus, this work aims to bring subsidies that contribute to water security actions and public policies through the development of an indicator database. Additionally, this research is a proposal for future work, helping to define an equation of the water security index for the municipalities in the watershed.

KEY WORDS: Water safety. Basic sanitation. Water resources. Sustainability.

Indicadores de Sostenibilidad para la Gestión del Agua: Análisis de la Seguridad Hídrica en la Cuenca del Río Capibaribe

RESUMEN

La seguridad del agua implica el uso sostenible y la protección de las fuentes de agua, de modo que el agua esté disponible en cantidad y calidad adecuadas para la salud, los medios de vida, los ecosistemas y la producción, además de protegerla de los efectos negativos de los fenómenos meteorológicos extremos. A nivel internacional, el concepto de seguridad hídrica comenzó a discutirse en la década de 1990, especialmente a partir de 2009, cuando el tema se convirtió en objeto de un mayor número de publicaciones. En Brasil, la Ley Federal 9433/97, que establece la Política Nacional de Recursos Hídricos, y las leyes estatales correspondientes traen implícitamente el concepto de seguridad hídrica. Sin embargo, recién en 2019 se puso en marcha el Plan Nacional de Seguridad del Agua, que se convirtió en el instrumento fundamental para la toma de decisiones sobre este tema. El objetivo de la investigación fue preseleccionar INDICATORes para analizar la seguridad hídrica de los municipios contemplados en la cuenca del río Capibaribe, en el marco de la gestión sostenible del agua. Para lograr el objetivo, se adoptó la siguiente metodología: preselección de INDICATORes; aplicación de un cuestionario a un grupo de expertos; Estructurar una base de datos. Así, este trabajo tiene como objetivo traer subsidios con el fin de contribuir a acciones y políticas públicas de seguridad hídrica a través de la elaboración de una base de datos de INDICATORes. Además, esta investigación es una propuesta para futuros trabajos, siendo posible definir una ecuación del índice de seguridad hídrica para los municipios de la cuenca.

PALABRAS CLAVE: Seguridad del agua. Saneamiento. Recursos hídricos. Sostenibilidad.

1 INTRODUCTION

In the 1970s environmental problems stemming from population growth and technological advances, caused growing concern about the availability of natural resources, including water resources. The problem of water supply affects even developed countries. Even with the efforts of the organizations involved, especially the members of the United Nations (UN), to raise the discussion and encourage countries to promote changes in the form of management and use, the goal of global water security has not yet been achieved (DELGADO, 2018).

Despite having good availability of water as compared to the world situation, the distribution of water resources in Brazil is disproportionate in the country's different states. The guarantee of water security is difficul especially when looking at the Northeast of Brazil (DELGADO, 2018).

For the United Nations Educational, Scientific and Cultural Organization UNESCO (2019), the most important natural resource for humanity is fresh water because it encompasses all social, economic and environmental activities.

Zhang et al. (2019) also highlight that water is certainly the most important among natural resources, and that it still remains a challenge to public management, especially in areas of greater scarcity. Faced with this reality regions present some economic limitations, as water scarcity, in addition to affecting the quality of human life in terms of education and health, compromises productive capacity.

According to Meadows (1998), there was a time in history when the objective was population growth, however, some essential guarantees for survival had not been considered, so that for the inclusion of more people it would be necessary to consider access to more food, material goods, clean air and water. Over the years, and with the evolution of society in search of a more sedentary way of life, it has become apparent that natural resources are not infinite or inexhaustible, including water, which from early times until today has been one of the great challenges of the world system.

Currently, the global objective is not centered on increasing the population, but on guaranteeing a minimilaly dignified life for people, aiming to achieve sustainable development. The World Commission on Environment and Development, through the Brundtland Report, known as Our Common Future, supports a balance between increasing population and a decent life, which can best be achieved by stabilizing population size at a level that is compatible with the productive capacity of the ecosystem (KEEBLE, 1988).

Thus, the UN, through the 2030 Agenda, established global goals, called Sustainable Development Goals (SDGs) to be achieved by the year 2030, at a global level. Considering the issue of water, one of the objectives, more specifically SDG 6, includes ensuring the availability and sustainable management of water and sanitation for all (ONU, 2018).

According to Brazil (2019), the need for world change is mainly derived from the expansion of agriculture and industry in developing countries. In Brazil, considering the impacts caused by extreme hydrological events that have occurred in the current decade, water security now plays a key role for the social and economic development of the country.

Still with regard to the impacts caused by extreme hydrological events, recently, in the years 2015 and 2016, an extreme drought event was recorded in the Capibaribe river watershed, where the Jucazinho Reservoir showed very low levels, affecting the the supply of water to the population that depends on the Jucazinho Integrated System. In view of the above, in this work, sustainability is understood to be efficiency from the viewpoint of water security, considering that the water infrastructure will be able to meet the necessary water demand. Thus, this research aims to answer the following question: how do the sustainability indicators used in this research contribute to water security in the Capibaribe river watershed? It is noteworthy that the indicators raised in this research can also be applied in other watersheds, in order to classify water security in another study area.

2 OBJECTIVES

Select water sustainability indicators with the aim to analyse water security of the municipalities included in the Capibaribe river watershed, within the scope of sustainable water management. The specific objectives are described below.

- Identify water sustainability indicators that reflect water security in the watershed
- Structure a database of selected indicators for the watershed.
-

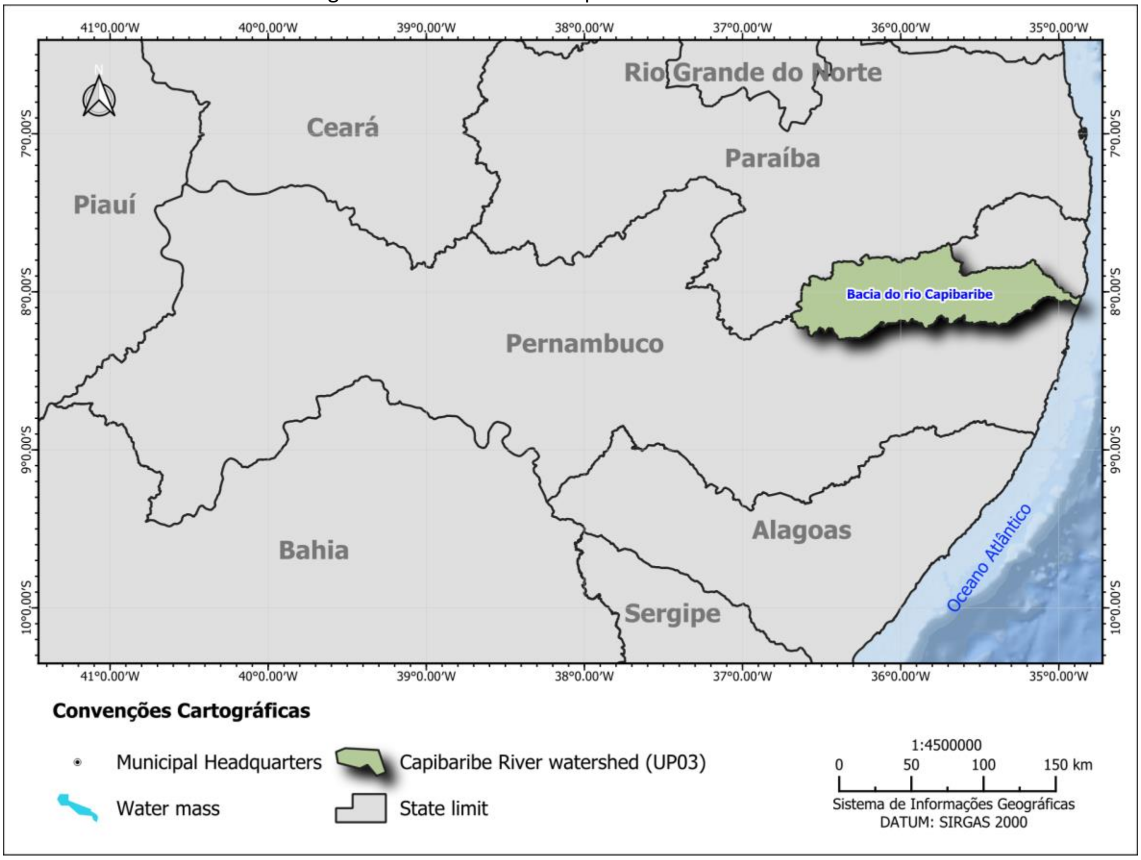
3 METODOLOGY

In this item, the methodologies used for the elaboration of this study will be presented, as well as a brief description of the study area.

3.1 Description of the Study Area

The watershed object of this study is the Capibaribe River (Planning Unit 03), one of the most significant watersheds in Pernambuco state’s water reserves (PERNAMBUCO, 2022). According to Pernambuco (2022), the Capibaribe river watershed is located in the north-eastern portion of the state of Pernambuco between the coordinates 07º 41' 20" and 08º 19'30" of Lat. South, and 34º 51' 00" and 36º 41' 58" of Long. West, as shown in Figure 1.

Figure 1 - Location of the Capibaribe River watershed



Source: Developed by the authors based on Pernambuco (2022).

The regional scope infers a complex environment to the Capibaribe watershed, in which extreme climate phenomena can be observed, requiring a water and environmental management model that meets its specificities (PERNAMBUCO, 2010).

The watershed area is 7,454.88 km², corresponding to approximately 7.58% of Pernambuco's territory. From its source between the municipalities of Poção and Jataúba, to its mouth in the Atlantic Ocean, in Recife, the river cuts through 42 municipalities which are shown in Chart 1 (PERNAMBUCO, 2010).

Chart 1 - Municipalities inserted in the Capibaribe River Watershed

Municipality	Area in the Watershed (%)	Municipality	Area in the Watershed (%)
Belo Jardim	5,5	Passira*	4,57
Bezerros	2,97	Paudalho*	3,57
Bom Jardim	0,73	Pesqueira	0,05
Brejo da Madre de Deus*	10,19	Poção	0,23
Camaragibe*	0,46	Pombos*	2,04
Carpina*	4,02	Recife*	0,92
Caruaru	7,13	Riacho das Almas*	4,11
Casinhas*	1,41	Salgadinho	1,12
Chã de Alegria*	0,66	Sanharó	0,08
Chã Grande	0,18	Santa Cruz do Capibaribe*	4,55
Cumaru*	3,99	Santa Maria do Cambucá*	1,18
Feira Nova*	1,42	São Caetano	0,17
Frei Miguelinho*	2,93	São Lourenço da Mata*	2,82
Glória do Goitá*	3,11	Surubim*	3,44

Municipality	Area in the Watershed (%)	Municipality	Area in the Watershed (%)
Gravatá	3,22	Tacaimbó	0,35
Jataúba*	9,57	Taquaritinga do Norte*	5,96
João Alfredo	0,72	Toritama*	0,41
Lagoa do Carro	0,52	Tracunhaém	0,14
Lagoa do Itaenga*	0,76	Vertente do Lério*	0,94
Limoeiro*	1,85	Vertentes*	2,62
Moreno	0,21	Vitória de Santo Antão*	2,71

* Municipalities with urban centres in the watershed
Source: Adapted by the authors from Pernambuco (2010).

Among the larger reservoirs of the Capibaribe River watershed the following stand out: Jucazinho, Carpina, Tapacurá and Goitá. These reservoirs were initially built to control floods, although today their waters are also used for other activities, characterising multiple uses of water (BRAGA, et al., 2015).

Conflicts of use and significant environmental impacts throughout the watershed require special attention to match current and future demands. In addition to its water contributions its various tributaries take support to various levels of occupation in productive chains in agriculture, industry and services sector. Among the main sources of environmental degradation is pollution from urban and industrial waste which begins in the soil, reaches the surface water and infiltrates with leachate, also contaminating the groundwater (PERNAMBUCO, 2010).

The Capibaribe still has great potential for various uses such as agriculture, fishing, water supply, among other activities, although today it is polluted by solid and liquid, organic and inorganic, industrial and agricultural waste, and a population estimated at 430 thousand inhabitants in its surroundings (PERNAMBUCO, 2010). This is due to environmental imbalances resulting from extreme climatic events, intensive use of soil, and interposed water deficiency. All this hinders human supply, causes operational problems of environmental sanitation systems, and hinders agricultural use in the dry season (PERNAMBUCO, 2010).

In the case of the industrial sector, in Alto Capibaribe, where the clothing industry is important for the Santa Cruz do Capibaribe and Toritama municipalities, there is a great demand for water due to the large number of laundrettes there are in these municipalities. Many factories have their water abstractions directly on the Capibaribe River. However, due to the river being intermittent, there are several constructions of small level dams in the riverbed to accumulate water in the dry season (BRAGA, et al., 2015).

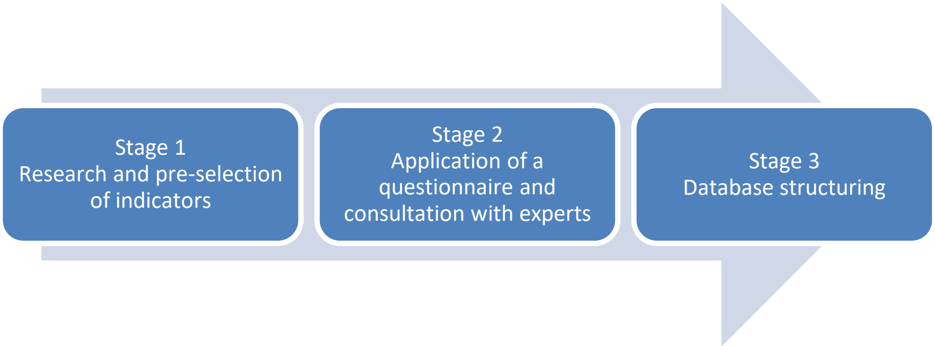
Agricultural production has caused deforestation due to inadequate soil management and is the main factor inducing erosion and silting processes, in addition to salinization and contamination by pesticides. (PERNAMBUCO, 2010).

The watershed of the river Capibaribe is environmentally protected by the Dois Irmãos forest area; the Tapacurá mill forest; the Outeiro do Pedro forest; the São João da Várzea forest; the Quizanga forest; the Toró forest; the Camucim forest; and the private reserve of natural heritage – RPPN Fazenda Bituri, in addition to the area for the protection of springs, instituted by Law 9.860/86 (PERNAMBUCO, 2010).

3.2 Method of Analysis

The specific methodology used in this study was subdivided into three work stages, as shown in figure 2. The details of each step of the methodology are presented below.

Figure 2 - Steps of the Methodology



Source: Developed by the authors.

<u>STAGE 01 - Indicator Search and Pre-selection</u>

This stage consists of the research and pre-selection of indicators and construction of the dimensions that make up the water security index for the municipalities of the River Capibaribe watershed. For this a detailed literature search was carried out in order to collect and select water security indicators.

With the application of such indicators it is possible to measure the conditions of water security in the areas of water supply and sanitation, hydroenvironmental, social and institutional capacity, and allow directed planning to the local reality of the municipalities, assisting in decision making.

<u>STAGE 02 - Questionnaire and Expert Consultation</u>

The pre-selected indicators in the previous stage, were arranged in a questionnaire for academic purposes, to be evaluated by experts. The questionnaire can be accessed at the link provided in item 4.4.

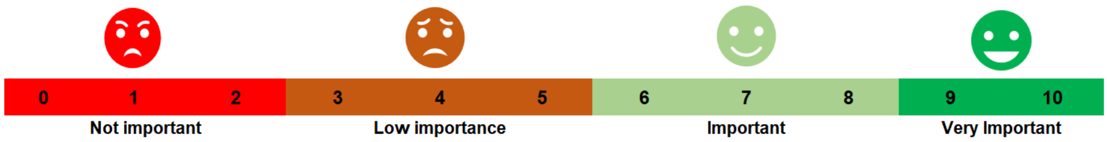
The application of the questionnaire will follow the Delphi method. Such methodology is used to structure the communication of a group of experts through interactions carried out in successive rounds of questionnaires, duly accompanied by feedback. It is important to highlight that the total anonymity of the participants' responses will be maintained.

For the implementation of the Delphi methodology, the following steps will be followed: 1) Choice of the expert group; 2) Preparation of the questionnaire; 3) Application of the questionnaire to the expert panel; 4) Collection and reflection of the experts' responses; 5) Analysis and compilation of questionnaire responses.

The questionnaire covers the following topics: Presentation of the survey; information of filling out the questionnaire; general information on the interviewee (email, age group, academic background, entity where they work, activity they perform, time in the institution) and allocation of the levels of importance of pre-selected indicators.

For each indicator presented, the Likert scale was used, divided into four levels, according to the degrees of importance as set out in Figure 3. The number closest to 0 (zero) represents an indicator unimportant for the analysis and can be discarded. In contrast, a number closer to 10 corresponds to a very important indicator, which is essential for this research.

Figure 3 - Importance Scale for Evaluation of Indicators



Source: Developed by the author.

Consultation was undertaken through forms prepared on the Google Forms platform and were applied virtually through emails. Specialists distributed in different areas of activity which have a direct connection with the management of sanitation and water resources were selected.

The number of experts to be interviewed is very varied (POWELL, 2003), however studies indicate that an optimal number should not be less than 10 (ten), in most cases, the panels have at most, a few dozen members (GRISHAM, 2009).

It is noteworthy that a number below ten (10) people compromises the results in terms of effective consensus and relevance of the information obtained. In contrast, a very high number generates a huge amount of information and makes management and analysis unfeasible (MIRANDA et al., 2012).

It is important to note that usually, at most, only half of the people respond to the first contact and it is common for participants to give up in the middle of the process, leading to a reduction in the size of the panel. Thus, it is recommended to start with a group of experts comfortably larger than the minimum number you wish to achieve (MARQUES; FREITAS, 2018).

Therefore, a total of 30 (thirty) specialists were defined for this research, distributed according to that suggested in Chart 2.

Chart 2 - Panel of Experts

Organization	Number of Experts
Government Agencies	
National Water and Sanitation Agency - ANA	5
State water resources management agencies	5
Sanitation Regulatory Agencies	5
Professors and Researchers from Public and Private Universities	5
Public Utilities of Basic Sanitation	
Public	5
Private	5
TOTAL	**30**

Source: Developed by the author.

The answers received from the questionnaires were analyzed through the frequency distribution of the evaluation categories. The consensus among experts on the importance of each indicator will be determined from the Consensus Level (CL) of the responses provided by the experts for each of the indicators. This methodology uses measures of central tendency and percentage and has been widely used in Yesilar analyses. Chart 3 shows the classification

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adopted to assess the level of consensus of the answers given by the experts.

Chart 3 - Consensus Level Classification

Nível de Consenso (NC)	Classificação
Alto	70% das respostas estão em uma única categoria de avaliação; ou, 80% estão em duas classes de avaliação adjacentes
Médio	60% das respostas estão em uma categoria de avaliação; ou, 70% estão em duas categorias de avaliação adjacentes.
Baixo	50% das classificações estão em uma única categoria de avaliação; ou, 60% em duas categorias de avaliação adjacentes
Inexistente	Menos de 60% das classificações estão em duas categorias de avaliação adjacentes

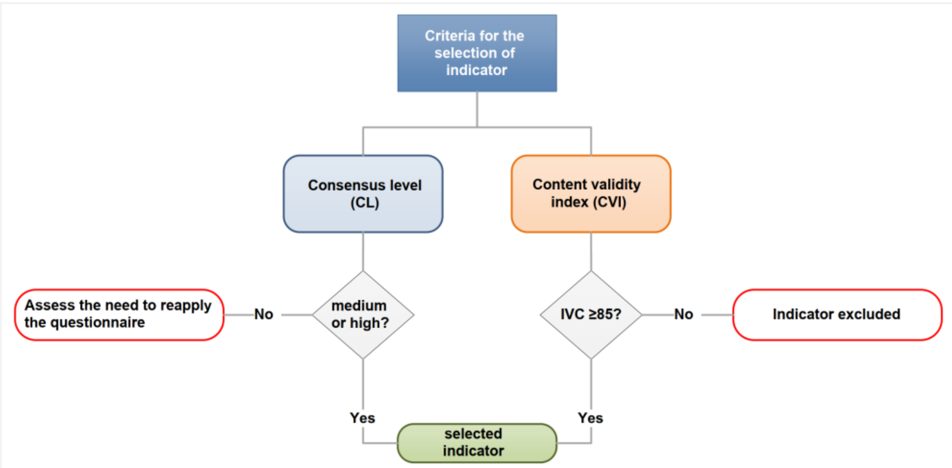
Source: Adapted by the authors from Rabelo (2022).

To assess the relevance of each pre-selected indicator, the Content Validity Index (CVI) will be used, this method measures the proportion of participants who agree on the items presented, quantitatively. The content validity index was calculated using Equation 1 (RABELO, 2022).

$$CVI = \frac{n° \; of \; answers \; "important" \; or "very \; important"}{n° \text{ total answers}} \qquad \text{Equation 1}$$

It is recommended that the CVI result be at least 80%, so for the validation of the data of this study, it was adopted that for the indicator to be selected, it must have a consensus level (CL) classified as medium or high consensus among experts and an IVC of at least 80%.

Figure 4 - Indicator Selection Criteria



Source: Adapted by the author from Machado (2018)

At the end of this stage the relevant indicators for the analysis of water security recommended by the experts will be defined and should thus continue in the subsequent stages of the study.

STAGE 03 - Database Structuring

In this stage a database will be structured, consisting of the information collected from the municipalities belonging to the Capibaribe river basin for each of the selected indicators. As such, it will be possible to perform an analysis on the consistency of information. This step is paramount because a poorly structured database directly impacts the results of the analyses, and may even imply errors or prevent the application of statistical treatment.

The collected data will be tabulated with the help of Excel software, aiming to treat problems such as: missing values and discrepant values, then the data will be loaded into the Statistical Package for Social Sciences (SPSS) softwareanalysis through factor analysis (FA), with extraction by principal component analysis (PCA).

Figueiredo Filho and Silva Júnior (2010) recommend that indicators with no data greater than 10% be eliminated for the municipalities.

It should be noted that actions can be employed to correct these data in order to minimize the effects of their losses or by an excess of exclusion of variables. However, it is important to stress that interfering as little as possible is the best choice to avoid a trend in results.

4 RESULT

Next, we present the results obtained in this study based on the methodology described above.

4.1 Pre-selection of Indicators

After the literature research described in stage 1, 28 indicators were selected and grouped into 4 aspects. These aspects were defined to cover all components of sanitation, as well as environmental, social and institutional aspects, since these aspects directly influence water security, as detailed in the sequence. It should be noted that, at the end of the research, the indicators can be regrouped depending on the correlation identified between them.

In chart 4 the indicators selected within the scope of the infrastructure of water supply and sewage, as well as its detailed description, are observed. In total, 11 (eleven) indicators were selected, 7 (seven) of water supply and 4 (four) of sewage.

Chart 4 - Indicators of the Infrastructure Dimension of Water Supply and Sewage

CÓD.	INDICATOR	DESCRIPTION	UND	SOURCE
A1	Urban population served with sewage	Urban population benefited from sewage by the service provider.	Hab.	SNIS (2020)
A2	Total population served with sewage	Total population served with sewage by the service provider.	Hab.	SNIS (2020)
A3	Urban population served with water supply	Urban population served with water supply by the service provider.	Hab.	SNIS (2020)
A4	Total population served with water supply	Total population served with water supply by the service provider.	Hab.	SNIS (2020)
A5	Index of total water service	Percentage of attendance of the total population with water supply	%	SNIS (2020)
A6	Index of urban water service	Percentage of attendance of the urban population with water supply.	%	SNIS (2020)
A7	Index of collection of sewage	Percentage of sewage collection.	%	SNIS (2020)
A8	Index of sewage treatment collected	Treated sewage volumes in relation to the total sewage produced.	%	SNIS (2020)

CÓD.	INDICATOR	DESCRIPTION	UND	SOURCE
A9	Average per capita consumption of water	Represents the average daily water consumption per inhabitant in a municipality.	l/hab.dia	SNIS (2020)
A10	Density of the water network	Represents the extension of water network by connection.	m/lig.	SNIS (2020)
A11	Technical Performance of Water Loss Management	Performance in controlling water losses in distribution.	Und.	ANA (2021)

SOURCE: Developed by the authors.

Chart 5 shows the indicators selected under the hydroenvironmental aspect, as well as their detailed description. In total, 11 (eleven) indicators were selected, which are directly linked to water security.

Chart 5 - Indicators of the Hydroenvironmental Dimension

CÓD.	INDICATOR	DESCRIPTION	UND	SOURCE
H1	Quantitative vulnerability index of water sources and water production systems	Represents the situation of water sources and efficiency of water production.	Und.	ANA (2021)
H2	Water Vulnerability Index (wvi)	Consists of the composition of social vulnerability and ecosystem vulnerability (natural disasters, climate change and water infrastructures) measured at the municipal scale.	Und.	Moura (2020)
H3	Green area index	Corresponds to the amount of green area present in a municipality.	%	MAPBIOMAS (2019)
H4	Surface water availability	The flow that is available at the source at least 95% of the time.	M^3/s	ANA (2021)
H5	Underground water availability	Amount of water available in the water reserve of an aquifer.	M^3/s	ANA (2021)
H6	Integrated Index of Drought	Represents the monitoring of droughts and their impacts.	Und.	CEMADEN (2022)
H7	Total service index of solid waste	Percentage of coverage of solid waste collection service in relation to the total population.	%	SNIS (2020)
H8	Direct and indirect regular collection index of solid waste	Percentage of regular coverage of the solid waste collection service in relation to the urban population.	%	SNIS (2020)
H9	Paving and curb index in urban area (Stormwater)	Percentage of urban public roads with paving and curb.	%	SNIS (2020)
H10	Index of public roads with underground rainfall networks or channels in the urban area (Stormwater)	Percentage of urban public roads with underground rainfall networks or channels.	%	SNIS (2020)
H11	Rainwater abstraction density in urban area (Stormwater)	Number of urban drainage catchments per area of a municipality.	Und/km^2	SNIS (2020)

SOURCE: Developed by the authors.

Additionally, the Social aspect was also considered, since this aspect is directly related to the water security of a municipality.

According to the Global Water System Project (2012), to ensure a sustainable approach to water management, it is not enough to document the physical, chemical and biological aspects of the hydrological cycle and to develop technical options to create more equitable access. It is necessary to understand the social and political dynamics, as well as the aspirations, beliefs and values that affect human behavior in relation to the use of water resources.

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Chart 6 shows the indicators selected in this dimension, as well as their detailed description. In total, three (3) indicators were selected.

Chart 6 - Indicators of the Social Dimension

CÓD.	INDICATOR	DESCRIPTION	UND	SOURCE
S1	Social Vulnerability Index	Represents, the acecess, absence, or, insufficiency of human capital, income and work in areas of the Brazilian territory.	Und.	IPEA (2015)
S2	Population Growth	Population projection at municipal level (urban and rural population).	Hab.	ANA (2021)
S3	Municipal Human Development Index	Represents the socioeconomic development of Brazilian municipalities.	Und.	FIRJAN (2016)

SOURCE: Developed by the authors.

Finally, indicators related to the institutional dimension were selected. Chart 7 shows the selected indicators, as well as their detailed description. In total, 3 (three) indicators were selected.

Chart 7 - Indicators of the Institutional Dimension

CÓD.	INDICATOR	DESCRIPTION	UND	SOURCE
I1	Legislation on selective collection of solid waste	Regarding the presence of regulations on the selective collection of solid waste.	Und.	IBGE (2019)
I2	Legislation on environmental sanitation	Regarding the existence of municipal sanitation plan that includes all components of sanitation	Und.	IBGE (2019)
I3	Index of compliance with water quality parameters established by Ordinance 888/2021	Percentage of attendance of control procedures and surveillance of water quality for human consumption and its standard of potability.	%	SNIS (2020)

SOURCE: Developed by the authors.

4.2 Expert Panel

The pre-selected indicators were arranged in a questionnaire for evaluation of a panel of experts through the Delphi method. The questionnaire was developed as detailed in the methodology, and is available at the link below.

Link to Access to Search Form:
https://docs.google.com/forms/d/e/1FAIpQLScSV0si7w0RgebK5HTMHWqDi_InD5W84k2O9mEgzBgGymQwYA/viewform?usp=pp_url.

After conducting the research of the experts, a total of 30 responses to the questionnaire applied were obtained, following are the detailed answers by type of company or entity where the expert works, academic training, time of experience in the area where they operate, and age group.

Regarding the academic training of specialists, it is observed that more than 50% are trained in Civil Engineering, as shown in Table 1.

Table 1 - Number of Respondents by Academic Background

Academic Background	Number of interviewees	Percentage (%)
Biology and Master in Public Health	1	3.33
Agricultural Engineering	2	6.67
Environmental Engineering	1	3.33
Civil Engineering	21	70.00
Forest Engineering	1	3.33
Chemical Engineering	2	6.67
Agronomist Engineering	1	3.33
Building Technician	1	3.33
TOTAL	**30**	**100.00**

SOURCE: Developed by the authors.

When we analyzed the time of work in the institution where they work we observed that a good portion of the specialists interviewed are full and senior, representing 40% of the sample, as shown in Table 2.

Table 2 - Expert Level by Number of Respondents

Expert Level	Time of Performance	Number of interviewees	Percentage (%)
Junior	1 - 5	18	60.00
Analyst	5 - 10	3	10.00
Senior	above 10	9	30.00
TOTAL		**30**	**100.00**

SOURCE: Developed by the authors.

Regarding the age group of respondents, the vast majority are in the 25 to 34 age group, representing 56.67% of the sample, as shown in Table 3.

Table 3 - Age Group by Number of Respondents

Age Group	Number of interviewees	Percentage (%)
Less than 25	1	3.33%
25 - 34 years	17	56.67%
35 - 44 years	5	16.67%
45 - 54 years	2	6.67%
More than 55	5	16.67%
TOTAL	**30**	**100.00%**

SOURCE: Developed by the authors.

4.3 Consensus Level and Content Validity Index

Applying the methodology to calculate the level of consensus and content validity index, it is observed that of the 28 pre-selected indicators to compose the database, only one was discarded, being the H9 indicator that represents the paving index and curb in the urban area (Stormwater), in chart 8 the result of the level of consensus and content validity index is observed.

Chart 8 - Result of the Consensus Level Calculation and Content Validity Index

INDICATOR	Consensus Level (CL)	Content Validity Index	Selected Indicator?
A1	High	1.00	Yes
A2	High	0.93	Yes
A3	High	1.00	Yes
A4	High	0.97	Yes
A5	High	1.00	Yes
A6	High	1.00	Yes
A7	High	1.00	Yes
A8	High	0.90	Yes
A9	High	0.90	Yes
A10	High	0.87	Yes
A11	High	0.97	Yes
H1	High	0.87	Yes
H2	High	0.87	Yes
H3	High	0.83	Yes
H4	High	0.87	Yes
H5	High	0.87	Yes
H6	High	0.90	Yes
H7	High	0.83	Yes
H8	High	0.83	Yes
H9	Medium	0.77	Não
H10	High	0.83	Yes
H11	High	0.87	Yes
S1	High	0.90	Yes
S2	High	0.90	Yes
S3	High	0.90	Yes
I1	High	0.97	Yes
I2	High	1.00	Yes
I3	High	0.97	Yes

SOURCE: Developed by the authors.

4.4 Database

Based on the results presented in item 4.3, a database containing all the selected indicators, each organized in its proper dimension, was structured using Excel software. A data dictionary was also developed to facilitate the understanding of the selected data.

Due to the size of the database it will be available via link for consultation and preparation of future work.

Link to Access to Database:
https://docs.google.com/spreadsheets/d/15S0H1lEhloIzUPyyVeuLxNW5L994D4yR/edit?usp=sharing&ouid=111383957665854458373&rtpof=true&sd=true

5 CONCLUSION

With the intention of understanding and evaluating the phenomena that interfere with water security, the present study's general objective was based on the selection of indicators and construction of the database that will assist in future works aiming to obtain a water security index of the basin (ISH-C).

It is known that despite the recognition that both the quantity and quality of water should also bring visibility to the social dynamics of water, understanding its path retaken by men and women, called the hydrosocial cycle, the vast majority of water sustainability indicators are limited by the problem of water supply.

Thus, it is observed here that the results of this study do not close the debate on water security. In order to bring subsidies that can contribute to the development of actions and public policies closer to the reality of each municipality, the continuity of this study is recommended, with the application of a statistical treatment in order to verify the correlation and possible associations between the indicators (variables) analysed which influence the water security of the basin.

To perform the analysis Factor Analysis (FA) of the main components can be used, through the extraction of factors by the correlation matrix, in order to determine the number of factors that best represent the pattern of correlation between the variables, and as such it will be possible to summarize different variables in a reduced set of factors.

From the analysis of the main components it will be possible to obtain an equation that will represent a water security index for each municipality in the basin.

Thus, the construction of the water security index of the Capibaribe river watershed is fundamental in order to produce important parameters for assessing the level of water security of municipalities, as well as providing decision-making in water management planning. This index is a proposal to contribute to planning and public management, creating the possibility to define priorities, formulation, evaluation and monitoring of public policies, among other perspectives.

The relationship between the municipality and its classification under water security shows its ability to cover different dimensions, and will provide different conditions for the state, allowing the state to achieve better levels of water, environmental, social and institutional supplies.

6 BIBLIOGRAFIC REFERENCE

BRAGA, R. A. P.; FARIAS, C. R. O.; SILVA, S. R.; CAVALCANTE, E. R. **Gestão e Educação Socioambiental na Bacia do Capibaribe**. 1. Ed. Recife: Ed. Clã, 2015. 144p.

BRASIL. Agência Nacional de Águas e Saneamento Básico. Ministério do Desenvolvimento Regional. **Plano Nacional de Segurança Hídrica**. Brasília, 2019. 116 p. Disponível em: https://arquivos.ana.gov.br/pnsh/pnsh.pdf. Acesso em: 02 maio 2022.

DELGADO, Juliana Aparecida da Silva. **Segurança Hídrica e a Gestão de Risco da RMSP**. 2018. 165 f. Dissertação (Mestrado) - Curso de Pós-Graduação em Ciência Ambiental, Instituto de Energia e Ambiente, Universidade de São Paulo, São Paulo, 2018.

FIGUEIREDO FILHO, Dalson Brito; SILVA JÚNIOR, José Alexandre da. Visão além do alcance: uma introdução à análise fatorial. **Opinião Pública**, v. 16, n. 1, p. 160-185, jun. 2010. FapUNIFESP (SciELO). http://dx.doi.org/10.1590/s0104-62762010000100007.

GRISHAM, Thomas. The Delphi technique: a method for testing complex and multifaceted topics. **International Journal of Managing Projects In Business**, v. 2, n. 1, p. 112-130, 23 jan. 2009. Emerald. http://dx.doi.org/10.1108/17538370910930545.

GWSP. GLOBAL WATER SYSTEM PROJECT. **Recomendações para Rio+20**: segurança hídrica para um planeta sob pressão. Rio de Janeiro. 2012. 8 p. Disponível em: http://www3.inpe.br/igbp/arquivos/Water_FINAL_LR-portugues.pdf. Acesso em: 02 maio 2022.

KEEBLE, Brian R. The Brundtland report: our common future. Medicine And War, v. 4, n. 1, p. 17-25, jan. 1988. Informa UK Limited. http://dx.doi.org/10.1080/07488008808408783.

MACHADO, Fernando Henrique. **Proposição de Indicadores de Segurança Hídrica: Seleção, Validação e Aplicação na Bacia Hidrográfica do Rio Jundiaí-Mirim**. 2018. 255 f. Tese (Doutorado) - Curso de Ciências Ambientais, Universidade Estadual Paulista Júlio de Mesquita Filho, Jundiaí, 2018. Disponível em: http://hdl.handle.net/11449/153669. Acesso em: 07 set. 2022.

MACHADO, Fernando Henrique. **Proposição de Indicadores de Segurança Hídrica: Seleção, Validação e Aplicação na Bacia Hidrográfica do Rio Jundiaí-Mirim**. 2018. 255 f. Tese (Doutorado) - Curso de Ciências Ambientais, Universidade Estadual Paulista Júlio de Mesquita Filho, Jundiaí, 2018. Disponível em: http://hdl.handle.net/11449/153669. Acesso em: 07 set. 2022.

MARQUES, Joana Brás Varanda; FREITAS, Denise de. Método DELPHI: caracterização e potencialidades na pesquisa em educação. **Pro-Posições**, v. 29, n. 2, p. 389-415, ago. 2018. FapUNIFESP (SciELO). http://dx.doi.org/10.1590/1980-6248-2015-0140.

MEADOWS, Donella. Indicators and Information Systems for Sustainable Development. **The Sustainability Institute**. p. 1-95. set. 1998. Disponível em: https://donellameadows.org/wp-content/userfiles/IndicatorsInformation.pdf. Acesso em: 19 set. 2022.

MIRANDA; CASA NOVA, CORNACCHIONE JUNIOR. Dimensões da qualificação docente em contabilidade: um estudo por meio da técnica Delphi. 2012, Anais. São Paulo: EAC/FEA/USP, 2012. Disponível em: http://www.congressousp.fipecafi.org/artigos122012/120.pdf. Acesso em: 24 set. 2022.

ONU. ORGANIZAÇÃO DAS NAÇÕES UNIDAS. **Documentos Temáticos**: objetivos de desenvolvimento sustentável 6-7-11-12-15. Brasília, 2018. 116 p.

PERNAMBUCO. Agência Pernambucana de Águas e Climas. Secretaria de Infraestrutura e Recursos Hídricos. **Plano Estadual de Recursos Hídricos de Pernambuco**. Recife. 2022.

PERNAMBUCO. Agência Pernambucana de Águas e Climas. Secretaria de Infraestrutura e Recursos Hídricos. **Plano Hidroambiental da Bacia do rio Capibaribe**. Recife. 2010.

POWELL, Catherine. The Delphi technique: myths and realities. **Journal of Advanced Nursing**, v. 41, n. 4, p. 376-382, fev. 2003. Wiley. http://dx.doi.org/10.1046/j.1365-2648.2003.02537.x.

RABELO, Nosliana Nobre. **Análise da Segurança Hídrica no Estado do Ceará**: subsídios para o planejamento e gestão dos recursos hídricos. 2022. 170 f. Tese (Doutorado) - Curso de Pós-Graduação em Engenharia Civil, Departamento de Engenharia Hidráulica e Ambiental, Universidade Federal do Ceará, Fortaleza, 2022.

RABELO, Nosliana Nobre. **Análise da Segurança Hídrica no Estado do Ceará**: subsídios para o planejamento e gestão dos recursos hídricos. 2022. 170 f. Tese (Doutorado) - Curso de Pós-Graduação em Engenharia Civil, Departamento de Engenharia Hidráulica e Ambiental, Universidade Federal do Ceará, Fortaleza, 2022.

UNESCO. ORGANIZAÇÃO DAS NAÇÕES UNIDAS PARA EDUCAÇÃO CIENCIA E CULTURA. **Water Security and the Sustainable Development Goals Water Security and**. 2019.

ZHANG, Xiang et al. Urban drought challenge to 2030 sustainable development goals. **Science of The Total Environment**, v. 693, p. 133536, nov. 2019. Elsevier BV. http://dx.doi.org/10.1016/j.scitotenv.2019.07.342.