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Urban water insecurity drivers in the Brazilian semi-arid region

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ABSTRACT

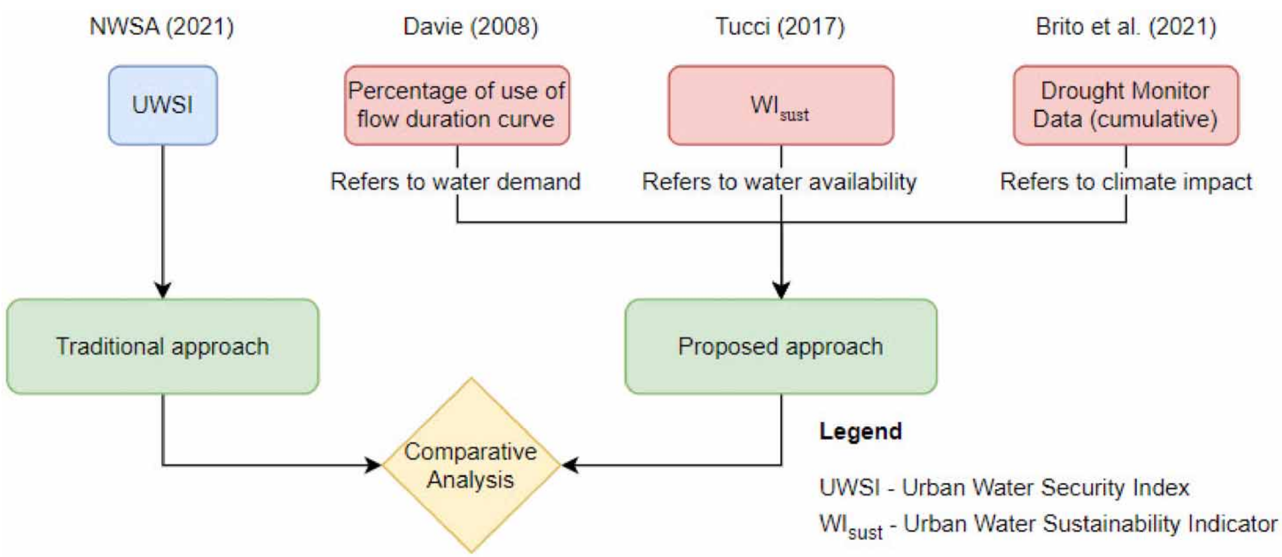
The imbalance between water supply and demand highlights the vulnerability of many people and the prospect of an uncertain future for water supply. This work aims to compare the Urban Water Security Index (UWSI) with three other methodologies (percentage flow duration curve, Urban Water Sustainability Indicator, and accumulated data from the Drought Monitor) for the municipality of Guarabira, Paraíba, Brazil. The results show water security based on the amount of water in the study area. However, there is a need for proposals for assessing urban water security to be based on local sustainability. Water-sensitive planning is the solution to maintaining and conserving natural resources for future generations in the face of impacts, particularly climate change and population growth. The methodology applied in this work can contribute to the investigation of probable and specific causes of water insecurity and gives evidence of improvement in the concept of water security based on the urban metabolism of water.

Key words: Brazilian semi-arid, flow duration curve, scale issues, urban water security index, water supply

HIGHLIGHTS

- Small cities in the Brazilian semi-arid region present different and peculiar drivers for water insecurity.
- The results (using a study case) suggest a close look at water availability, demand, and sustainability.
- Even a very well-developed water security index designed for a country faces problems of scale or can mask some local realities and issues.

GRAPHICAL ABSTRACT



INTRODUCTION

Generally, a definition of water security includes the amount of water available for health, livelihood, and ecosystem needs. How to define a water security condition in a local context such as a small city? Srinivasan *et al.* (2017) raise some possible drivers, such as environmental determinism (hydrological conditions), cultural choices (use of water resources), economic decisions, infrastructure, and governance. These problems can be drivers for the initial water shortage condition and demonstrate the global water crisis (Srinivasan *et al.* 2017). Currently, 2.3 billion (2.3×10^9) people live with water scarcity, of which 721 million live in countries with high water shortages (UN-Water 2021).

Furthermore, the water supply for billions of people is intermittent, especially in rural and peri-urban areas (Taonameso *et al.* 2021). According to UN-Water (2021), based on data from 2018, the regions that suffer the most from water stress are Central, Western, and Southern Asia and Northern Africa. Many drivers are related to water insecurity, resulting from a lack of water. Pollution of water sources is one such problem. According to UN-Water (2021), the lack of data on water quality for 3 billion people highlights the potential risk caused by unknown water supply sources. Another factor is the increased demand for water resources. Increasingly, water use has become more intensive to meet the needs of a growing population (UN-Water 2021). Because of this, water supply services have been unable to keep up with the increase in demand (Taonameso *et al.* 2021).

Urban development, continuous population growth, climate changes, and ill-planned cities aggravate the urban scale's water crises (Serrao-Neumann *et al.* 2019). This growth trend in urban areas causes pressure on natural and energy resources. It might result in an overload of existing urban equipment and services if they are not adequately planned to absorb the increased demands in water consumption, collection and treatment of wastewater, appropriate disposal of garbage, and road support (Simpson 2013). In developing countries and emerging economies, water scarcity is often caused by ill water supply policies and governance crises (Taonameso *et al.* 2021). Maingey *et al.* (2021) studied the increase of scarcity impacts on Kenya and showed a failed water resources access and how climate change is the main driver. The same authors highlight the human action impacts on the water cycle as water consumption, irrigation, and land-use changes.

Many semi-arid and arid regions, such as the Eastern Mediterranean basin, Western USA, Southern Africa, Northeastern Brazil, and Arabian Peninsula, are exposed to climate change, and these regions are destined to experience scarcity in water resources (Şen 2021). The impact on the economy, humans, and ecosystems should be considered to ensure water security.

An Environmental Flow Reference (EFR) is defined as the quantity, timing, and quality of the water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend upon these ecosystems (Brisbane Declaration 2007). The selection of an appropriate method to obtain an EFR is primarily constrained by data availability for a region and local limitations in terms of time, funding, expertise, and logistical support (Liu *et al.* 2016).

In the Brazilian semi-arid region, where annual evaporation rates exceed precipitation (Lindoso *et al.* 2018), the lack of water for the population is a reality in many cities (Lindoso *et al.* 2018; Brito *et al.* 2021). Not only megacities but small municipalities have experienced collapses in their water supply systems.

Therefore, this work aims to evaluate the water security for a small city located in the Brazilian semi-arid region, using a percentage of the flow duration curve; from Urban Water Sustainability Indicator (WI_{sust}) (Tucci 2017); and the Drought Monitor in Brazil (DMB), through a cumulative approach (Brito *et al.* 2021). Those results are compared with the Urban Water Security Index (UWSI) used by the National Water and Sanitation Agency (NWSA), showing how a generic indicator could include other parameters to improve water resources planning and management in semi-arid urban areas.

MATERIALS AND METHODS

Study area

Guarabira is a small town with about 59,115 inhabitants (IBGE[1]), with more than 88% living in urban areas. It is located in Paraíba, under geographic coordinates 6°48′41″N and 6°57′52″S of Latitude; 35°22′50″E and 35°31′48″W of Longitude, in the Brazilian semi-arid region. It occupies an area of 165 km^2, with an average altitude of 150 m. Its main economic activities include the tertiary, secondary, and primary sectors. The location of the study site can be found in Figure 1.

Historically, the semi-arid region has been affected by moderate to extreme droughts, which implies difficulties and changes in living standards, resulting in hunger, loss of assets, and emigration (Lindoso *et al.* 2018). The region is characterized by

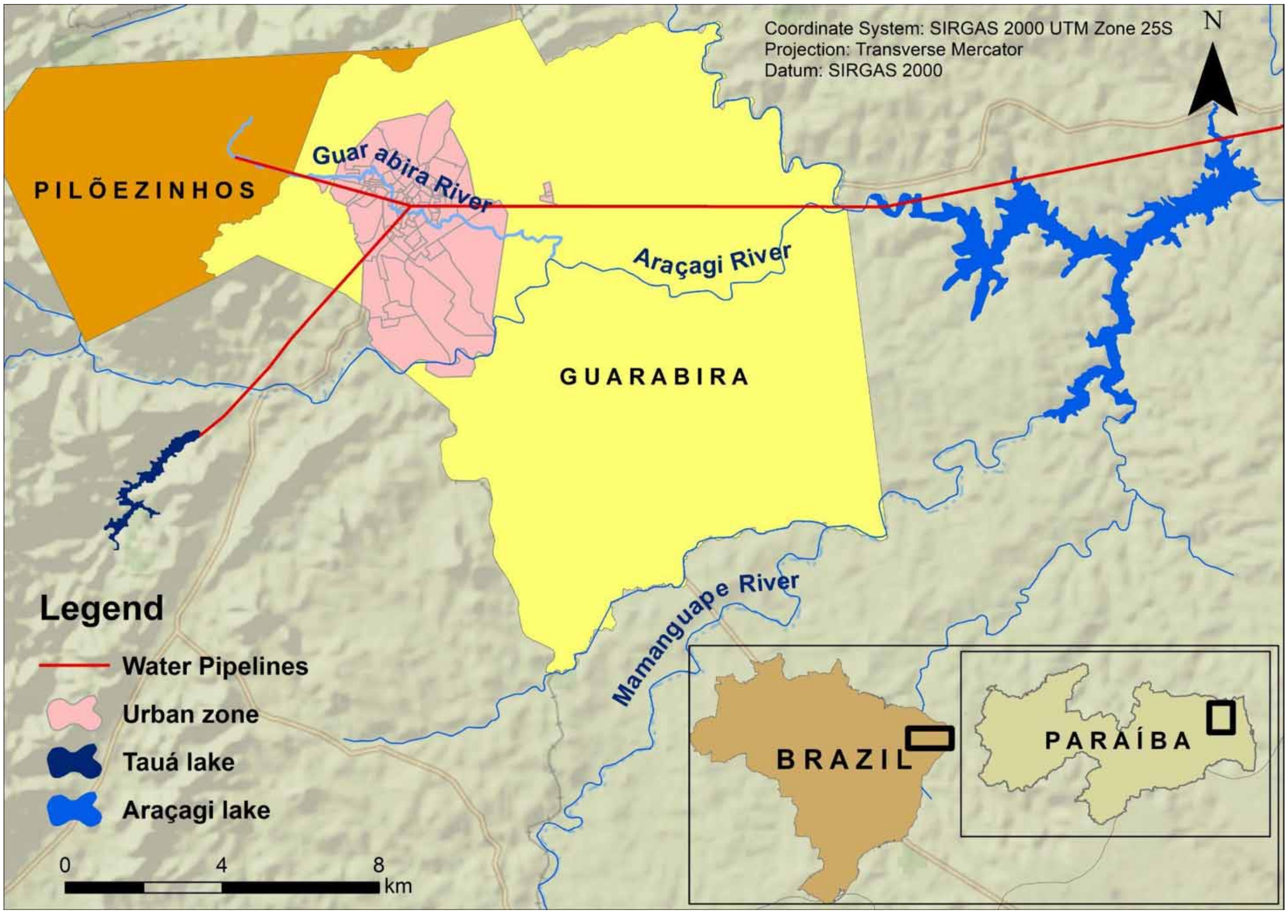


Figure 1 | Municipality of Guarabira – PB and its water supply system. *Sources:* IBGE (2020) and Google Maps.

high temperatures and irregular yearly rainfall, alternating between above-average rainfall periods and extreme scarcity times. Rainfall has high spatial and temporal variability, with a rainy season from March to June and a dry season from September to December (Santos *et al.* 2006). The average annual precipitation in the region is less than 800 mm, and evaporation rates exceed 2,000 mm (Magalhães 2016). Due to the geological conditions in the region, there is a low groundwater availability which makes surface water management essential (Lindoso *et al.* 2018). Such a location compromises the water supply with interruptions that can be aggravated in periods of water scarcity.

Guarabira represents a small global city with sanitation rates under development (e.g., only 55.12% of the sewage generated by the population and delivery to the environment has some quality treatment. In addition, the rate of water loss in the distribution network is 35%, although the rate of water service attendance is 100%, in the urban area, according to National Databases (SNIS 2019). In addition, the study area has no local legal support for water management, such as a municipal sanitation master plan, and specific mechanisms or environmental targets for managing water demand in water restriction periods. The main river that integrates the city's hydrographic micro basin is degraded and receives sewage without treatment. The water supply system has two main surface lakes (Araçagi and Tauá) and some in-line pipelines (Figure 1). Human impacts on this whole system have been increasing over the years. Regarding relevance, Araçagi lake holds 64.12% of the water supply, while Tauá lake holds only 35.88% of the water supply.

Methodology

This study seeks to answer the following question: how does the demand, availability, and climate affect water security in a small semi-arid city? The objective is to examine whether three methodologies can explain the water security framework described by the UWSI.

First, the percentage of use of the flow duration curve to understand the level of demand for each lake (primary water sources). Second, the WI_{sust} elucidates how the lack of sanitation can affect water availability. Finally, with data from the drought monitor, the cumulative approach highlights the most severe climatic periods of Guarabira and the water supply lakes. A comparative analysis was carried out between the traditional and proposed approaches, as shown in the graphical abstract.

Urban Water Security Index (UWSI)

The UWSI is provided by the ATLAS ÁGUAS (NWSA 2021), which evaluates the water security of urban supply in Brazilian municipalities. As it gathers more detailed information on a local scale, it is seen as an advance in the human dimension's Water Security Index (global scale), proposed by the National Plan for Water Security (NPWS) in Brazil. The study area is assessed as 'High water security', as shown in Figure 2. Not only the municipality but also the lakes are classified within this range.

The ATLAS ÁGUAS is a national publication developed by NWSA, which involved sanitation service providers, the Ministry of Regional Development (MRD), and several federal, state, municipal, and private institutions throughout Brazil (NWSA 2021).

The index combines two sub-indices: production efficiency and distribution efficiency. Production efficiency considers the source's vulnerability and the production system's adequacy; distribution efficiency considers water supply service coverage; and technical performance in managing losses. Each sub-index is evaluated through water security levels: minimum (red), low (orange), medium (yellow), high (green), and maximum (blue), as shown in Figure 3.

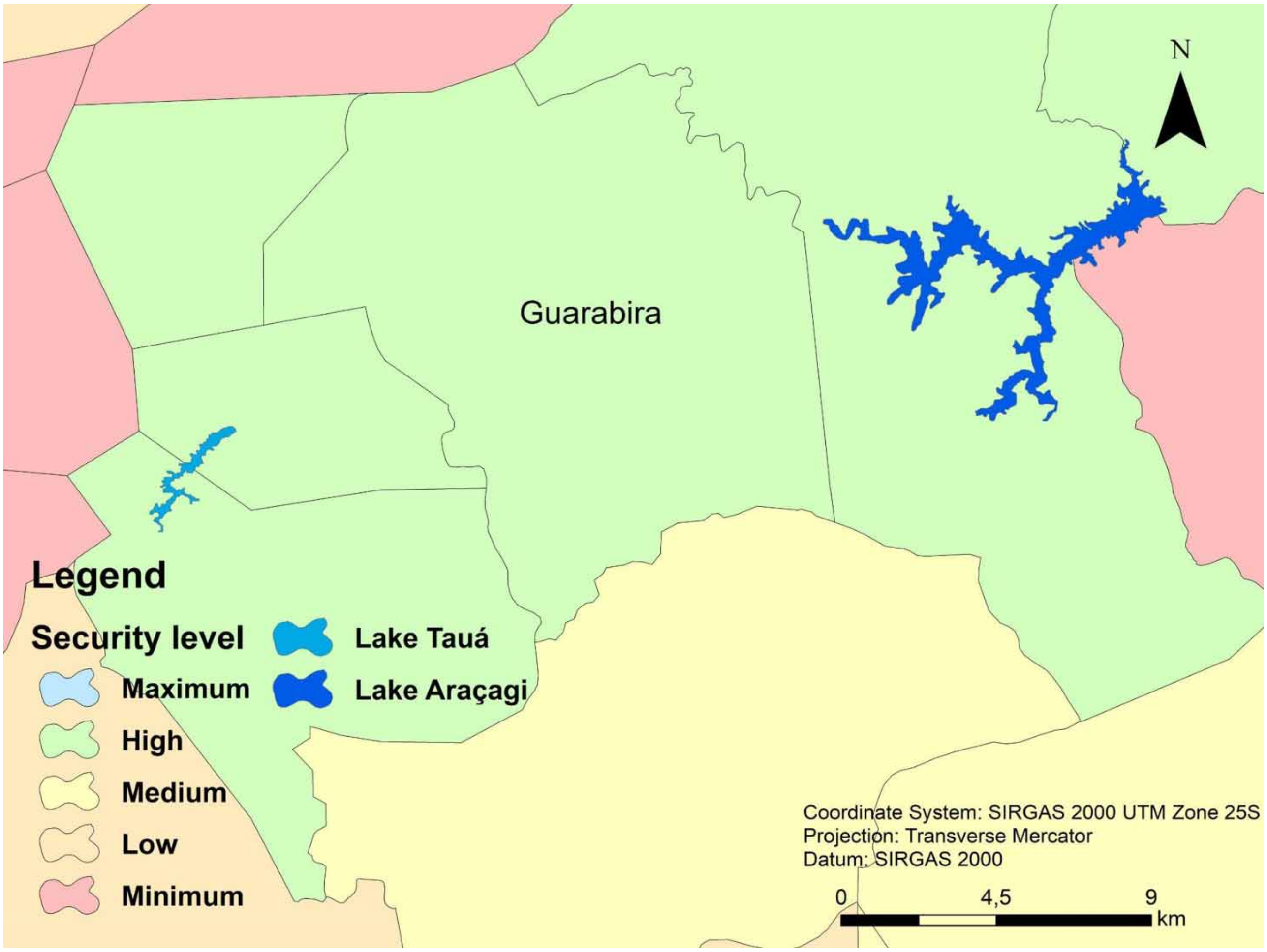
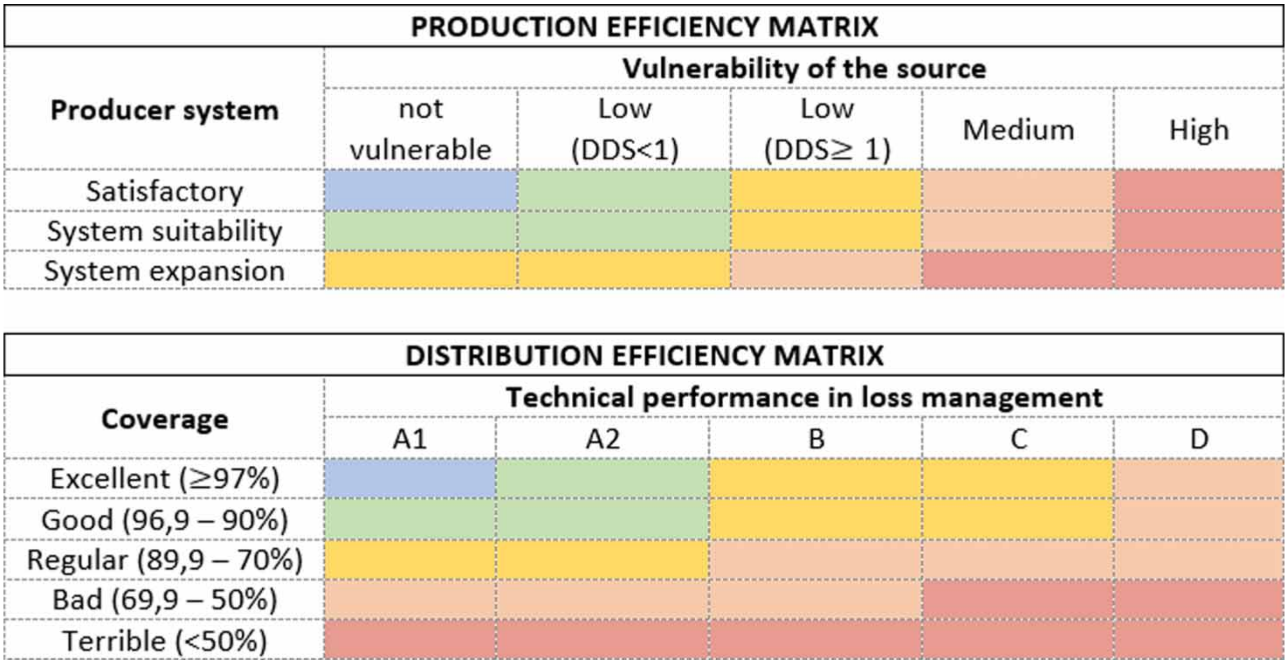


Figure 2 | Human dimension of the WSI in the municipality of Guarabira. *Source:* NWSA (2021).



PRODUCTION EFFICIENCY MATRIX					
Producer system	Vulnerability of the source				
	not vulnerable	Low (DDS<1)	Low (DDS≥ 1)	Medium	High
Satisfactory					
System suitability					
System expansion					

DISTRIBUTION EFFICIENCY MATRIX					
Coverage	Technical performance in loss management				
	A1	A2	B	C	D
Excellent (≥97%)					
Good (96,9 – 90%)					
Regular (89,9 – 70%)					
Bad (69,9 – 50%)					
Terrible (<50%)					

Figure 3 | Conceptual model for Urban Water Security Index in Brazil (used by the national agencies and policymakers). Legend: DDS[3] – Degree of Demand Service. *Source:* NWSA (2021). Please refer to the online version of this paper to see this figure in colour: https://dx.doi.org/10.2166/ws.2023.015.

The loss management assessment is assessed at five levels (A1, A2, B, C, and D) that indicate the need for only marginal leakage reductions (A1) – better performance – to where leakage reduction is imperative and a priority (D) – worse performance.

The UWSI result combines the water security levels of the two matrices in Figure 3. More information can be found in the Supplementary Information

Percentage of the use of flow duration curve

'Flow duration curves are concerned with the amount of time a certain flow is exceeded' (Davie 2008); these curves are also called regularizable flow (Q_{reg}). When Q_{reg} is the same during 100% of the time interval of the curve, it is called Q_{100}. Moreover, it corresponds to the supply guarantee for the population, referring to the maximum flow rate granted for demand. The demand level calculation is made by removing water permits (licenses for water use) from Q_{100} and observing the residual percentage. The flow resulting from this difference is the possible available flow, also called the residual flow (Q_{res}). The lower the possibility of granting flow, the higher the percentage of use, the greater the need for use in the lake. The lake is then acting on the edge of its limit. Therefore, any climatic disturbance, such as a lack of rain, can cause the supply system to be intermittent.

According to information available on the website of the Executive Agency for Water Management of Paraíba (AESA is the Portuguese acronym), called the State Water Resources Management System (SIEGRH is the Portuguese acronym), the Araçagi and Tauá lakes have the following water permits and Q_{100} (Table 1).

WI_{sust}

Tucci (2017) defines WI_{sust} as the relationship between total demand and water availability, as shown in Equation (3). If it is less than 1, it indicates that the city is sustainable from the point of view of serving the population; if it is higher than 1, it indicates a demand upper than the supply (Tucci 2017). In order to be able to determine the WI_{sust}, one must know the subsidy flow (Q_s) (receives this nomenclature because it benefits the inoperative society), presented in Equation (1). Such flow is defined as the flow necessary for the river to carry out the self-purification process, recovering its quality according to the established framing pattern. Another important variable is the consumptive demand (Q_c). It corresponds to the flow value

Table 1 | Input data

Data	Value	Unit/format	Period	Source
Urban population (p)	52,061	Inhab (inhabitants)	2019	Municipality of Guarabira (*aguaesaneamento.org.br*)
The portion of water demand that returns to the river (α)	0.8	dimensionless	2019	Manual of consumptive uses of water in Brazil (*snirh.gov.br*)
Water demand (q)	104.59	liters/day/inhab	2019	Diagnosis of water and sewage services in the municipality of Guarabira (*snis.gov.br*)
The amount of treated sewage (μ)	0.8	dimensionless	–	Tucci (2017)
The effluent that is collected and treated (β)	0.55	dimensionless	2019	Diagnosis of water and sewage services in the municipality of Guarabira (*snis.gov.br*)
Target river class concentration for BOD (C_s)	5	mg/l (milligrams/ liter)	2005	CONAMA (2005)
The concentration of the river before receiving the effluent (C_i)	2	mg/l	2017	Tucci (2017)
Parameter concentration in raw sewage (C_n)	569.04	mg/l	2015	Sewage scheme for the municipality of Guarabira (*atlasesgotos.ana.gov.br*)
Q_{100} (Araçagi lake)	6,443.64	m^3/h (cubic meters/hour)	2018	Update of the Paraíba State Water Resources Plan (*aesa.pb.gov.br*)
Q_{100} (Tauá lake)	326.02	m^3/h	2018	Update of the Paraíba State Water Resources Plan (*aesa.pb.gov.br*
Total water permits (Araçagi lake)	1,027.48	m^3/h	Current	(*aesa.pb.gov.br*)
Total water permits (Tauá lake)	130.57	m^3/h	Current	(*aesa.pb.gov.br*)
The volume of the Araçagi lake	63.3	hm^3 (hectomer)	–	(*aesa.pb.gov.br*)
The volume of the Tauá lake	8.6	hm^3	–	(*aesa.pb.gov.br*)
Urban Water Security Index (UWSI)	–	Shapefile	2015	Urban Water Security Index (*metadados.snirh.gov.br*)
Drought severity and duration condition	–	GeoTIFF	2014–2019	Drought monitor (*monitordesecas.ana.gov.br*)

that the population uses, which does not return to the environment. The sum of Q_s and Q_c is configured in the total demand. The Q_{100} presented above is used here for water availability. All input data used are shown in Table 1.

Substituting Equations (1) and (2) in Equation (3), we have the final WI_{sust} (Equation (4)), the detailed equation for calculating the sustainability indicator. The other information that makes up the WI_{sust} calculation regarding water quality is presented below.

- The Biochemical Oxygen Demand (BOD) parameter is considered the leading indicator of organic load in effluents. It is introduced into the WI_{sust} Equation through the concentrations C_n, C_i, and C_s.
- The β parameter is related to the collection and treatment indices available on the National Sanitation Information System (SNIS).
- μ parameter: According to Tucci (2017), in the Brazilian context, for cases where there is incomplete information about the effectiveness of the treatment adopted equal to 0.8 (80%).

$$Q_s = \frac{\alpha \cdot q \cdot [(1-\mu\beta) \cdot C_n - C_s]}{(C_s - C_i)} \quad (1)$$

$$Q_c = q \cdot p \cdot (1-\alpha) \quad (2)$$

$$WI_{sust} = \frac{Q_c + Q_s}{Q_{100}} \quad (3)$$

$$WI_{sust} = \frac{q \cdot p}{Q_{100} \cdot (C_s - C_i)}\{(1-\alpha)(C_s - C_i) + \alpha[(1-\mu\beta)C_n - C_s]\} \quad (4)$$

where Q_s is the subsidy flow (L/day/inhabitant); Q_c is the consumptive demand (L/day); WI_{sust} is the urban water sustainability indicator (dimensionless); α is the portion of water demand that returns to the river (dimensionless between 0 and 1); q is the city supply-demand (L/day/inhabitant); μ is the proportion of raw sewage that is treated (dimensionless between 0 and 1); β is the effluent portion that is collected and treated (dimensionless between 0 and 1); C_n is the concentration of a given parameter in sewage (mg/L); C_s is the target river concentration for a given parameter (mg/L); C_i is the concentration of a given parameter in the river (mg/L); Q_{100} is the water availability to 100% (L/day); and p is the urban population (inhabitant).

Drought Monitor data (cumulative)

The data matrix of the Drought Monitor maps in Brazil (DMB), used in the cumulative approach (Brito *et al.* 2021), have a spatial resolution of 1,000 m (regional scale). In this analysis, the area of the municipality of Guarabira (local scale) was clipped using a zonal statistics tool. According to Brito *et al.* (2021), the three categories of most intense droughts were considered: severe, extreme, and exceptional. For a total of 60 months, five assessment intervals are adopted by Brito *et al.* (2021):

- Interval 1: under dry conditions, for up to 12 months;
- Interval 2: under dry conditions, for more than 12 months and up to 24 months;
- Interval 3: under dry conditions, for more than 24 months and up to 36 months;
- Interval 4: under dry conditions, for more than 36 months and up to 48 months;
- Interval 5: under dry conditions, for more than 48 months and up to 60 months.

Based on the methodology of Brito *et al.* (2021), it is possible to analyze drought conditions using zonal statistics in a GIS environment to observe the severity and the duration of the droughts condition for any pixel available in the time interval.

Using Brito *et al.* (2021) cumulative outputs, zonal statistics for Guarabira shows for the whole municipality that it has been under severe drought conditions from 18 to 24 months; under extreme drought conditions from 7 to 8 months; and under exceptional drought conditions for 3 months.

RESULTS

As a result, the percentage of use of flow duration curve calculations is first presented by identifying the demand levels of the Araçagi and Tauá lakes; then, the values for Q_s and WI_{sust} have explained changes in the quality of effluent treatment that can change current standards. Then, drought trajectories are presented for the municipality of Guarabira and the water supply lakes. In the end, a comparison of these proposed methodologies with the result of the UWSI was carried out.

Percentage of the use of flow duration curve

The Araçagi lake has 24 water permits totaling 1,027.48 m^3/h and has a Q_{100} of 6,443.64 m^3/h. Therefore, the demands correspond to 15.94% of Q_{100}. The Tauá lake has three water permits totaling 130.57 m^3/h, and a Q_{100} of 326.02 m^3/h. Therefore, the demands correspond to 40% of Q_{100}.

WI_{sust}

Using Equations (1) and (4), and the data available in Table 1, Q_c and Q_s are equal to 1,089.01 and 455,442.8 m^3/day, respectively. In this case, the amount of the flow that returns for rivers is 418 times greater than the population's consumption flow. As 64.12% of the total water demand comes from Araçagi lake, the WI_{sust} calculation (Equation (3)) used only this percentage of Q_{100}. The WI_{sust} result is then 4.60. So the water demand is approximately five times higher than the water availability.

According to the results, the Q_s deficit is approximately 418 times the real needs. The Q_s will always be greater than the consumptive consumption, as 80% of the water used returns to the water bodies. However, a possible way to reduce demand and Q_s is through water reuse practices (Tucci 2017). Although reducing this difference between flows is possible, the biggest problem is the water quality that returns to the rivers. The study area has 55.12% for sewage collection and 80% for treatment. The application of sanitation improvements, such as increasing sewage collection to 100% and ensuring an efficiency level of 87%, would promote a reduction in subsidy flow to 100,153.1 m^3/day, and, thus, the WI_{sust} would be in balance, being equal to 1. Being balanced means water use is equal to its availability (Tucci 2017).

Drought Monitor data (cumulative)

For the Guarabira urban zone, the temporal analysis (Brito *et al.* 2021) shows 15 months under a severe drought, 5 months in an extreme drought, and 3 months in exceptional drought during the 60 months analyzed from 2014 to 2019 (Figure 4).

The most critical drought period (extreme and severe) was from September 2016 to April 2017. In addition, at least 41.67% and 33.33% of the time, the drought was classified as severe for Araçagi and Tauá lakes, respectively. It is possible to observe that the lakes (Tauá and Araçagi) also had the lowest volume levels in the same period (Figures 5 and 6).

Araçagi has an average of 75.06% of the total volume, and Tauá has an average of 35.85%. However, according to the water utilities, there was no public action on rationing from 2014 to 2019. Water rationing is a common initiative in many Brazilian semi-arid cities to manage the scarcity in urban areas.

This situation can be explained by the fact that the Araçagi lake, even in a drought, kept higher relative volumes than the Tauá lake. Although the city is located in a semi-arid region, the Araçagi lake is very close to a climate frontier (semi-arid-coastal zone), with higher precipitation levels, which keeps its volume always higher than the Tauá Lake. There is apparent water security in this situation, and the policymakers have not applied water rationing as a management tool. Water rationing is very common in many semi-arid cities, but it is still not widely accepted, especially because there is no equity regarding households' water storage capacity.

Comparative analysis

According to the results, Araçagi and Tauá lakes were not operating at maximum capacity; there is residual flow, which shows a water supply that, even in drought conditions, is managed to maintain itself without the need for rationing. Thus, the multiple water users are not the main drivers for water insecurity. The main implication in the Q_{reg} analysis is often the need for updating the data in the granting system. A limitation that should be highlighted is the misapplication of the Q_{reg} by those who manage the reservoirs. It is known that Q_{100} cannot be taken as a reference flow for non-essential uses, such as irrigation. For these cases, more restrictive flow rates (less time guarantee) should be applied.

As for the WI_{sust}, even though the city has water unsustainability, with the generation of polluted flows that degrade water quality and make demand greater than water availability ($Q_c + Q_s > Q_{100}$), the impact generated is much more local, at the urban level, given the impossibility of using the waters of the Guarabira river. There is no evidence that the scenario presented by the WI_{sust} affects the water availability of Araçagi lake. As seen in Figure 1, this river, shortly after crossing the urban area, joins the Mamanguape river and runs approximately 10.4 km until it reaches the lake in the municipality of Araçagi. A limitation of the WI_{sust} is that only 20% of the total percentage of water that returns to the environment has efficient treatment. As an implication, it scores the amount of effluent released as solely responsible for the insufficient self-purification of water bodies, not considering aspects such as microbiological presence, hydrological characteristics, geology, channel geometry, and temperature (Zhang *et al.* 2022).

The cumulative approach of Drought Monitor data did not indicate a strong influence of climate variability on water supply. It is noticed that even during the most severe drought (September 2016 to April 2017), the Araçagi dam (main source) did not significantly vary its available volume. According to the Utility Water responsible for the supply, there is

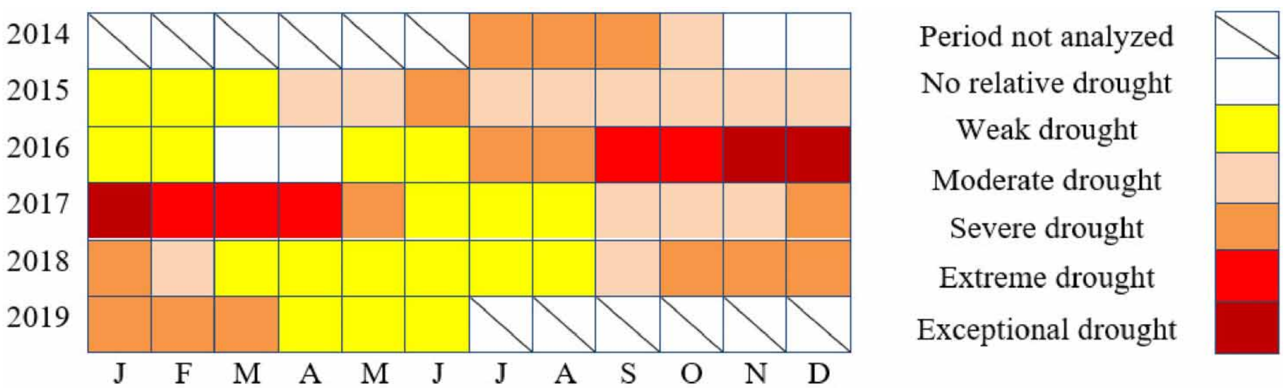


Figure 4 | Pixel trajectory, over the months, in the urban area of Guarabira for analysis of droughts in a temporal perspective.

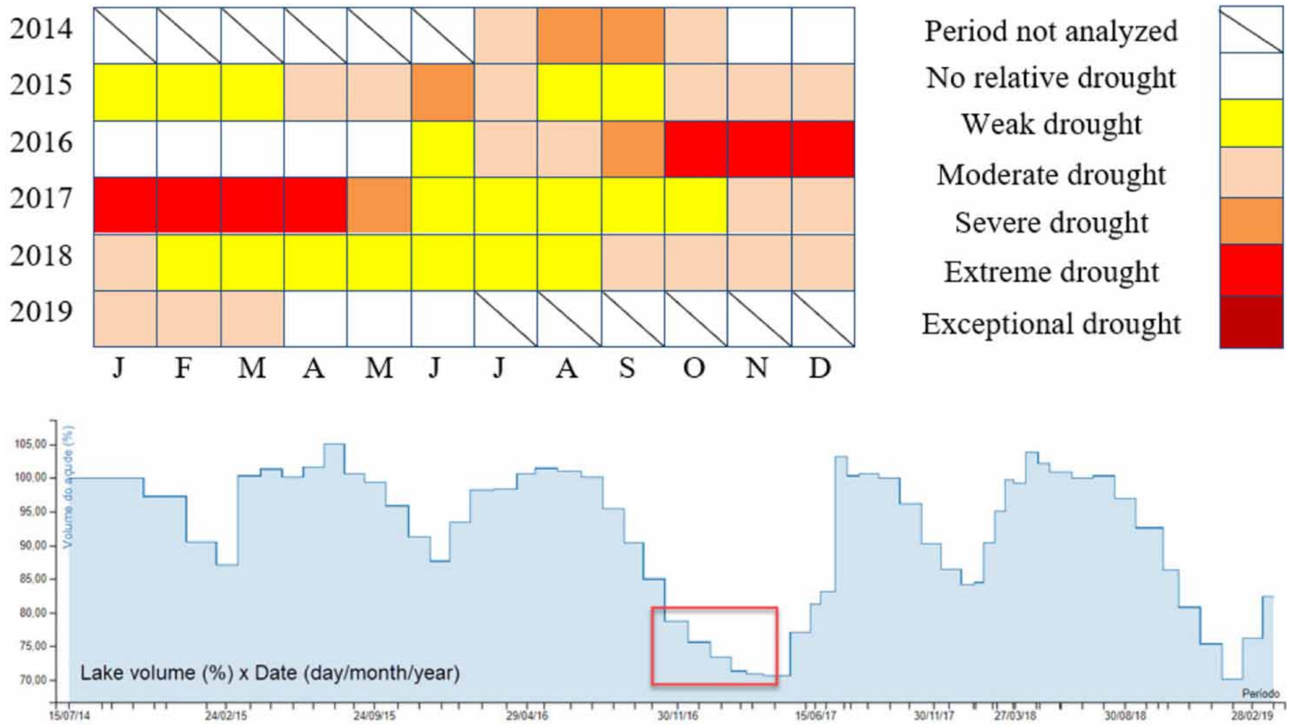


Figure 5 | Monthly trajectory of pixels and monthly volumes (%) referring to the Araçagi lake (AESA, undated).

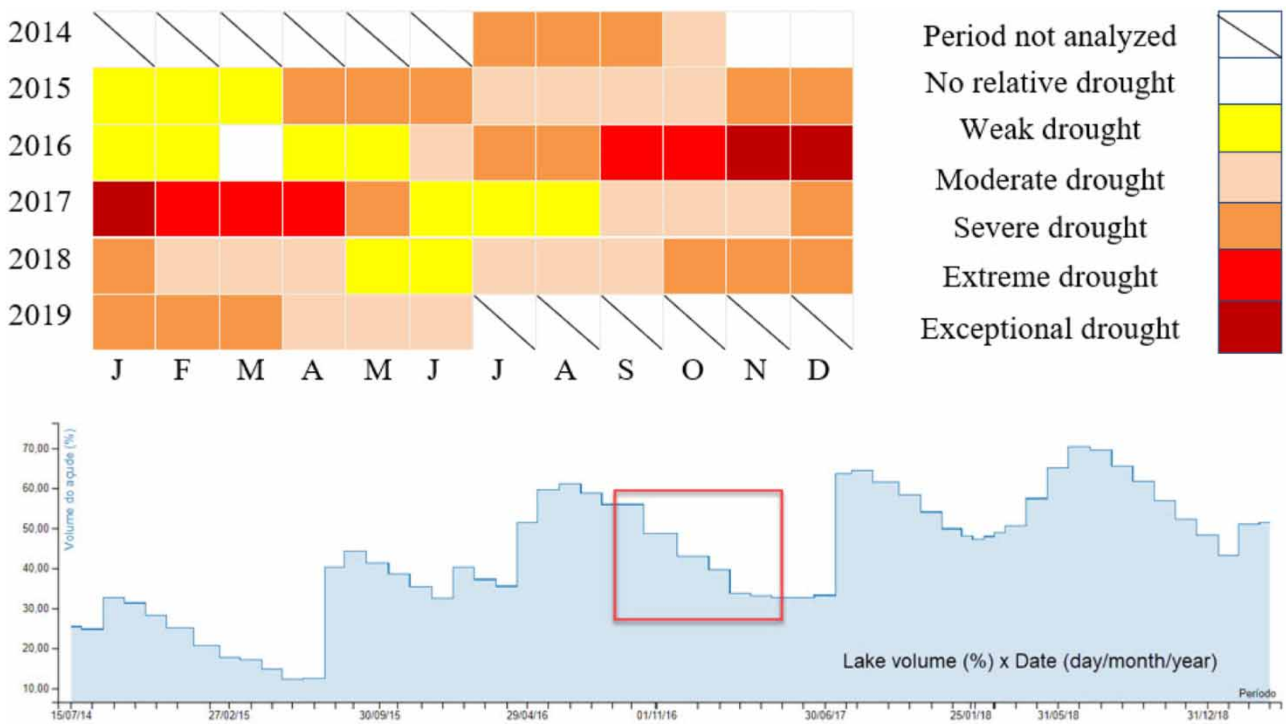


Figure 6 | Monthly trajectory of pixels and monthly volumes (%) referring to the Tauá lake (AESA, undated).

no rationing because there is a good supply of water and good control of production and distribution. This good water supply (flow volumes from both aggregated lakes are sufficient) is evidenced by one of the sub-indexes that make up the UWSI (Figure 2) and that classifies Araçagi and Tauá lakes as non-vulnerable. A limitation of the cumulative approach is that the DMB works with the representation of drought on a regional scale. Furthermore, the DMB may have implications for public policies about water resources management.

In addition to the implications and limitations already exposed, it is recommended, in further research, that urban water security indicators in semi-arid areas include more dimensions, such as the water governance system (Empinotti *et al.* 2019), infrastructure (Campos *et al.* 2021), and consumers' ability to access water (Campos *et al.* 2021), toward to a water sustainability concept especially for small cities and their peculiarities.

DISCUSSION

The UWSI is a suitable tool for planning and allocating resources in public policies. Its appearance improved the scale problems of the predecessor (NPWS water security indicator) and brought more reliable results (NWSA 2021). Research involving water security at a local scale is not easy, mainly due to data availability challenges. Improving the water security evaluation requires zooming in at the local level to capture spatial variations rather than conventional measurements at the national or basin level.

The 'percentage of the use of flow duration curve' and 'Drought Monitor data (cumulative)' methodologies are in line with the UWSI when pointing out that there is water security for the study area. However, the WI_{sust} proposal demonstrated that amid the sense of security, there is an imbalance between the supply and availability of water, which shows a city with a low sustainability index. The portion of water that returns to the environment (subsidy flow) has not been appropriately treated. In this sense, water security is negatively affected, as there is an imbalance between the use of water resources and environmental pollution. Water is seen only from the binary 'resource/waste', and urban water resources are not exploited. A sustainable city presupposes exploiting its water resources within its urban limits. It is intended to apply reclamation and restoration strategies. This is the urban water circularity principle (Kakwani & Kalbar 2022). If individuals can use and return water to the environment without harm, then availability would not be so strongly affected.

The UWSI proposal is valid in involving local information on water distribution and production as contributors to water security assessment. However, a city cannot rely only on centralized and traditional infrastructure (Serrao-Neumann *et al.* 2019) while in need of sustainable management of urban waters. The scenario evidenced by WI_{sust} highlights future difficulties in water availability, mainly due to climate changes and population growth. Social, economic, and environmental pressures interfere with water security for generations to come (Bakhtiari *et al.* 2020). Hence, the movement toward a sustainable urban approach is essential.

In this sense, the concept of urban metabolism arises to identify the critical processes in urban water management through the analysis of input and output flows, observing how water flows and transforms, and improving the use of resources – environmental issues (Nezami *et al.* 2022). In the case of presented unsustainability, it is possible to (i) promote the increase of availability through the increase of the provided water capacity or (ii) use practices sensitive to water resources (Brown *et al.* 2018). In general, managers have always sought the first alternative and failed most of the time, as the search for new sources will always attract new uses for water, in addition to the fact that it is highly sensitive to climatic variations. Sustainable alternatives are based on reducing the demand for potable water (use of rainwater and reuse of wastewater), reduction of wastewater generation, and rainwater treatment (Sedrez *et al.* 2021). A holistic approach is needed instead of the traditional approach to obtain genuine water security in the cities.

CONCLUSION

Water security is one of the great challenges of the 21st century. As urban populations grow and cities urbanize, individuals face an uncertain water supply future due to climate change and increased demand. The imbalance between supply and demand highlights the vulnerability of cities in semi-arid regions. This paper investigated how demand, availability, and weather conditions affect water supply security, based on a local analysis, in a small city in the semi-arid region of Brazil.

Approaches for verifying the level of demand from the reservoirs and the impacts of the drought did not influence the water supply. There were no water rationing actions during the analyzed period (2014–2019). On the other hand, the city showed signs of water unsustainability through the WI_{sust} approach, although it does not currently affect the amount of water that supplies it.

It is concluded that there is water security. However, it is a traditional approach that balances supply and demand without measuring environmental damage and managing resources sustainably. Water security, in this way, becomes fragile and does not have prospects of water availability in the future in the face of social, environmental, and economic pressures.

The results presented in this work can contribute to water security assessments at the urban level, as well as promoting the discussion of water sustainability, warning about the responsibility of individuals in properly managing the flows that represent the urban metabolism of water.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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