WATER RESOURCES AVAILABILITY AND DEMAND IN BRAZIL

Disponibilidade e demanda de recursos hídricos no Brasil

DOI: 10.48075/igepec.v26i1.27755

Antonio Pasqualetto
Alan Gabriel Natã Pasqualetto
Thales Luan Lucas Pasqualetto
Thiago Augusto Mendes

WATER RESOURCES AVAILABILITY AND DEMAND IN BRAZIL

Disponibilidade e demanda de recursos hídricos no Brasil

Antonio Pasqualetto
Alan Gabriel Natã Pasqualetto
Thales Luan Lucas Pasqualetto
Thiago Augusto Mendes
DOI:10.48075/igepec.v26i1.27755

Resumo: Objetiva-se neste trabalho analisar a disponibilidade e usos da água no Brasil, garantindo equilíbrio entre oferta e demanda às atividades necessárias. Uma ampla revisão sobre o assunto foi realizada e dados de disponibilidade e demanda por água foram coletados. O cenário de disponibilidade de água por demanda no Brasil, entre 1931 e 2030, foi traçado, realizando um diagnóstico das principais demandas por atividades e necessidades. Doze municípios foram selecionados e seus dados foram analisados e comparados por atividade e região. Os resultados demonstraram que a oferta e demanda por água no Brasil varia significativamente por regiões e atividades desenvolvidas. Vários projetos e leis, como novas ferramentas de gestão, têm se desenvolvido para melhorar o gerenciamento de recursos hídricos. Porém, problemas como a negligência política e a falta de sensibilidade de algumas partes da população são desafios para melhorar a eficiência no uso da água.

Palavras-chaves: Demanda. Disponibilidade. Recursos Hídricos.

Abstract*: The aim of this work is to analyze the availability and uses of water in Brazil, ensuring a balance between supply and demand for the necessary activities. A comprehensive review of the subject was carried out and water availability and demand data were collected. The scenario of water availability on demand in Brazil, between 1931 and 2030, was outlined, carrying out a diagnosis of the main demands for activities and needs. Twelve municipalities were selected, and their data were analyzed and compared by activity and region. The results showed that the supply and demand for water in Brazil varies significantly by regions and developed activities. Several projects, such as new management tools, have been developed to improve the management of water resources. However, problems such as political negligence and the lack of sensitivity of some parts of the population are challenges to improve the efficiency of water use.*

Keywords *Demand. Availability. Water Resources.*

Resumen: *El objetivo de este trabajo es analizar la disponibilidad y usos del agua en Brasil, asegurando un equilibrio entre la oferta y la demanda de las actividades necesarias. Se llevó a cabo una revisión exhaustiva del tema y se recopilaron datos sobre la disponibilidad y la demanda de agua. Se delineó el escenario de disponibilidad de agua bajo demanda en Brasil, entre 1931 y 2030, realizando un diagnóstico de las principales demandas de actividades y necesidades. Se seleccionaron doce municipios y sus datos fueron analizados y comparados por actividad y región. Los resultados mostraron que la oferta y demanda de agua en Brasil varía significativamente según las regiones y las actividades desarrolladas. Se han desarrollado varios proyectos y leyes, como nuevas herramientas de gestión, para mejorar la gestión de los recursos hídricos. Sin embargo, problemas como la negligencia política y la falta de sensibilidad de algunas partes de la población son desafíos para mejorar la eficiencia del uso del agua.*

Palabras claves: *Demanda. Disponibilidad. Recursos Hídricos.*

.

Informe GEPEC, ISSN:1679-415X, Toledo, v. 26, n.1, p. 46-61, jan./jun. 2022.

1 INTRODUCTION

The quantity and quality of water in Brazil has instigated better management action in the country. The water resources considered abundant justify the lack of commitment of the government and the population to anthropic interventions and climate change. Nevertheless, water has become scarce and the use of water in a consistent manner is expected to increase.

Despite campaigns that seek to make people more aware of their necessary responsibility with water consumption, only a minority is aware of how much they spend. Often, water is more available where there is less concentration of population and less demand for activities. There is the case of the Amazon basin region that has very low population density and high-water supply. In contrast, the Southeast and Northeast regions, with higher population concentration, do not present the same water availability and suffer pressure for consumption.

The current situation problems are unsustainable water use, increased demand for water resources and reduced supply. These issues have generated conflict, quality degradation, floods, droughts, and vulnerability of human populations. Thus, if nothing is done about it, aiming at improving planning and management, the water daily used by millions of people in the country, with several application destinations, will become scarcer.

Planning and responsible management of water resources are directly related to the central issue of democracy and sustainability. It is essential to manage this vital resource to humans and nature, recovering the debate about the participation of society in the discussion on the water use and on the partnership between State and companies to change the paradigm.

Therefore, the society is responsible for discussing this consumption model again and placing citizens as agents to plan and manage water resources. In this way, they are engaged in this challenge to recover the capacity to deal with this problem, individual and collectively, pointing out durable and responsible solutions of management. Additionally, it is necessary to understand the availability and demand of resources as well as to establish the best policies to preserve the quality and quantity of water.

The knowledge of the flows granted and the spatial distribution of the uses of water in the basin becomes indispensable for the proper management of water resources. (DA SILVA *et al.*, 2015)

Therefore, the objective was to analyze the availability and demand of water resources in Brazil to make a diagnosis and strengthen water planning and management.

2 - LITERATURE REVIEW

Besides the natural forces affecting water resources, there are the new human and economic activities that have become the primary 'drivers' of the pressures affecting our planet's water systems. Requirements for water to meet our fundamental needs and the collective pursuit of higher living standards, coupled with the need for sustaining our planet's fragile ecosystems, make water unique among natural resources (WORLD WATER ASSESSMENT PROGRAMME – WWAP, 2009).

Water use has grown by more than the double of population growth in the last century (WORLD WATER ASSESSMENT PROGRAMME – WWAP, 2009). According to De Fraiture *et al.* (2007), it is expected to increase the demand for water in agriculture by at least 20% by 2050. Water sustainability implies precisely maintaining a dynamic balance between supply and demand for water. For that, command and control mechanisms are needed, observing the polluter pays and preserving receiving principles.

Pasqualetto *et al.* (2019) address the historical process of planning and management of water resources, which is associated with the territorial occupation of Brazil since the Empire. Carter *et al.* (2004) and Pedrão (2020) suggest that land use planning and water management activities can be assessed through the development of a normative model.

However, an important landmark is the Federal Constitution of 1934, which states in its Article 5, item XIX, line "j" that it is privately incumbent upon the Union to legislate on waters (BRASIL, 1934). In the same year, the Brazilian National Congress, through Decree 24.643, promulgated the Water Code. Costa e Silva *et al.* (2017) stated that the focus of this Code was to attribute competence to the Ministry of Agriculture for managing water resources, given the agrarian propensity of the country.

Following years were highlighted for new promulgations in favour of water resources management. The 1946 Constitution defined the waters as a property of the states and of the Union (RESENDE *et al.*, 2019). In the Brazilian Federal Constitution of 1988, it introduced Chapter VI on the environment was introduced, considering Federal Law 6938 of 1981, which establishes national environmental policy.

In 1997, Law 9433, the "Water Act" was enacted, which was a major advance in the water resources regulation. According to the premises of the National Water Resources policy, five essential instruments for good management are considered: granting of the right to use water resources, collection of water use, framing of water bodies in classes of use, National Information System on Water Resources, and National Water Resources Plan (BRASIL, 1997).

Resolution n. 32/2003 of the National Council of Water Resources established the National Hydrographic Division in 12 Hydrographic Regions. This division started from the premise of considering as hydrographic region the Brazilian territorial space comprised by a basin, group of basins or contiguous sub-basins with natural, social and economic homogenous or similar characteristics, in order to guide the planning and management of water resources (AGÊNCIA NACIONAL DE ÁGUA – ANA, 2014).

In Brazil, territorial extensions are an advantage in water availability, but discrepancies in the disposition of water resources and the population are aggravating water conflicts. The average annual rainfall in Brazil is 1797 mm, ranging from less than 800 mm in the semi-arid region of the Northeast to more than 2500 mm in the Amazon (ANA, 2005).

According to Branco (2006), Brazil distinguishes in the world scenario by the vast discharge of fresh water from its rivers, whose water production on the Brazilian

side (177900 $m^3 s^{-1}$) and that of the International Amazon (73100 $m^3 s^{-1}$), constitutes 53% of the freshwater production of the South American continent and 12% of the world total.

The emergence of human and irrigation demands, and degradation of water quality reaches the water availability in Brazil. These reasons imply eminently the future supply. Therefore, the need to establish control over these uses is urgent.

According to ANA (2018), the reduced refills of existing reservoirs are due to total rainfall volumes in the wet periods from 2012 to 2017 which were far below average. The demand for water uses in Brazil is growing, with an estimated increase of approximately 80% in the total water use over the last two decades. By 2030, the withdrawal is expected to increase by 24% (ANA, 2018).

3 – MATERIAL AND METHODS

This study aims to better understand the water resources in Brazil, their availability and demand. The research methodology adopted enabled the data searching for data for macro analysis of use and consumption of water in Brazil as well as water withdrawal.

The analysis of the data is based on the set of information on water flows in $m^3 s^{-1}$ in each hydrographic region of Brazil, which can be found in articles and online materials of the National Water Agency (ANA), National Water Resources Information System (SNIRH) and Mineral Resources Research Company (CPRM).

The following variables were analyzed:

a) Water availability (natural flow, drought): We used natural flow and drought data to analyze the water availability of the main hydrographic regions in Brazil. The flows determination (mean and drought) in the hydrographic regions was based on the Conjuncture of Water Resources in Brazil, Brazilian hydrographic regions (ANA, 2005), and Conjuncture of Water Resources 2018 (ANA, 2018).

b) Water demand (withdrawal, return and consumption): Water consumption was evaluated according to the following steps:

1) At first, a scenario was drawn with the data available for demand in Brazil in the period from 1931 to 2030, which served to establish a diagnosis of the predominant uses and the moment when the demand curve starts to rise in a more evident way. To assess the demand for water resources, focusing on updated data, we sought demographic census and population distribution by geographical regions conducted by IBGE of the dates: 1960, 2001, 2005, 2010, 2015 and 2019.

2) In a second moment, due to the observation of greater demand from the 1960s onwards, especially for irrigation and urban supply, an analysis of geographic participation. The period from 1960 to 2000 was set to analyze the water consumption in main activities - irrigation, urban supply, animal use, industry - based on geographic participation.

3) Finally, in a third moment, 12 municipalities of Brazil 2020 were selected, distributed by Brazilian regions with distinct characteristics and predominant type of use of the highest flows consumed ($m^3 s^{-1}$) for comparison and analysis.

The data were presented in tables and figures, either by river basin in the case of water availability, or by geographical region for water demand, as well as 12 municipalities were selected by type of predominant water use, to better illustrate consumption in 2020.

4 – RESULTS AND DISCUSSION

4.1 – AVAILABILITY OF WATER RESOURCES

The population concentration is found in the coast and coastal regions, far from basins with high water flows (Figure 1).

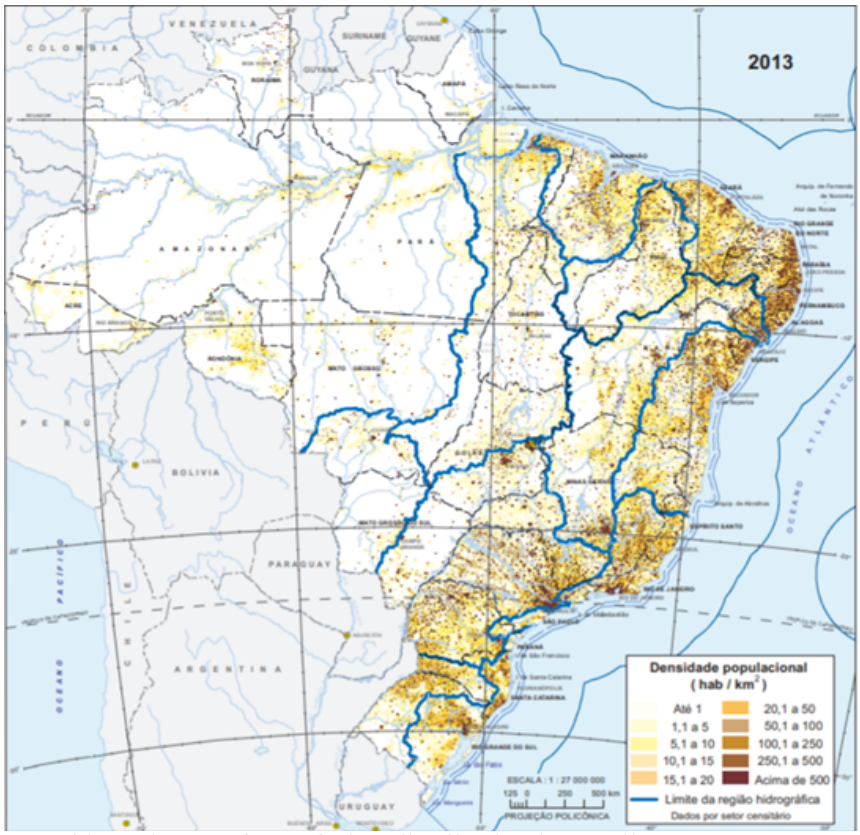

Figure 1 - Hydrographic regions and population distribution in Brazil, 2013
Source: IBGE (2013).

The waters in the Brazilian territory run through 12 hydrographic regions, defined by the National Council of Water Resources of Brazil (CNRH) in Resolution n. 32, 2003: Amazon, Tocantins-Araguaia, Northeast Atlantic West, Parnaíba, Northeast Atlantic East, San Francisco, East Atlantic, Southeast Atlantic, South Atlantic, Uruguay, Parana, Paraguay (Figure 2).

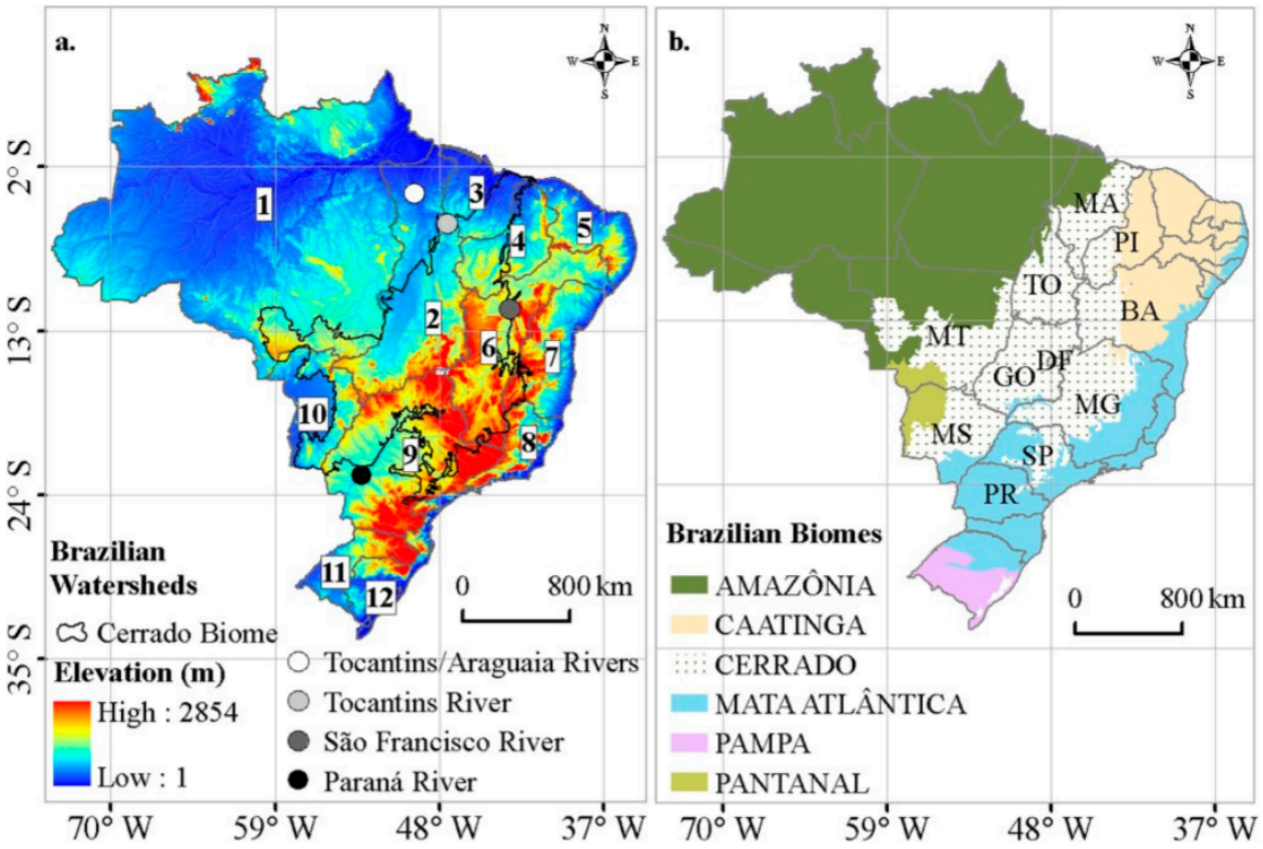

Figure 2 - Hydrographic regions of Brazil: a) Brazilian watersheds; (b) Brazilian biomes
Source: Oliveira *et al.* (2014).

It should be noted that Brazil's surface availability is 91071 $m^3 s^{-1}$ and only the Amazonian hydrographic region has water availability of 73748 $m^3 s^{-1}$, about 80% of the country's total (ANA, 2018). However, the Amazon region has a very low population density compared to the other regions, and there is much water availability for too little demand.

The annual water resources reports, such as that of ANA (2005), allow access to complete information. With the advance of technology and adoption of online systems with periodic updates, it is possible to find real-time data from measurements. However, it is difficult to find complete information in status reports.

Due to technological advances of the last decades, the hydro-meteorological monitoring has been modernized, going from the records on paper field pluviometer and ruler data by observers to the use of several automatic sensors connected to a data collection platform (PCD), with the storage of data in loco by recorders and transmission by mobile phone or satellite (ANA, 2019).Accessing the water balance of the National Water Resources Agency (ANA, 2020a), we have the entry and exit values by State. However, the system offers limitations, since it does not provide all the data. Even so, it is considered relevant to give a focus by State and by geographic region to allow confronting population data and water demands, generally presented by geographic region, UF or municipality. The data must be carefully observed, however, as the ANA water balance system in Brazil is updated every 5 minutes. Determinants such as incident precipitation, evaporation and uses can alter the water inlet and outlet flows.

The fact that the data is not available may mean that there is no water inlet and outlet flows, as well as being an indicator that the system cannot measure all the water flows of the states.

Thus, the state of Amazonas is a contributor to the outgoing flow, because it is 81.74 higher than the incoming flow. On the other hand, the state of Pará reduces by 41 times the outgoing flow in relation to the incoming one. In the Northeast, states of Sergipe and Maranhão outgoing flows stand out, respectively 1310 $m^3 s^{-1}$ and 10600 $m^3 s^{-1}$.

The flows of the main hydrographic regions and the growth of the Brazilian population allow for a future perspective on the lack of water in the main federal capitals. The Amazon, Paraná and Tocantins/Araguaia the basins are satisfactorily supplied with water when compared to others. On the other hand, regions such as Paranaíba and the Eastern Northeast Atlantic have low average flows, which implies in worrying about water scarcity.

Taking it into consideration, the average flow per inhabitant in the year tends to decrease. As the Atlantic Northeast Atlantic hydrographic region has greater human densification, it is already under water stress heading for water scarcity in periods of drought, based on the Unesco reference (2003): < 500 $m^3 hab^{-1} year^{-1}$ - Scarcity situation; 500 to 1700 $m^3 hab^{-1} year^{-1}$ - Stress situation; > 1700 $m^3 hab^{-1} year^{-1}$ - Comfortable situation.

Aggravated by long periods of drought and climate changes that prevent the natural cycle of rainfall, the flow decrease can not only cause water shortages, but also cause permanent damage to nearby watersheds.

4.2 – DEMAND FOR WATER RESOURCES

Figure 3 shows the predominant consumptive uses in Brazil where the arrow indicates when demand starts to intensify, especially in irrigation. There is a notably increase that raises the water withdrawal and consumption curves in Brazil from 1960 on. While in 1960, water consumption for irrigation represented 33.2% withdrawal and 34.1% consumption of the total, in 2020 the values rose to 50.1% and 66.3%, respectively. The increase in demand in all activities is clear, however in the case of irrigation practically doubled consumption in 60 years. Souza *et al.* (1994) point out: "the poverty of census data does not allow a better characterization of irrigated agriculture in the region. There has been questioning even about the size of the irrigated area".

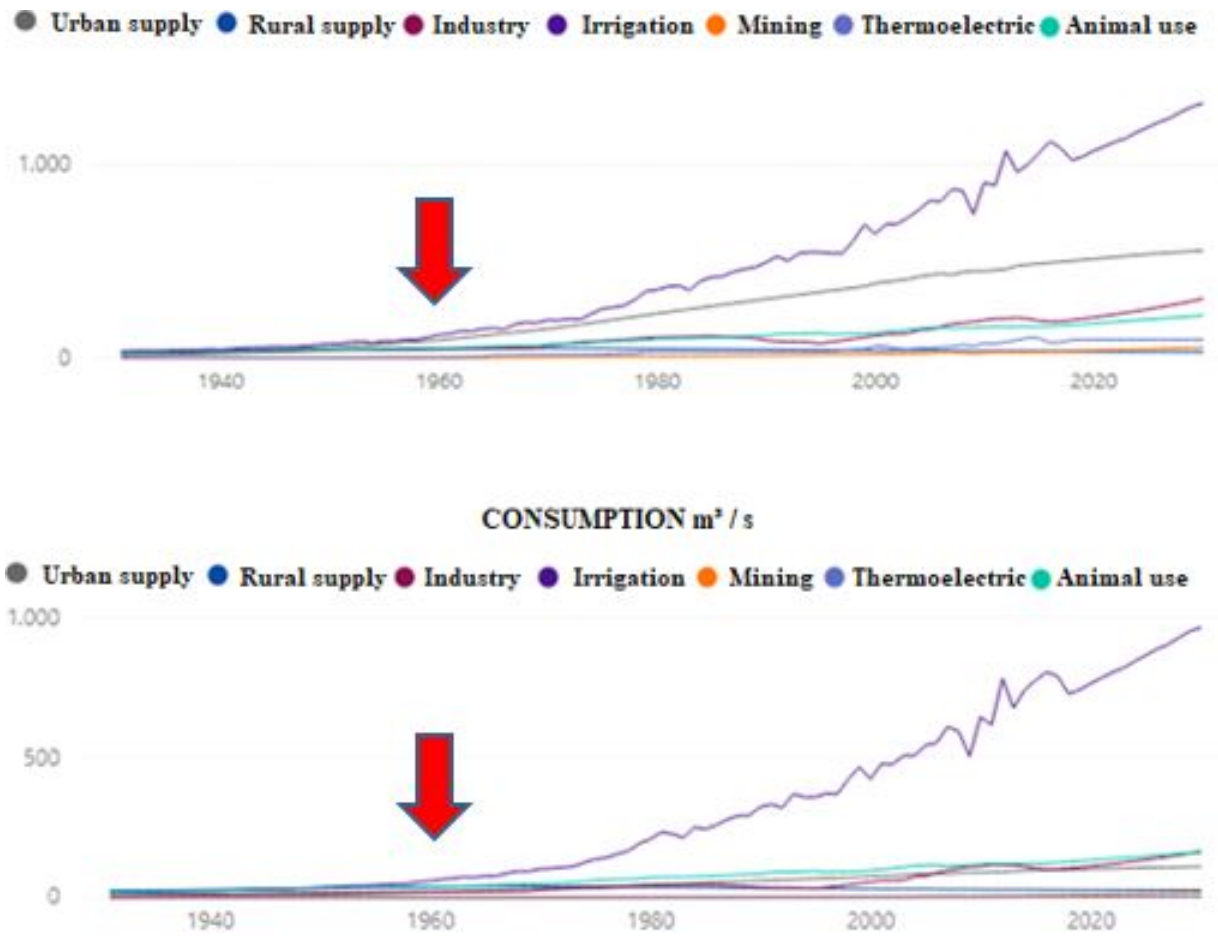

Figure 3 - Consumptive uses of water in Brazil (1931-2030)
Source: ANA (2020b).

Among the factors that may have contributed to the high consumption of water resources in irrigation, some can be mentioned: the expansion of the agricultural area and export of products, the use of modern technologies, added to the food needs by the increase in population in Brazil and the world.

Concerning the irrigation, an increase of 1289.9% between 1960 and 2020 can be seen, as shown in Figure 3. The agricultural expansion in the Brazilian Cerrado guaranteed a 10% participation in water consumption for the central western region, which practically did not exist. In a second analysis, the South region offered some possibilities to the Southeast and Northeast, especially to produce vegetables and fruits for local supply and export.

Teixeira *et al.* (2012) report the irrigation in grapevines in the region, highlighting the table grapes in areas west of the states of Bahia, Pernambuco, Paraíba and almost all areas of the states of Rio Grande do Norte, Ceará, Piauí and Maranhão. Considering the vines for wine, the authors also highlight the states of Bahia, Pernambuco, Paraíba, Alagoas, and Sergipe, and the southwest part of the state of Maranhão.According to Buainain and Garcia (2015), the National Department of Works Against Drought (DNOCS) and Development Company of the São Francisco and Parnaíba Valleys (CODESVAF) are the main responsible for irrigation projects in the Northeast region. In terms of urban supply, the Central West and North of the country gains presence due to the migratory flow (Table 1). Population growth in the North between 1960 and 2020 was over 800%.

Table 1 - Resident population sent to the Brazilian Court of Auditors, Large Regions and Units of the Federation - 1960-2020. Source: adapted from Directorate of Research, Population Coordination and Social Indicators, IBGE (1960; 2020)

Regions	**1960**	**2001**	**2005**	**2010**	**2015**	**2020**
North	2,321,461	13,245,084	14,698,878	15,880,839	17,472,636	18,672,591
Northeast	15,731, 916	48,331,186	51,019,091	53,078,137	56,560,081	57,374,243
Southeast	23,107, 600[1]	73,470,763	78,472,017	80,353,724	85,745,520	89,012,240
South	22,693, 558[2]	25,453,264	26,973,511	27,384,815	29,230,180	30,192,315
Center-West	2,447, 736	11,885,529	13,020,767	14,050,340	15,442,232	16,504,303
Brazil	66,302, 271	172,385,826	184,184,264	190,747,855	204,450,649	211,755,692

[1] The region called Southeast today was the East region in 1960, which São Paulo did not belong to.
[2] The Southern region in 1960 included the State of São Paulo.

An important detail, which cannot go unnoticed, is the migratory flow that occurred to the Center-West region of Brazil, becoming a granary to produce grains and meats. Between 1960 and 2020, the population increase in the region was 675%, demanding greater water consumption. Figure 4 exposes the consumptive uses of water in Brazilian geographic regions by main activities.

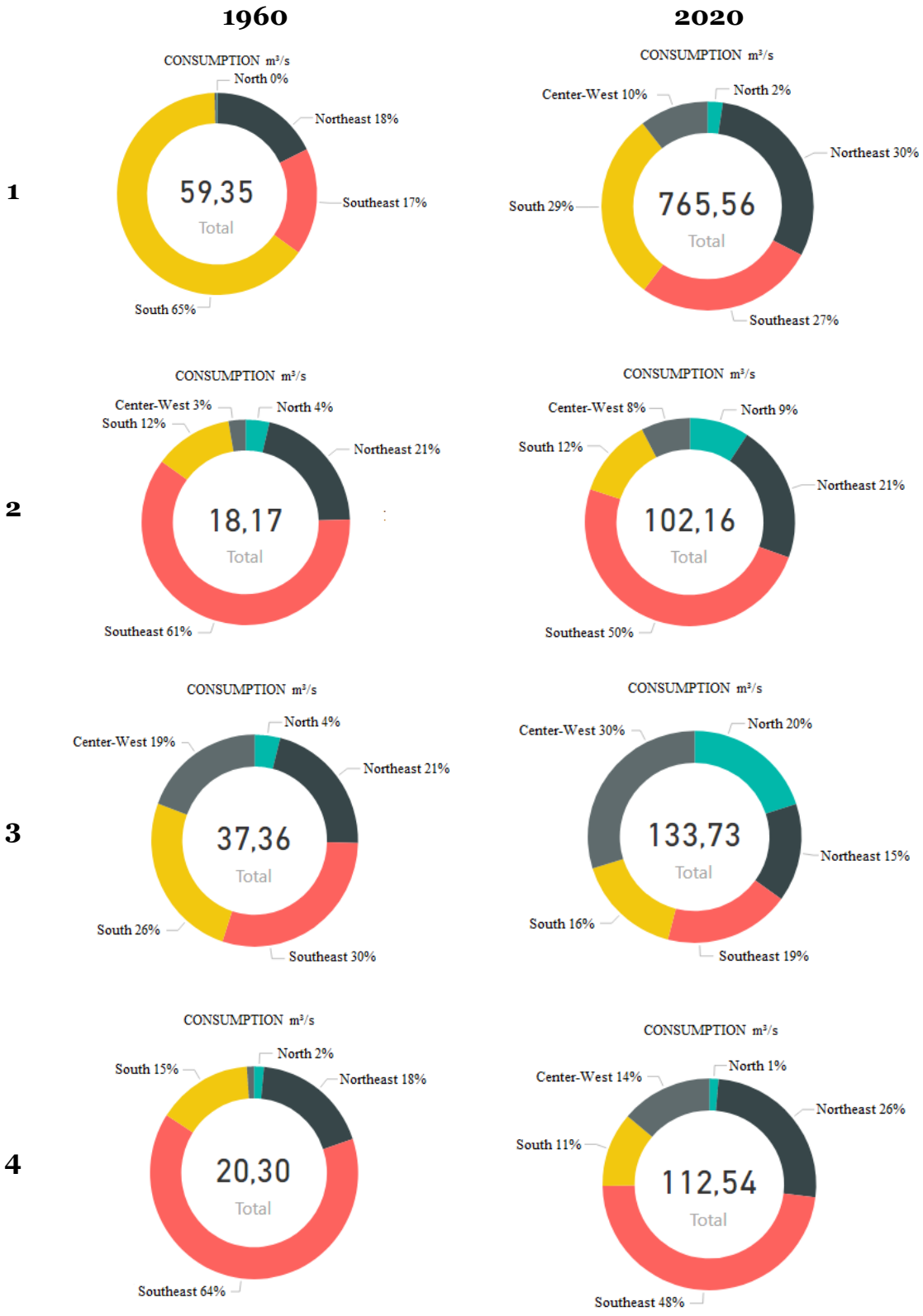

Figure 4 - Participation by geographic region in water consumption by main activities in the period between 1960 and 2020: 1) irrigation; 2) urban supply; 3) animal use; 4) industry. Source: ANA (2020b)

The low representative value of the Centre West and North can be noted, which can be explained by the lower number of inhabitants and higher water availability. Water consumption for animal use grew from 4% in 1960 to 20% in 2020 in the North, and Center West from 19% to 30%, changing the representation of the South, Southeast and Northeast.

Ferreira and Salati (2005) state that livestock farming is one of the first activities in the process of area occupation. It happens due to the internal demands of the country, especially in the center-south region, as well as the international market. They also report that in the initial 470 years of Brazilian Amazon colonization, only 1% of the area was deforested. However, in the last 35 years (1970-2005) deforestation has already reached 17% of the region and the population has increased from two million to over 20 million inhabitants.

Regarding to industry, the participation of the Midwest and Northeast in water consumption shows that these regions are attracting a productive sector that predominated in the Southeast and South of the country, either by following the advance of the agricultural frontier and the emergence of new ones, or by tax incentives and availability of labor.

According to Abdal (2017), between 1970 and 1985, some investments in the Second National Development Plan (II PND) were made to mitigate the growing regional inequalities. Among these initiatives, some specific policies of production decentralization can be mentioned. For this author, policies to promote extra-RMSP industry had been placed since the late 1960s, highlighting the superintendencies for the development of the Northeast and Amazon (SUDENE and SUDAM) and the Manaus Free Zone (ZFM). Brasilia and the colonization programs of the Amazon and Midwest are examples of industrial focus abscence.

Table 2 - Predominant type of the highest flows use, consumed in 12 Brazilian municipalities in 2020. Source: adapted ANA (2020b).

UF	Municipality	Total Outflow Withdrawal (m^3/s)	Total Flow Consumption (m^3/s)	Consumption Flow Urban supply (%)	Consumption Flow Irrigation (%)	Consumption Flow Animal use (%)	Consumption Flow Industry (%)	Consumption Flow Thermoelectric (%)	Consumption Flow Rural supply (%)	Consumption Flow Mining (%)
SP	São Paulo	48,16	9,33	87,08	0,11	-	12,26	0,26	0,14	0,13
RJ	Rio de Janeiro	42,39	6,56	75,55	1,83	0,09	20,51	1,94	-	0,08
DF	Brasília	10,95	3,64	46,93	43,29	3,39	3,96	-	2,12	0,31
PE	Recife	6,46	1,36	88,16	-	0,07	11,62	-	-	0,14
BA	Salvador	8,82	1,76	93,20	-	-	6,31	0,12	0,06	0,31
MT	Sorriso	3,10	2,03	2,56	89,73	6,16	1,01	-	0,52	-
MA	Balsas	0,92	0,67	6,59	85,61	6,01	0,41	-	1,34	0,04
PE	Petrolina	14,35	12,65	1,09	97,60	0,47	0,17	-	0,67	-
MS	Dourados	1,90	1,04	12,81	40,85	8,51	36,78	-	1,04	0,01
RO	Ji-Paraná	0,99	0,45	22,79	18,89	50,67	5,69	-	1,91	0,05
PR	Cascavel	1,11	0,30	44,34	3,15	31,78	16,72	-	4,00	-
RS	Uruguaiana	25,68	12,90	0,60	97,65	1,66	0,01	-	0,08	-

Zehnder *et al.* (2003) present the four main defined categories of water use: water for people and industry, water for food and rural development, water for nature, and water for energy production.

São Paulo, Rio de Janeiro, Recife, Salvador, and Brasília are metropolises where the predominant water use water is for public supply. Industrial consumption stands out in these areas, except in Brasilia, where irrigation demands almost the same amount of water as urban supply. Cities with agricultural activities such as Petrolina, Uruguaiana, Balsas, and Sorriso, demand a lot of water for irrigation, with percentages above 80%. In turn, Dourados shows an increase in industrial demand for water, almost equivalent to that used for irrigation, approximately 40%. Ji-Paraná stands out

for having half of its water consumption destined for animal use, characteristic of the predominance of livestock. In contrast, Cascavel consumes 44.34% of the water for urban supply and 38.93% for animal use, rural and irrigation, and industrial demand.

Brazilian legislation does not allow municipalities to legislate on water resources, so they cannot issue grant. On the other hand, they are allowed to license activities that use water, as well as inspect its use. There are also programs for the protection of springs and environmental education to ensure the rational use of water and the availability in quantity and quality for future generations.

At macro level, the National Water Agency (ANA) made 20 proposals to improve the constitutional, legal and infralegal framework of water management in Brazil. (ANA, 2017).

CONCLUSION

In Brazil, even with great water availability, there are situations of public supply lack, regional disparities, and territorial dimensions are factors that alter water resource flows.

Among the main uses of water, there are variations caused by geographic region, municipality according to the population contingent, as well as the predominant activities such as agriculture, livestock, industry and services.

The greatest water availability is the Amazon, also the least inhabited region. In turn, the Southeast has higher water demand for public supply (in São Paulo, for example) and industry. The Northeast releases water consumption for irrigation in 2020, especially Petrolina.

It is notorious that because it is a country of continental territorial extension, challenges with water planning and management become more important, especially with the especially with society participation.

Projects that mitigate high consumption should also be mentioned: normal flow restoration of the main basins, creation of theoretical and practical instruments for water management in industries, use of technologies that allow better use and reuse of water in irrigation.

Federal law 9433, the "Water Act", if well implemented, brings the instruments for integrated management of water resources. The national water resources management system aggregates the bodies and allocates responsibility to the participants.

Therefore, it is not due to lack of legal or institutional mechanisms that the water theme will no longer be observed. It may be because political negligence or sensitivity lack and citizen responsibility may cause serious problems of water conflicts.

REFERENCES

ABDAL, A. Desenvolvimento regional no Brasil contemporâneo: para uma qualificação do debate sobre a desconcentração industrial. *Novos estudos*. CEBRAP, vol. 36, n.2, p.107-126, 2017.

AGÊNCIA NACIONAL DE ÁGUA - ANA. *O equilíbrio hídrico do Brasil*. Available online: http://balancohidrico.ana.gov.br/Mapa.aspx (accessed on 22 May 2020). 2020a.

AGÊNCIA NACIONAL DE ÁGUA - ANA. *Projeto Legado*. 20 propostas de melhoria dos marcos constitucionais, legais e infralegais da gestão da água no Brasil-

Preparação para o 8º Fórum Mundial da Água 2017. Available online: https://www.ana.gov.br/programas-e-projetos/projeto-legado-1 (accessed on 22 May 2020).

AGÊNCIA NACIONAL DE ÁGUA - ANA. *Usos consumíveis de água no Brasil (1931-2030)*.
Available online:https://app.powerbi.com/view?r=eyJrIjoiNmFhMjA4NmQtY2Y4Yy00OWE4LTkyNzEtOTk2MTY4MTQzMTliIiwidCI6ImUwYmI0MDEyLTgxMGItNDY5YS04YjRkLTY2N2ZjZDFiYWY4OCJ9. (accessed on 4 May 2020). 2020b.

AGÊNCIA NACIONAL DE ÁGUA-ANA. *Conjuntura de recursos hídricos no Brasil*. Brasília: ANA. 2018.

AGÊNCIA NACIONAL DE ÁGUA-ANA. *Conjuntura de recursos hídricos no Brasil*. Brasília: ANA. 2019.

AGÊNCIA NACIONAL DE ÁGUA-ANA. *Disponibilidade e demandas por recursos hídricos no Brasil*. Brasília: ANA. 2005. Available online: http://arquivos.ana.gov.br/planejamento/planos/pnrh/VF%20DisponibilidadeDemanda.pdf. (accessed on 20 October 2019).

BRANCO, O. E. de A. *Avaliação da disponibilidade hídrica*: Conceitos e aplicabilidade. 2006.
Available online:<http://www.ufjf.br/engsanitariaeambiental/files/2012/04/DisponibilidadeH%C3%ADdrica.pdf> (accessed on 3 October 2019).

BRASIL. 1997. *Lei nº 9.433, de 01/08/1997*. Institui a Política Nacional de Recursos Hídricos, cria o Sistema Nacional de Gestão de Recursos Hídricos, regulamenta o inciso XIX do art. 21 da Constituição Federal e altera o art. 1 da Lei nº 8.001, de 13/03/1990, que modificou a Lei nº 7.990, de 28/12/1989. Available online: http://www2.camara.leg.br/legin/fed/lei/1997/lei94338janeiro1997374778publicacaooriginal-1-pl.html (accessed on 29 November 2019).

BRASIL. Conselho Nacional de Recursos Hídricos. *Resolução 32, 15/10/2003*. Estabelece a divisão hidrográfica do Brasil. Available online: http://www.cnrh.gov.br/divisao-hidrografica-nacional/74-resolucao-n-32-de-15deoutubro-de-2003/file (accessed on 16 September 2019).

BRASIL. *Constituição da República Federativa do Brasil*, 1946. Brasília, DF: Senado Federal.

BRASIL. *Constituição de 1934*. Presidência da República: Casa Civil. Available online: http://www.planalto.gov.br/ccivil_03/Constituicao/Constitui%C3%A7ao34.htm (accessed on 3 June 2019).

BRASIL. *Constituição de 1988*. Presidência da República: Casa Civil. Available online: http://www.planalto.gov.br/ccivil_03/constituicao/constituicao.htm (accessed on 20 October 2019).

BRASIL. *Decreto nº 24.643*, de 10 de julho de 1934. Código de Água. Available online: < http://www.planalto.gov.br/ccivil_03/decreto/d24643.htm> (accessed on 24 May 2019).

BUAINAIN A.M.; GARCIA Jr. R. Polo de Irrigação no Nordeste do Brasil, *Confins*, n 23, 2015. DOI: 10.4000/confins.10031.

CARTER, N.; KREUTZWISER, D. R.; LOË, R. C. Closing the circle: linking land use planning and water management at the local level. *Land Use Policy*, v. 22, p. 115-127, 2004. DOI: 10.1016/j.landusepol.2004.01.004.

DA SILVA, B.; DA SILVA, D.; MOREIRA, M. Índices de gestão e planejamento de água na Bacia do Rio Paraopeba, Minas Gerais. *Revista Ambiente & Água*, vol.10, n 3, p. 685-697, 2015. DOI: 10.4136/ambi-agua.1597.

DE FRAITURE, C.; WICHELNS, D.; ROCKSTROM, J.; KEMP-BENEDICT, E.; ERIYAGAMA, NISHADI; GORDON, L. J.; HANJRA, M. A.; HOOGEVEEN, J.; HUBER-LEE, A.; KARLBERG, L. *Looking ahead to 2050: scenarios of alternative investment approaches*. In Molden, David (Ed.). Water for food, water for life: a Comprehensive Assessment of Water Management in Agriculture. London, UK: Earthscan; Colombo, Sri Lanka: International Water Management Institute (IWMI), p 91-145, 2007. Available online: https://cgspace.cgiar.org/handle/10568/36869 (accessed on 10 June 2021).

FERREIRA, A.M.M.; SALATI, E. Forças de transformação do ecossistema amazônico. *Estudos avançados*, São Paulo, vol. 19, n 54, 2005. DOI: 10.1590/S0103-40142005000200003.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA - IBGE. Anuário Estatístico do Brasil - 1960. Available online: https://biblioteca.ibge.gov.br/visualizacao/periodicos/20/aeb_1960.pdf (accessed on 10 January 2020).

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA - IBGE. *Estimativas da população residente no Brasil - 2000, 2005, 2010, 2015, 2020*. Available online: ftp://ftp.ibge.gov.br/Estimativas_de_Populacao/ (accessed on July 2021).

OLIVEIRA, P.T.; NEARING, M.; MORAN, S., GOODRICH, D; WENDLAND, E; e GUPTA H. V. 2014. *Tendências em Componentes de Equilíbrio Hídrico em todo o Cerrado Brasileiro*. Available online: https://doi.org/10.1002/2013WR015202 (accessed on 1 June 2019).

ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT - OECD. *Principles on water governance*. 2015. Available online: http://www.oecd.org/gov/regional-policy/OECD-Principles-on-Water-Governance-brochure.pdf (accessed on 15 November 2019).

PASQUALETTO, A.; LO PRESTI, D.; ROVAI, M.; MURO JR., A. Comparison of Water Resources Policies between Brazil and Italy. *Laws*, vol 8, n 4, 32; 2019. DOI: 10.3390/laws8040032.

PEDRÃO, F. C. A dinâmica do subdesenvolvimento e a tensão hídrica na Bahia. *Informe GEPEC*, 24(1), 151-161, 2020.

SOUZA, H.R.; FIGUEIREDO, A.P.; MACHADO, R.RT.; RAMOS, A.S. *Agricultura irrigada e desenvolvimento sustentável no Nordeste do Brasil*. Brasília: Secretaria de Planejamento, Orçamento e coordenação da Presidência da República, 1994. GTIV-IV.3. Projeto ARIDAS. Uma estratégia de desenvolvimento sustentável para o Nordeste.

TEIXEIRA A. H. de C.; TONIETTO J.; PEREIRA G. E.; ANGELOTTI F. Delimitação da adequação agroclimática para videiras sob irrigação no Nordeste brasileiro. *Revista Brasileira Engenharia Agrícola Ambiental*, vol.16, n.4, Campina Grande. Available online: https://doi.org/10.1590/S1415-43662012000400010 de 2012.

UNESCO. The United Nations World Water Development Report. *Water for people, water for life*, 2003. Available online: http://www.unesco.org/water/wwap (accessed on 20 May 2020).

WORLD WATER ASSESSMENT PROGRAMME - WWAP. United Nations World Water Development Report 3: Water in a Changing World. 2009 Paris/London, UNESCO. Available online: <https://unesdoc.unesco.org/ark:/48223/pf0000181993> (accessed on 17 May 2020).

ZEHNDER, A. J. B., YANG, H., & SCHERTENLEIB, R. Water issues: the need for action at different levels. *Aquatic Sciences*, vol. 65, n. 1, p. 1-20, 2003. DOI: 10.1007/s000270300000.

Submetido em 8/10/2021.
Aprovado em 20/12/2021.