Brazilian Water Resources Report 2017

FULL REPORT

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NATIONAL WATER AGENCY

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Brazilian Water Resources Report 2017

FULL REPORT

BRASÍLIA - DF
ANA
2018

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Contents

Introduction

Although Brazil is reassuringly endowed with some of the world's largest freshwater resources, they are distributed unequally in terms of territory, space and time. Intensified by water quality problems and demands from a wide variety of economic activities in Brazil's river basins, these factors trigger areas of conflict.

This **Water Resources Report** is a benchmark publication for systematic monitoring of the situation of water resources in Brazil, through a set of indicators and statistics on water and its management. Furthermore, it is also a structured source of data and information available to the public in general.

Over the years, this Report has provided input for a broad range of government actions, such as the System for Environmental-Economic Accounting – Water, monitoring the Pluri-Annual Plan drawn up by the Federal Government, and verifying compliance with Sustainable Development Goal 6 (SDG-6): Water and Sanitation indicators. It also underpins other actions undertaken by non-governmental organizations.

Although produced by ANA, this publication is the outcome of a network that encompasses more than fifty partner institutions, including all State environment and water resource management entities and other Federal Government partners. In the Brazilian context, where management is shared between Federal and State governments, based on water ownership allocations, partnerships are vital for building up knowledge of water resources, thus underpinning their comprehensive management.

Firmly committed to steadily upgrading the form and content of this Report since it was first published in 2009, ANA presents this **2017 Water Resources Report** with a completely new visual identity, reaching out to its readers at the same time as it moves into a new report cycle.

All its information falls within the public domain and is entered into the **National Water Resources Information System (SNIRH)**, available worldwide through accessing the ANA website.

Pleasant reading!
The Board of National Water Agency

Brazilian Water Resources Report 2017

Chapter 1

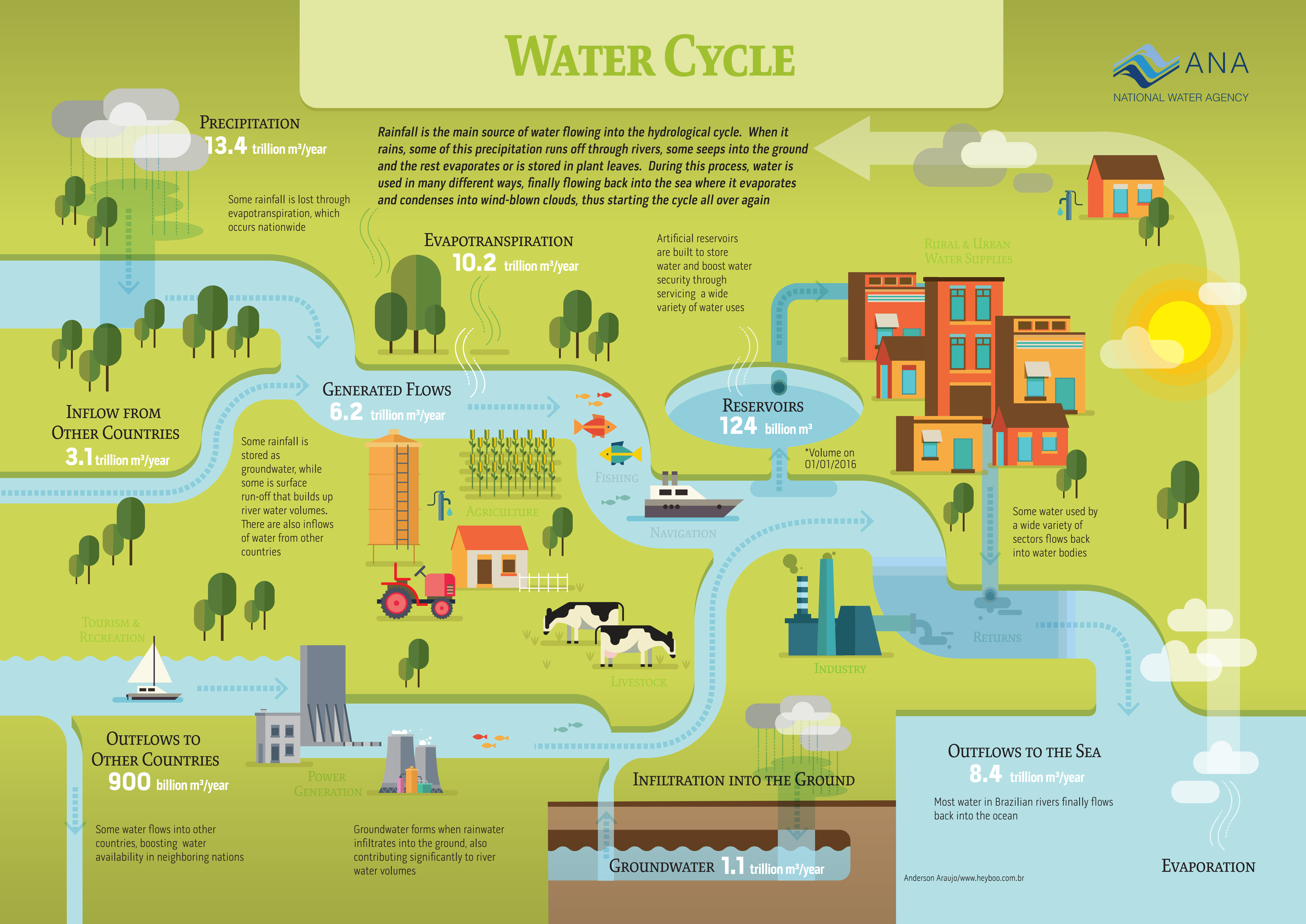
Water Cycle & Water Resources Report

Water evaporates from oceans and rivers, soil and plants, condensing into clouds. It then falls as rain, infiltrating into the ground and running off through rivers into the sea.

This cycle defines the amount of water that actually reaches you. **How?**

Click on this tab to see the infographic we have prepared for you to understand this, quite simply!

Open here


WATER CYCLE
ANA
NATIONAL WATER AGENCY
Rainfall is the main source of water flowing into the hydrological cycle. When it rains, some of this precipitation runs off through rivers, some seeps into the ground and the rest evaporates or is stored in plant leaves. During this process, water is used in many different ways, finally flowing back into the sea where it evaporates and condenses into wind-blown clouds, thus starting the cycle all over again
PRECIPITATION
13.4 trillion m³/year
Some rainfall is lost through evapotranspiration, which occurs nationwide
EVAPOTRANSPIRATION
10.2 trillion m³/year
Artificial reservoirs are built to store water and boost water security through servicing a wide variety of water uses
RURAL & URBAN WATER SUPPLIES
GENERATED FLOWS
6.2 trillion m³/year
RESERVOIRS
124 billion m³
*Volume on 01/01/2016
INFLOW FROM OTHER COUNTRIES
3.1 trillion m³/year
Some rainfall is stored as groundwater, while some is surface run-off that builds up river water volumes. There are also inflows of water from other countries
FISHING
AGRICULTURE
NAVIGATION
Some water used by a wide variety of sectors flows back into water bodies
TOURISM & RECREATION
LIVESTOCK
INDUSTRY
RETURNS
OUTFLOWS TO OTHER COUNTRIES
900 billion m³/year
Some water flows into other countries, boosting water availability in neighboring nations
POWER GENERATION
Groundwater forms when rainwater infiltrates into the ground, also contributing significantly to river water volumes
INFILTRATION INTO THE GROUND
GROUNDWATER 1.1 trillion m³/year
OUTFLOWS TO THE SEA
8.4 trillion m³/year
Most water in Brazilian rivers finally flows back into the ocean
EVAPORATION
Anderson Araujo/www.heyboo.com.br

Water Cycle and Water Resources Report

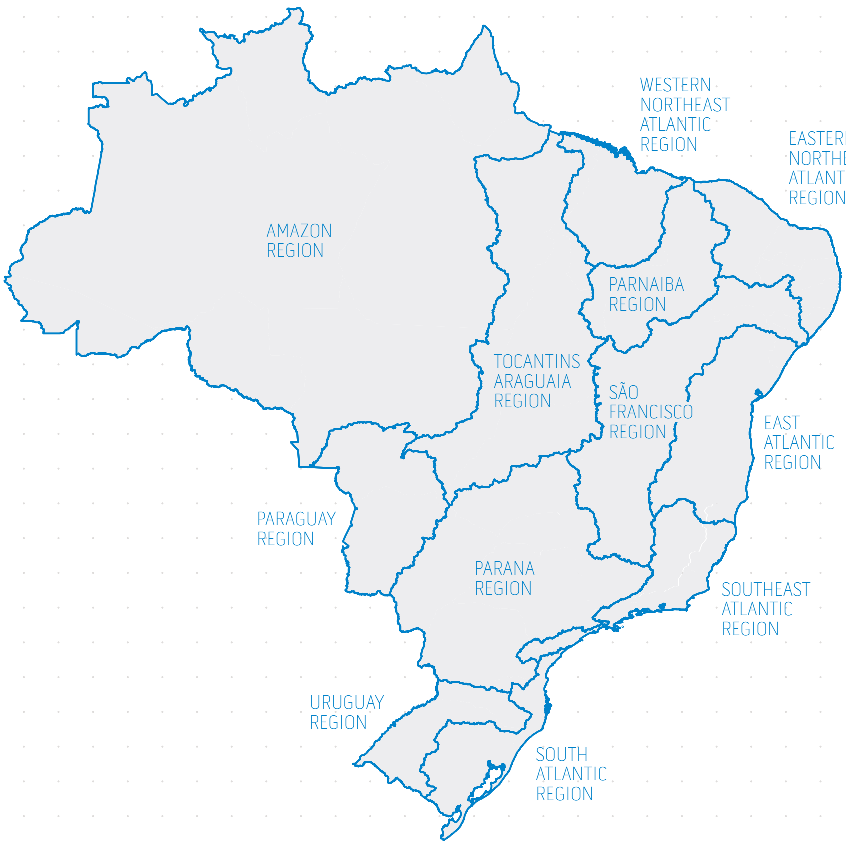
Water flows in Brazil may be analyzed in a manner similar to the hydrological cycle in a river basin, encompassing both surface and ground water. Brazil's main water inflow sources consist of rainfall and streamflows from other countries, mainly in Amazonia. All this water is used for a wide variety of economic activities, returning to the environment and leaving Brazil through flowing out into the Atlantic Ocean or neighboring countries through the River Plate basin.

In Brazil, water flows through many basins, where it has a wide assortment of uses. In order to underpin nationwide hydrographic planning, Brazil is divided into twelve regions, defined in 2003 by the **National Water Resources Council (CNRH)** through Resolution Nº 32.

The National Water Resources Council is an advisory and regulatory collegiate body that heads up the National Water Resources Management System (SINGREH).

Sub-divisions are frequently adopted for more detailed systematic monitoring of water resources and their status, together with the presentation of information and indicators in this Report, such as water planning units and micro-basins, for example.

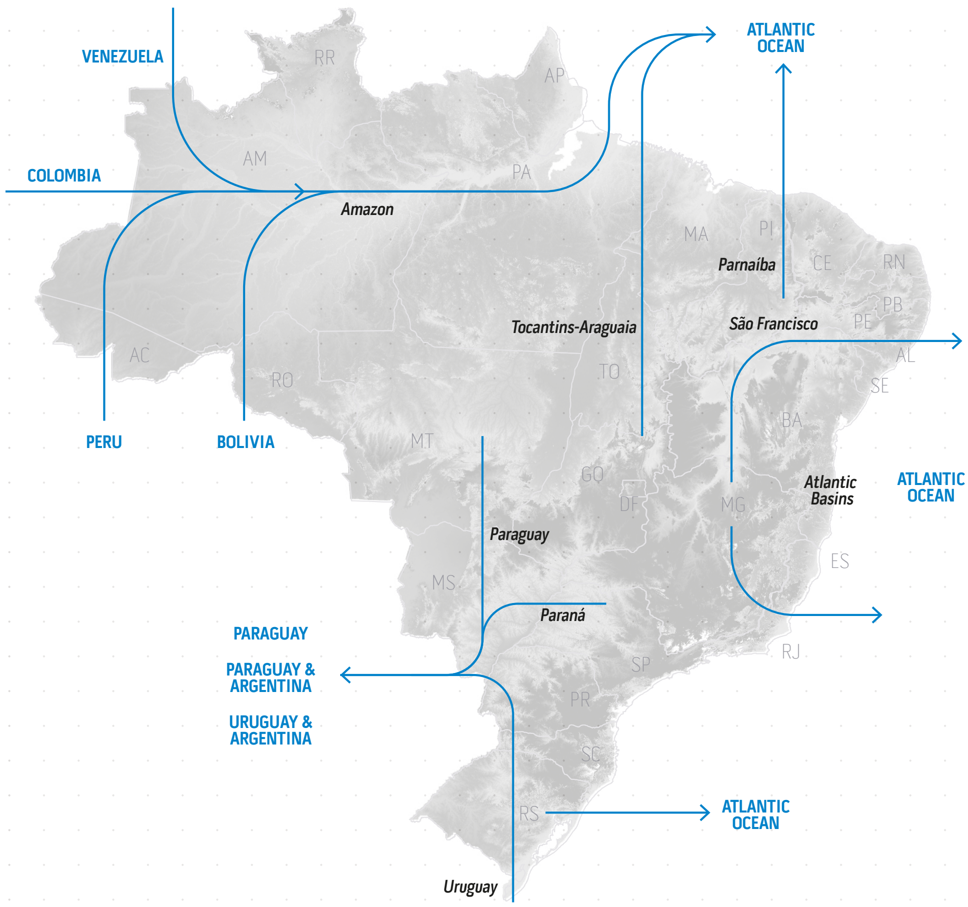
HYDROGRAPHIC REGIONS – BRAZIL



Supplementing the logic of hydrography, the political and administrative structure of Brazil has a decisive impact on its water management. Each State is endowed with distinctive characteristics in terms of surface water quality and quantity, although connected in geographical terms. Some of them play crucial roles for water delivery, as they are endowed with headwaters streams feeding major water-courses that traverse the boundaries of other States, such as Minas Gerais and Goiás. Other States – such as Rio de Janeiro and Bahia – receive and use water from other supplier States. These complex territorial dynamics are regulated by the **National Water Agency (ANA)**, which administers the conditions, characteristics and thresholds of water deliveries between States.

ANA is the entity that implements Brazil's National Water Resources Policy, as stipulated in the Act that stablished it in 2000: Law Nº 9,984.

SHARED SURFACE WATER THROUGHFLOWS IN BRAZIL



In addition to this issue, water availability is distributed unequally in Brazil's river basins and consequently its States as well. Some 80% of its surface water is found in the Amazon Hydrographic Region, with low demographic density and light water use demands.

Knowledge of water availability and flows throughout Brazil, in addition to the amount of water required by so many different uses, is a crucial step for steering river basin planning, regulation and management actions, as well as at the State level. This information may be obtained from the **Water Accounts**.

In 1992, the United Nations Conference on Environment and Development was held in Rio de Janeiro, with an Agenda presented at this event for monitoring the progress achieved by countries in moving towards sustainable development. The selected solution was to draw up comprehensive economic and environmental accounts. Since then, the international statistics community has been engaged in structuring an accounting system for extending the System of National Accounts (SNA).

This is a standardized set of organized data reflecting the economic activities of a country, based on internationally agreed methodologies. Economic data are presented in condensed form, providing input for drawing up public policies and planning. These accounts provide a full and detailed record of a broad range of economic activities, offering an overview of a nation's output, income, outlays and wealth, including transactions with the rest of the world. This System records flows between economic activities and inventories during a specific period.

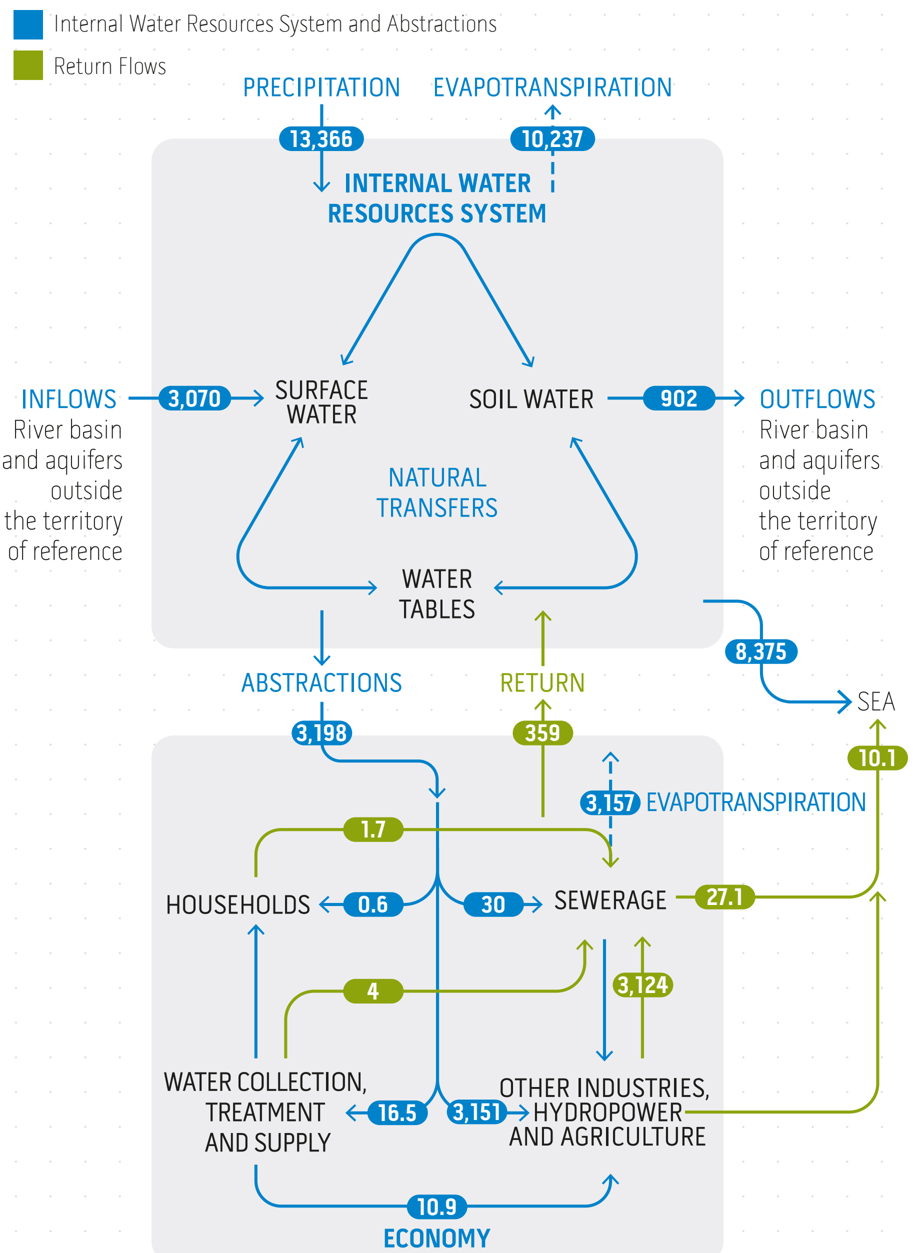
The SNA logic gave rise to the System for Environmental Economic Accounting (SEEA), developing specific accounting methodologies for water, forests and ecosystems, which are issues rated as top priorities for countries. In 2007, this allowed the United Nations Statistical Commission to adopt the System for Environmental Economic Accounting – Water (SEEA-Water) as an international statistics standard.

During the Rio+20 conference in 2012, the United Nations Statistics Division (UNSD) recommended that Brazil should start preparing its own environmental economic accounts. As a result, the Environmental Economic Accounts Committee – Water was set up through Interministerial Edict Nº 236 in May 2012, in order to draw up these accounts, observing and adapting international recommendations on good practices already in place.

WATER ACCOUNTS IN BRAZIL

System of Environmental-Economic Accounting for Water (SEEA-Water)

Amounts in billion m³/year in 2015



WATER IN YOUR LIFE
Have you ever stopped to think how much water availability influences your daily life? It is not just in that glass that you put on your desk while you work or study. It defines what you do in your daily life. **The Brazilian Water Resources Report** will show you, as indicated in the following examples:

This Report is a reference publication for regular systematic monitoring of water-related statistics and indicators in Brazil, as well as the structuring and supply of information to the public.

This Report is published annually, in a four-year cycle. A "Full Report" is published in the first year, offering a **retrospective analysis** of the situation and water resource management during the previous four years or an even longer period, when possible. This publication may also contain other topics that are important for understanding this overview. During the three subsequent years, "Annual Reports" are published, **updating information** for the period between the Full Reports. These Annual Reports are more compact, highlighting changes since the previous year and providing input for assessing the implementation stage of Brazil's National Water Resources Plan.

The National Water Resources Council (CNRH) established the preparation of the Brazilian Water Resources Report through Resolutions N° 58 (2006) and N° 180 (2016).

Responsibility for drawing up this Report is assigned to Brazil's National Water Agency (ANA), with a first edition published in 2009. This regulator is part of the system set up and introduced through Brazil's 1988 Constitution – **The National Water Resources Management System** (SINGREH).

This System encompasses several government departments and entities as well as civil society. It is regulated by Law n° 9.433 promulgated in 1997, which established Brazil's National Water Resources Policy, together with its grounds, goals and tools.

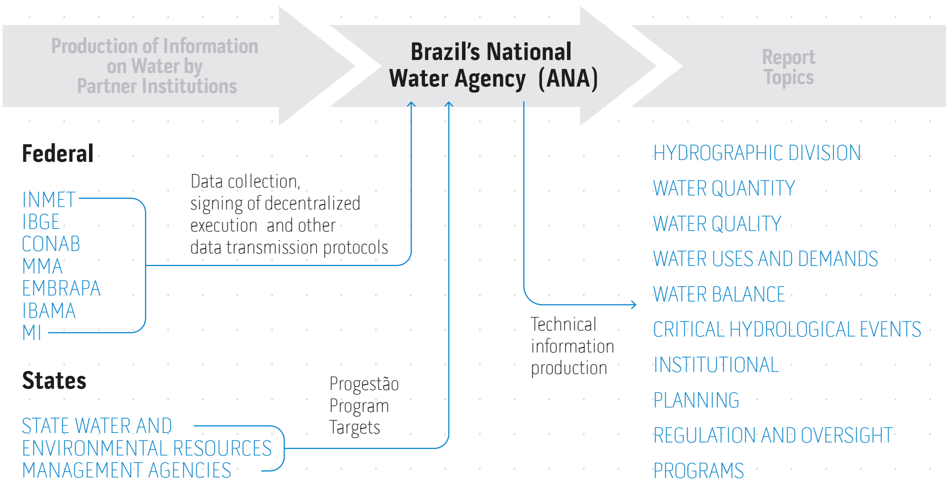
PREPARATION PROCESS OF BRAZILIAN WATER RESOURCE REPORTS

ANA strives to integrate the institutions engaged in the preparation of this Report, ever since its first edition. These efforts led to the concept of a dynamic structure comprised of a network of widely-varying partners and actors.

The data used to prepare this Report are collected from ANA, State Water Resource and Environment Bureaus and Federal Government entities with information on these aspects. More than fifty institutions contributed to this publication. The complex data uptake structure set up through a network of connections among these institutions is steadily fine tuned each year, constituting a major achievement for SINGREH.

An indicator is a statistic that is selected and defined to convey a message within the context. Its purpose is to establish and quantify trends, demonstrate progress or weak points and spotlight changes measured in specific data over the long term.

NETWORKING DYNAMICS FOR PREPARING THIS REPORT



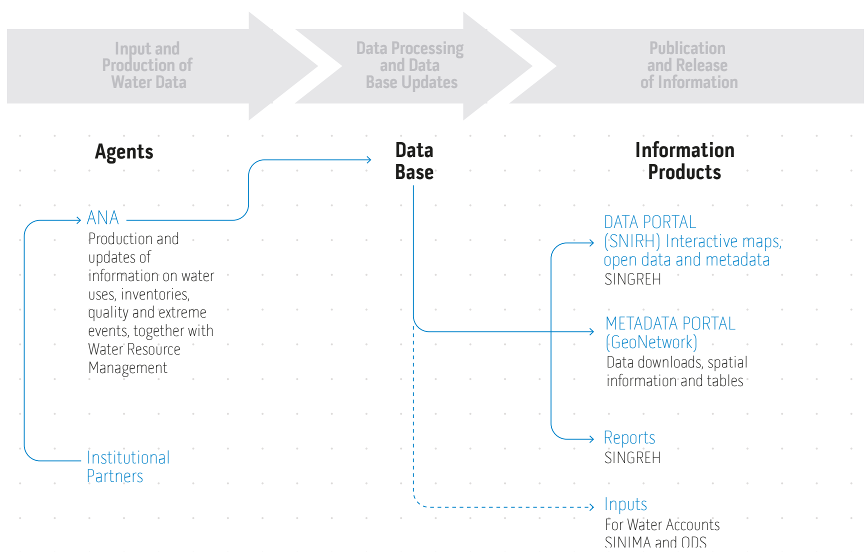
The SNIRH is a broad-based data collection, processing, storage and retrieval system set up specifically for water resources and available to all internet users at: ***www.snirh.gov.br/***

This Report has a more defined work flow that extends from data uptake through to **indicator** construction and release of the information. Its division into topics was adopted during the process of organizing information for the **National Water Resources Information System (SNIRH)**.

There are seventeen Sustainable Development Goals agreed by the UN+ member nations, to be reached by 2030. The SDG 6 indicators presented in this Report can be located in this publication by the icon.

Through the indicators presented in the Reports, compliance with the **Sustainable Development Goals (SDGs)**, can be monitored and overseen, particularly SDG 6 – Clean Water and Sanitation, whose elements for calculating the preliminary indicators are presented in the **2017 Water Resources Report.**

WATER DATA MANAGEMENT



The Supplements are published sporadically, linked to a Report for a specific year, with detailed information on an extraordinary event with nationwide repercussions and/or scope, such as the 2014 Water Crisis and the Mariana Dam Breach in 2015.

A new four-year cycle begins with the publication of the full Brazilian Water Resources Report in 2017, which will be supplemented in 2018, 2019 and 2020 through the respective Annual Reports.

Throughout the history of this publication, the Full and Annual Reports have been unable to provide more immediate and detailed responses to demands from society for information on specific topics. This is why publications must be presented in a new format, called **Supplements**.

Underpinned by the successful experiences built up through these sporadic publications, this new Water Resources Report cycle will add new publications to its output: **Thematic Reports and Technical Studies**.

A Thematic Report addresses a specific topic related to water resources and water user sectors in a more complete and detailed manner, spotlighting methodological aspects and outcomes.

Technical Studies are explanatory texts focused on analyses and results related to specific data and information, produced in order to provide direct or indirect support for the Water Resources Report.

Conveying information efficiently to a wide variety of publics is the ongoing challenge faced by this Report. At the same time, the quality of the information is crucial. The 2017 Report features a new layout and editorial line encompassing all four years of its publication cycle, keeping pace with cutting-edge Information Design trends. This new concept of communication includes more efficient tools and methods that modernize the presentation and ensure easier understanding of its content.

The main innovation is the presentation of infographics that summarize and integrate information on water resources in Brazil. The structure through which its topics are presented is also innovative, with aspects related to water resource management and situations presented in an integrated manner, highlighting links behind the causes and effects of specific events.

For example, climate variability during the past few years and dropping water levels in Brazil's reservoirs are linked and connected to actions undertaken in response to this problem, such as stepping up regulation and inspection activities in regions subject to water stress.

In terms of its content, one of the innovative aspects of the 2017 Full Report lies in its quest to adapt its information and indicators to international standards and rules.

The rationale underpinning the sequence of chapters in this Report runs from basic to more complex.

Chapter 1 presents statistics on Brazil's Water Cycle, together with the construction of environmental economic accounts for water.

Chapter 2 presents an overview of surface and groundwater quantity and quality in Brazil, analyzed through data obtained by hydro-meteorological monitoring activities.

Chapter 3 describes the main uses for water in Brazil, with detailed information on water volumes withdrawn, consumed and returned flows into the environment.

Chapter 4 presents structure and functioning of Brazil's Water Resource Management System.

Chapter 5 identifies critical areas for water quantity and quality in Brazil, addressing aspects that intensifies this criticality, such as climate variability and extreme weather events. Major water shortages are also described, caused by droughts over the past few years, together with the steps taken to address them.

Finally, **Chapter 6**, presents conclusions and reflections on topics addressed in this Report and the main water-related challenges faced by Brazil.

Brazilian Water Resources Report 2017

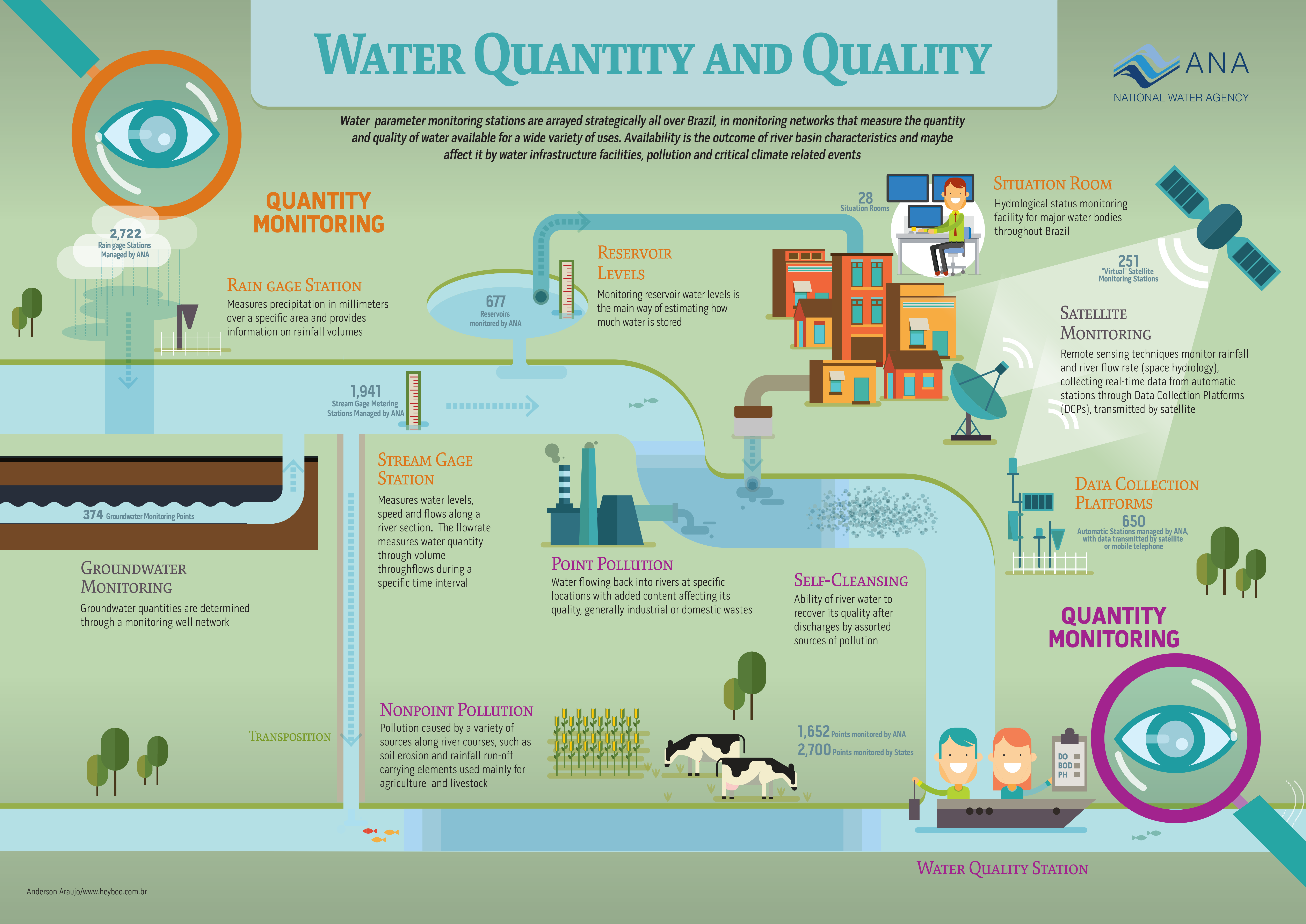
Chapter 2
Water Quantity & Quality

Water supplies are defined by the hydrological, social and economic dynamics of river basins, in addition to water quality conditions.

Knowledge of these supplies requires monitoring river basin water quantity and quality. **How?**

Click on this tab to see the infographic we have prepared for you to understand this, quite simply!

Open here



WATER QUANTITY AND QUALITY
ANA
NATIONAL WATER AGENCY
Water parameter monitoring stations are arrayed strategically all over Brazil, in monitoring networks that measure the quantity and quality of water available for a wide variety of uses. Availability is the outcome of river basin characteristics and maybe affect it by water infrastructure facilities, pollution and critical climate related events
QUANTITY MONITORING
2,722
Rain gage Stations Managed by ANA
RAIN GAGE STATION
Measures precipitation in millimeters over a specific area and provides information on rainfall volumes
677
Reservoirs monitored by ANA
RESERVOIR LEVELS
Monitoring reservoir water levels is the main way of estimating how much water is stored
28
Situation Rooms
SITUATION ROOM
Hydrological status monitoring facility for major water bodies throughout Brazil
251
"Virtual" Satellite Monitoring Stations
SATELLITE MONITORING
Remote sensing techniques monitor rainfall and river flow rate (space hydrology), collecting real-time data from automatic stations through Data Collection Platforms (DCPs), transmitted by satellite
1,941
Stream Gage Metering Stations Managed by ANA
374 Groundwater Monitoring Points
STREAM GAGE STATION
Measures water levels, speed and flows along a river section. The flowrate measures water quantity through volume throughflows during a specific time interval
GROUNDWATER MONITORING
Groundwater quantities are determined through a monitoring well network
POINT POLLUTION
Water flowing back into rivers at specific locations with added content affecting its quality, generally industrial or domestic wastes
SELF-CLEANSING
Ability of river water to recover its quality after discharges by assorted sources of pollution
DATA COLLECTION PLATFORMS
650
Automatic Stations managed by ANA, with data transmitted by satellite or mobile telephone
QUANTITY MONITORING
TRANSPOSITION
NONPOINT POLLUTION
Pollution caused by a variety of sources along river courses, such as soil erosion and rainfall run-off carrying elements used mainly for agriculture and livestock
1,652 Points monitored by ANA
2,700 Points monitored by States
DO
BOD
PH
WATER QUALITY STATION
Anderson Araujo/www.heyboo.com.br

Water Quantity and Quality

Some of the rain falling within Brazil's borders infiltrates into the soil and is stored as groundwater, while the rest becomes runoff, flowing into rivers. Both surface and groundwater contribute to river flows. All this water must be monitored in order to determine the available quantities, in addition to checking its quality.

Hydrological monitoring is performed in order to provide information over time on the quantity and quality of surface and underground water resources nationwide. Much of these monitoring activities are handled through the rain and stream gage stations run by the **National Hydrometeorological Network (RHN)**.

This Network consists of a set of hydrometeorological monitoring stations installed nationwide, maintained and operated by public and private entities, generating data that is provided free of charge to the public through the SNIRH. Not all gage stations in Brazil are connected to the RHN.

In 2016, the National Hydrometeorological Network (RHN) encompassed than 20,000 gage stations set up by several entities, with 4,663 stations managed directly by ANA, of which 2,722 were rain gage stations and 1,941 were stream gage stations. Discharge is measured at 1,646 of these stream gage stations, with 1,652 measuring water quality and 480 analyzing suspended sediments.

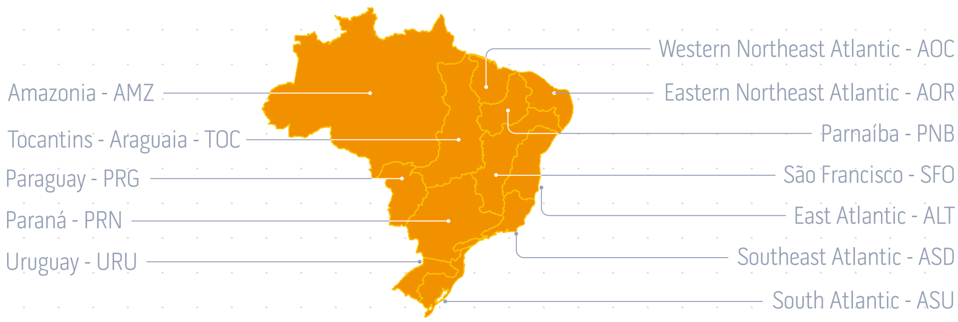
Water volume running through a cross-section by unit of time. For example, an open tap that takes five seconds to fill a five liter bucket has a flow rate of 1 L/s.

This Network also has a specific mandatory monitoring system for the power sector, with monitoring handled by 583 companies operating hydropower plants, and 860 enterprises of which 188 Hydropower Plants (UHE), according to 2016 data.

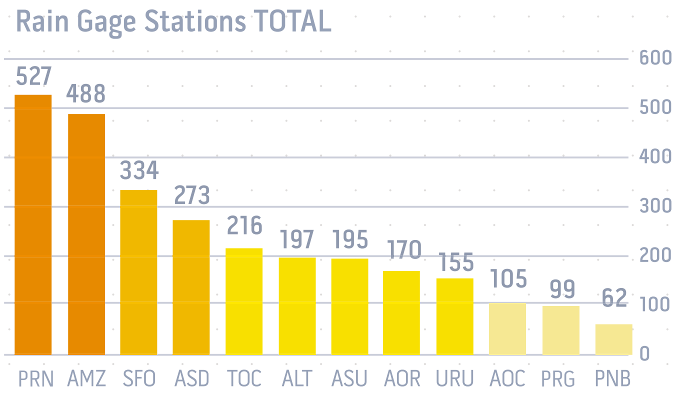
The **geographical distribution of these stations** is relatively even throughout Brazil's Hydrographic Regions, although some have denser networks. Station registration and inventory control is the responsibility of ANA.

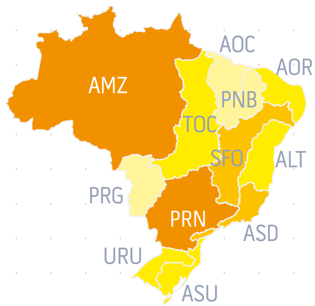
RHN stations managed directly by ANA

In order to understand the graphs, the names of the Hydrographic Regions have been abbreviated, with the following map serving as a reference.

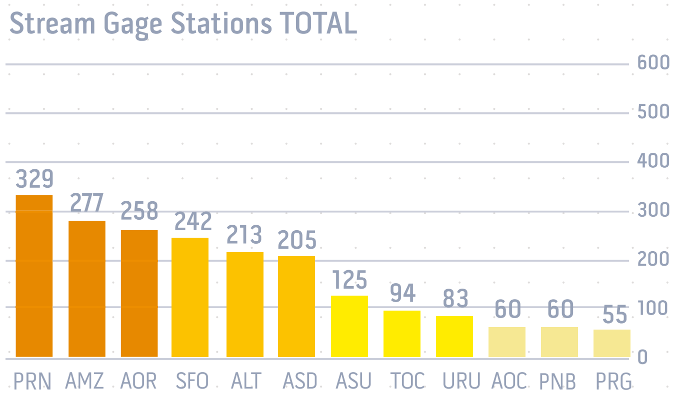


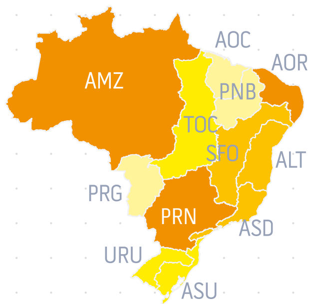
RAIN GAUGE STATIONS MANAGED BY ANA

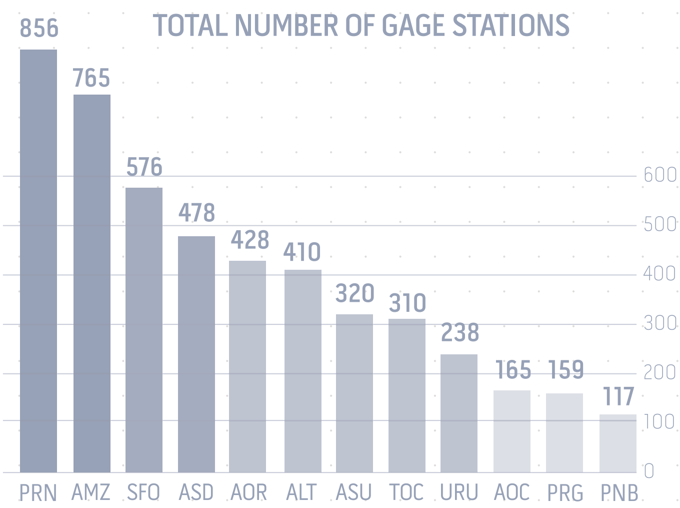




STREAM GAGE STATIONS MANAGED BY ANA

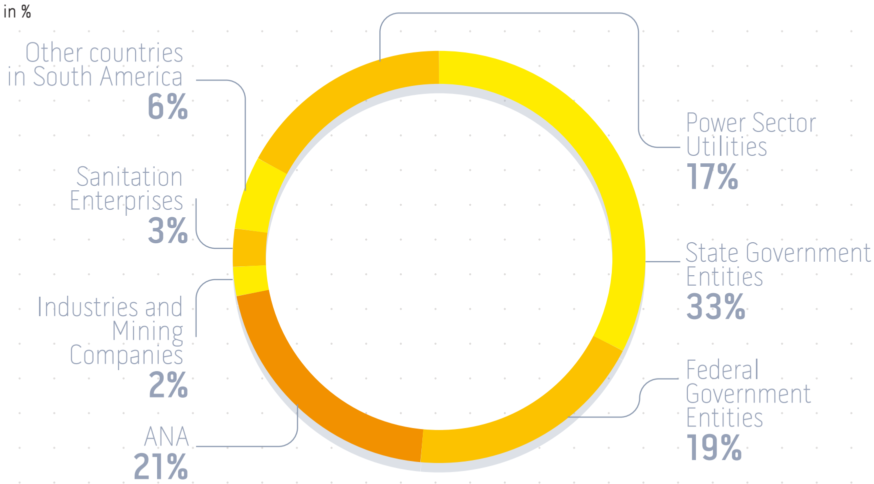




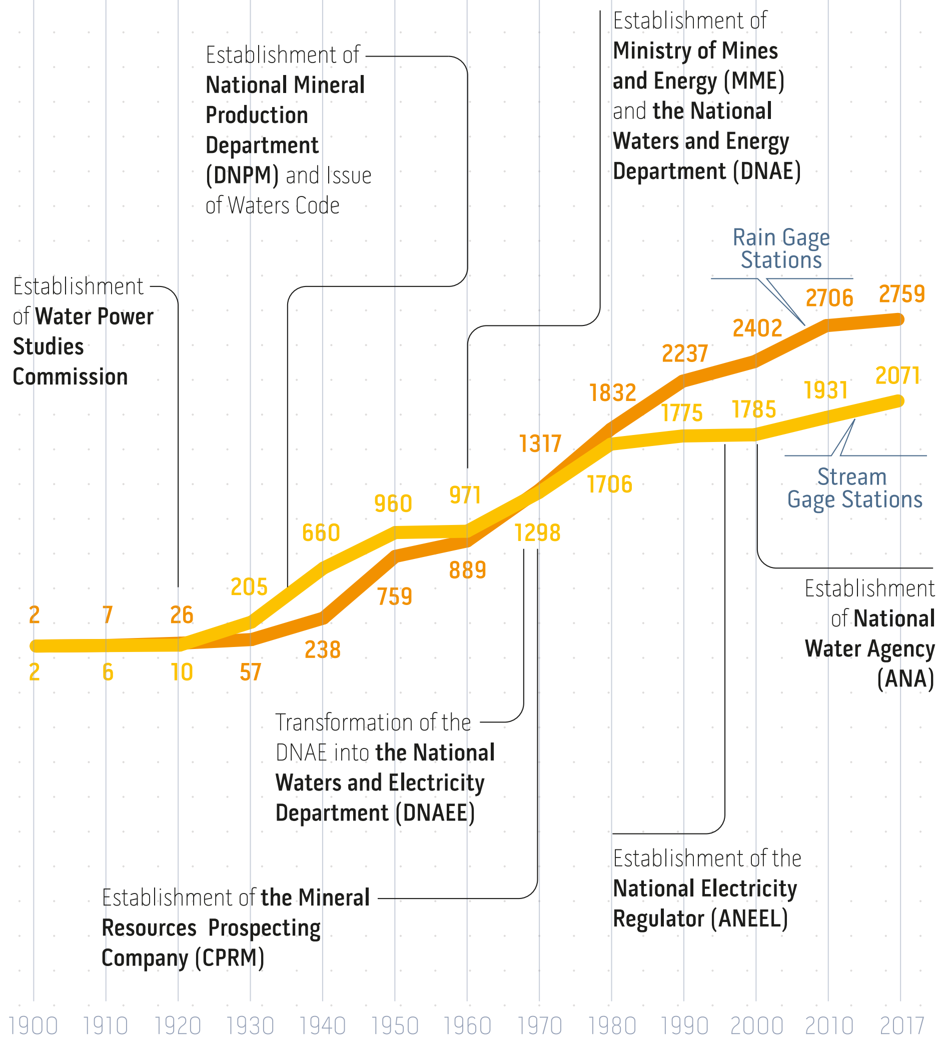


ENTITIES IN CHARGE OF RHN STATIONS IN OPERATION

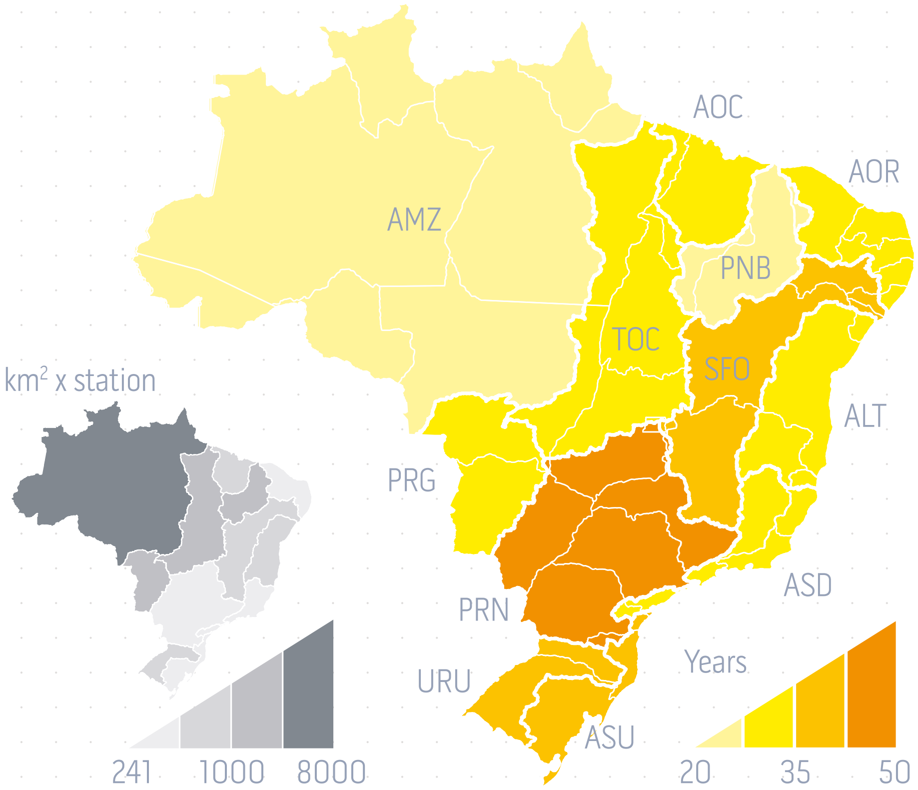
Values in %



DEVELOPMENT TIME LINE FOR NETWORK MANAGED BY ANA



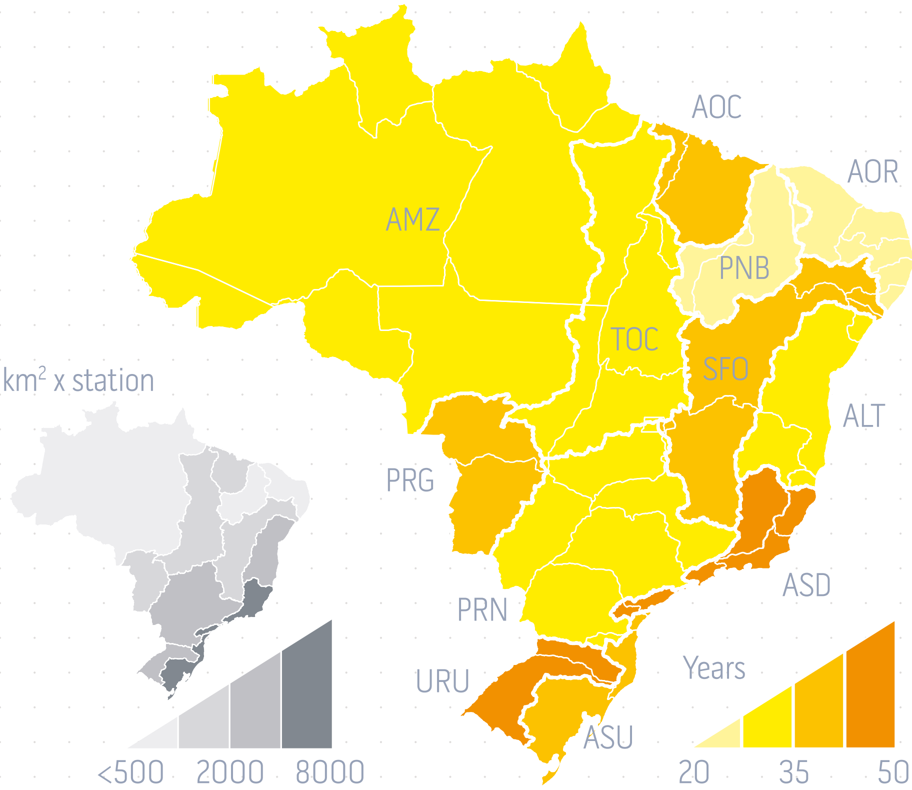
RAIN GAGE DENSITY AND RAINFALL RECORDS LENGTH BY HYDROGRAPHIC REGION



All data on rainfall, minimum and maximum water levels, flows and water availability are calculated from this dataset. Hydrological datasets tend to be more reliable for longer record periods, together with the estimates based on this information.

In addition to the special distribution of the stations, it is important that the **length of hydrological records** are representative, with their values reflecting the variability of the hydrological phenomena under analysis. The average record length for Brazilian river basins is 35 years for the rain gage stations and 30 years for the stream gage stations, ensuring good representativity for hydrological studies.

STREAM GAGE DENSITY AND STREAMFLOW RECORDS LENGTH BY HYDROGRAPHIC REGION



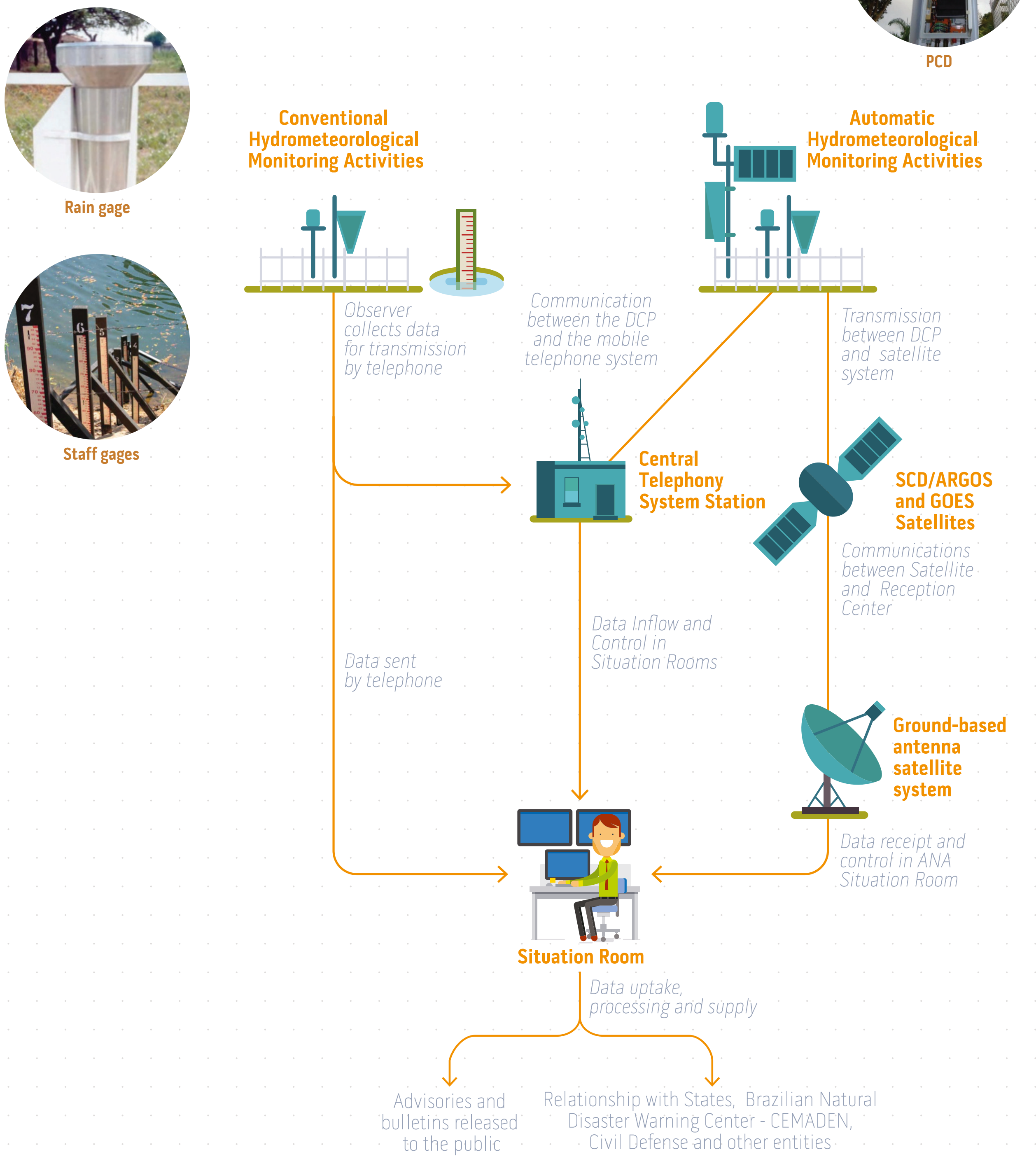
As technology progressed over the past few decades, **hydrometeorological monitoring activities have been updated**, switching from rainfall and water level data recorded on paper by observers to the use of an assortment of automatic sensors connected to a data collection platform (DCP), with data stored on-site by recording devices and transmitted by mobile telephone or satellite technology. In Brazil, factors such as distance, difficult access to stations (in Amazonia and the Pantanal, for example) and the need for information over brief periods of time justify the use of telemetric monitoring, with remote data measurement in real time.

Hydrological monitoring activities are performed by the DCPs in river basins of strategic interest to Brazil, providing data and information for mitigating damage caused by critical events that must be monitored systematically and pro-actively in real time, ensuring fast and accurate responses.

In 2016, there were around 1,000 automatic stations in operation managed directly by ANA, with 650 of them transmitting data by satellite or mobile telephone.

Most of the DCPs are linked into extreme hydrology events warning networks, with data released in State and ANA **Situation Rooms**. These facilities serve as management hubs for critical situations, where specialists from many different fields provide input for decisions taken by government entities in charge of water resources, working closely with civil defense organizations.

DATA FLOWS IN SITUATION ROOMS



Gage stations operation and maintenance are handled by public and private entities active in the various operating areas into which Brazil is divided. The main RHN partner is the Geological Survey of Brazil (CPRM), with eleven operating areas, being actively engaged since its inception in planning and operating the hydrometeorological network.

In 2016, quarterly visits to these stations covered a total of 193 operating routes. These routes are followed from twenty operating bases by some 87 hydrometry teams each year. Overland trips covered a total of some 1.6 million kilometers, together with 16,000 kilometers in boats and 300 hours in air-taxis.

Access to monitoring data and information is handled through the Hydrological Information System **(HidroWeb)**, lined to the SNIRH. **In 2016, more than three million filed datasheets were available through the SNIRH**. In addition to conventional monitoring, **hydrological monitoring by satellite** measures water quantities (river levels by radar) and quality (sediments, chlorophyll and turbidity estimates) in the rivers and lakes of some basins in Brazil. Data for 251 "virtual" stations is released through the Hidrosat portal.

Streamflow and rainfall analyses are generally referenced to the **hydrological year**. Year-by-year variations in rainfall are common, and may top 50% of the average in the Brazilian **Semi-arid** region, while hovering around only 15% of the average figures in the Southeast Region.

Hydrological year: a twelve-month window between the start of the rainy season and the end of the dry season. The period between October and September truly characterizes the rainy season, with high flows in most Brazilian river basins, considered as the mean for the hydrological year in Brazil.

The Brazilian Semi-arid region cover 969,589.4 km² with specific mate characteristics encompassing 1,133 municipalities, of hich 85 are located in Northern Minas Gerais State, and the remainder in the Northeast Region. This area is acknowledged under Brazilian law as subject to critical periods of prolonged drought.

Pioneering activities in the Spatial Hydrology field are being implemented by ANA and the Institut de Recherche pour le Développement (IRD) in France, underscoring the importance of remote sensing data for monitoring water resources. the results are available at: ***goo.gl/FHBvAF***

Hidroweb: available at ***goo.gl/7zsWsA****. Hydrological information is also released through the Internet in real time by various systems managed by ANA. The Reference Hydrological Data Base (BDHR) is currently being set up, to which all the ANA hydrological data bases will be migrated, with information released through Hidroweb.*

The annual average rainfall in Brazil is 1,760 mm but, due to its continent-sized territory, annual rainfall totals vary from 500 mm in the Semi-arid region of the Northeast to more than 3,000 mm in Amazonia.

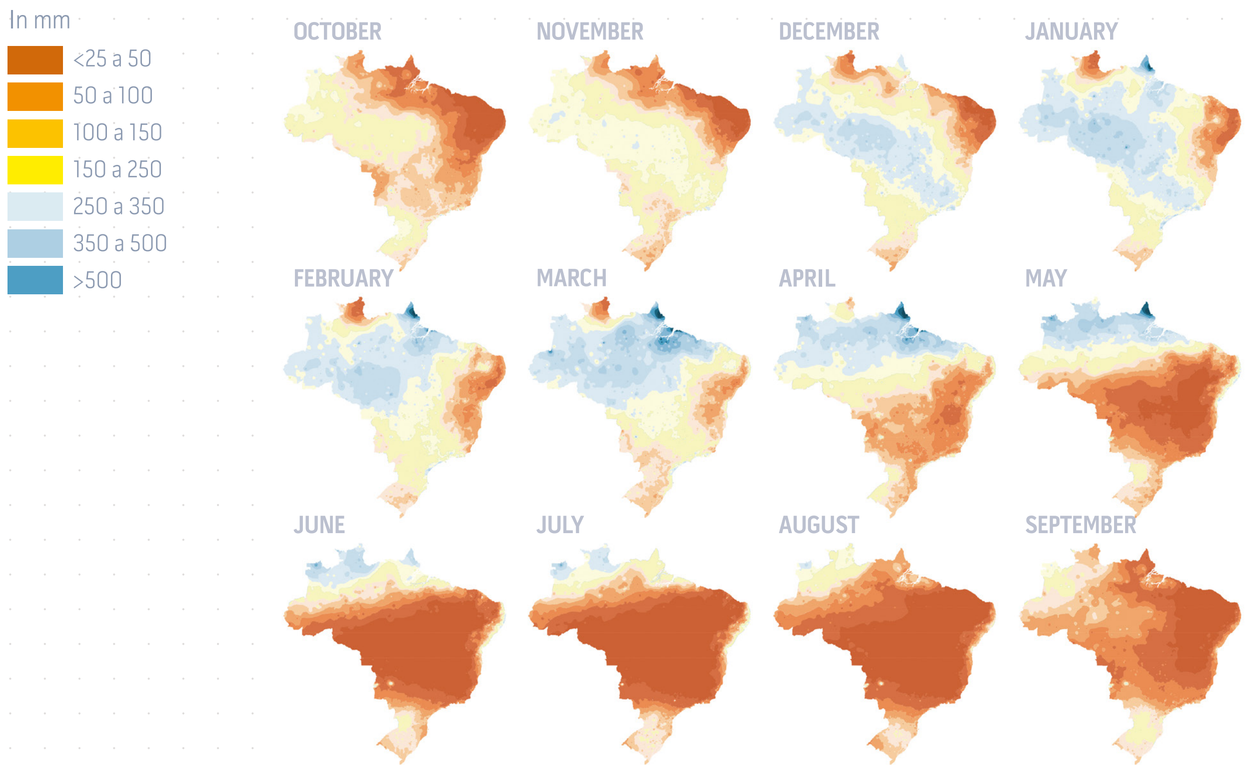
1 mm of rain corresponds to a water level (height) of 1 liter of water distributed over 1 m²

In addition to spatial variability, rainfall may present clearly-defined seasonal behavior over the year, in addition to inter-annual variations. For example, total mean rainfall in Northeast Brazil may top 300 mm during the rainy season, while failing to reach 25 mm during the drier months.

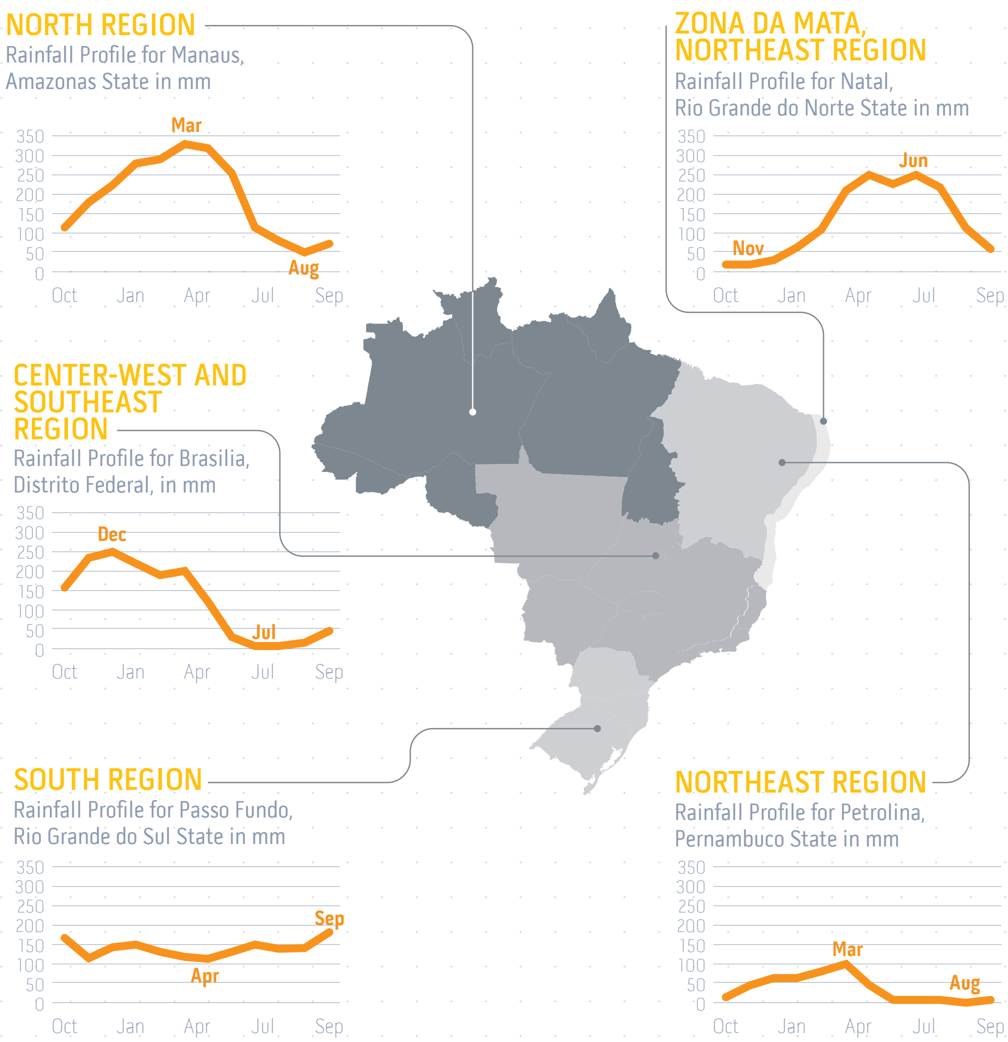
Studies indicate that changes are under way in variables such as temperature and rainfall, among others, which may alter climate characteristics worldwide, and in Brazil. According to these studies, global warming will modify Brazil's rainfall patterns, with stronger and more frequent rains in the South and Southeast, while droughts become even more common in the Northeast.

LONG-TERM MEAN MONTHLY RAINFALL IN BRAZIL

Rains are heavier and more frequent during summer in the Southern Hemisphere throughout much of Brazil, becoming lighter and more widely spaced during the winter months. In the South Region, rainfall is fairly steady throughout the year, while the Center-West and Northeast are subject to clearly-defined dry seasons. In the northern part of Northeast Brazil, rain is more frequent from February to May, while rainfall peaks occur between May and July in the eastern part of this region.



LONG-TERM MEAN MONTHLY RAINFALL AT SOME LOCATIONS IN BRAZIL



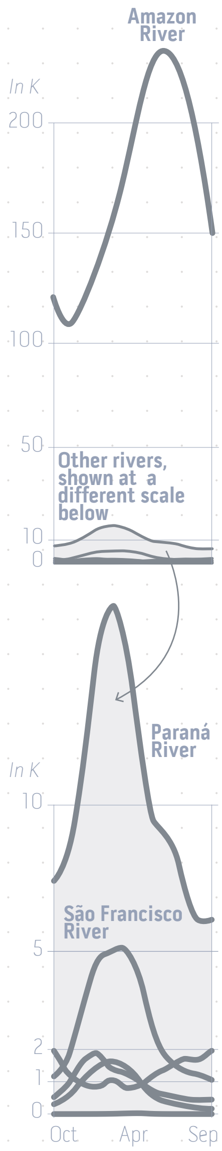
In Brasilia, the nation's capital, rain falls mainly between October and March, followed by a period when almost no rain falls. In Natal, the rainy season runs from March to July, while rain falls fairly steadily throughout the year at asso Fundo, Rio Grande do Sul State In terms of quantity, during the rainy season at Petrolina in Pernambuco State, for example, total rainfall figures are similar to those for the dry season in Manaus, the Amazonas State capital, where the total average rainfall is nine times greater than the total figures recorded for Petrolina.

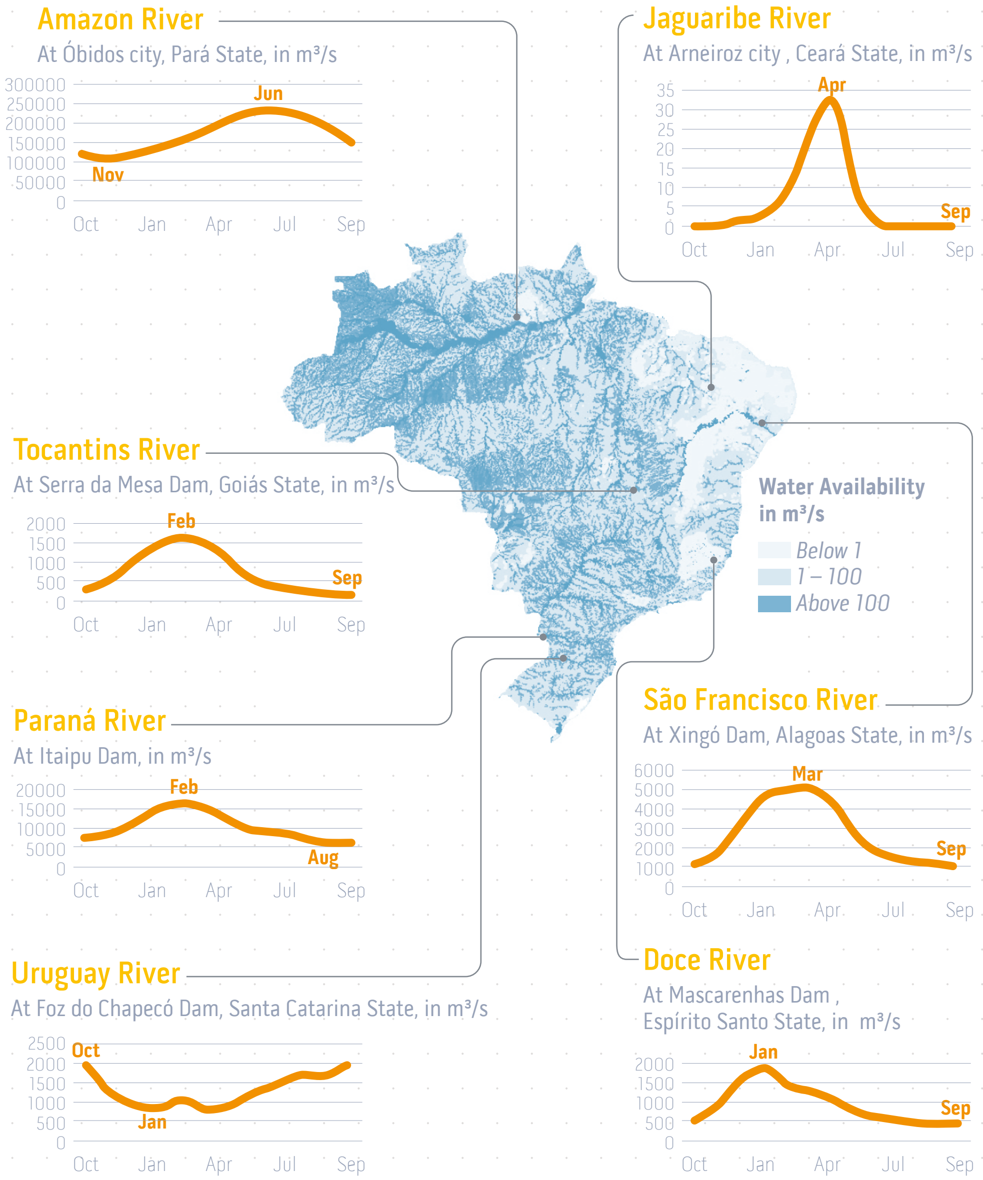
LONG-TERM MEAN MONTHLY STREAMFLOWS AT SOME LOCATIONS IN BRAZIL

The high-flow periods over the year also vary by region. For example, the Paraná (Itaipu), Tocantins (Serra da Mesa) and Sao Francisco (Xingó) rivers generally flow highest between February and March; for the Doce River this occurs between December and January; between March and April for the Jaguaribe river; between May and June for the Amazon River (Óbidos) and between September and October for the Uruguay River.

Comparing scales

The graphs alongside highlight streamflow dynamics throughout the year. However, in order to compare total streamflows, they must all be presented in the same scale, which is not possible due to the Amazon River, whose streamflow far exceeds that of the others. In order to offer an idea, the following graph compares their scales.

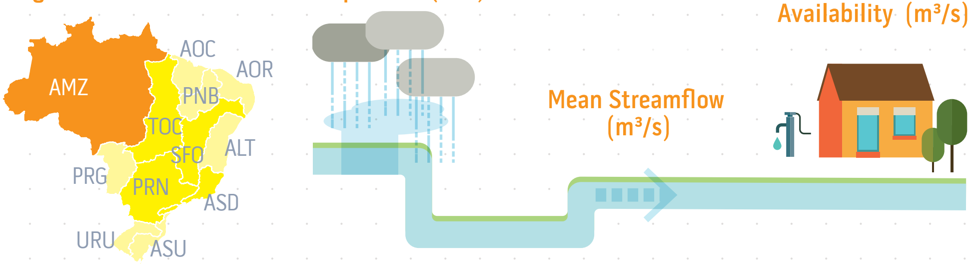




On average, 260,000 m³/s of water flow through Brazil. Although abundant, some 80% is found in the Amazon Region, with low population density, and, consequently, less water demands. Part of these outflows are allocated to a wide of Water Uses, even in drier years. **Surface water availability in Brazil** is estimated at around 78,600 m³/s or 30% of the mean flow, with the Amazon Basin contributing 65,617 m³/s.

Water availability is an estimate of the amount of water available for a wide variety of uses that encompasses a specific safety margin, for management purposes. In this case, availability along river reaches corresponds to the dry season streamflows Q95 (flow observed at some river location at least 95% of the time). In reaches under the influence of reservoirs, the availability is estimated specifically: for areas downstream from the dam is adopted the minimum outflow from the reservoir added to Q95 streamflow contributions from tributaries and; For the reservoir behind the dam, the flow guaranteed for 95% of the time less the reservoir outflow is adopted. For hydropower dams managed by the National Electrical System Operator (ONS) the regularization capacity is disregarded, using only the Q95 for the dam location.

MEAN PRECIPITATION AND STREAMFLOWS WITH WATER AVAILABILITY BY HYDROGRAPHIC REGION



Hydrographic Region	Mean Annual Precipitation (mm)	Mean Streamflow (m³/s)	Water Availability (m³/s)
Amazon	2,253	208,457	65,617
Tocantins-Araguaia	1,760	14,895	3,098
Western Northeast Atlantic	1,791	3,112	397
Parnaiba	1,040	774	325
Eastern Northeast Atlantic	841	791	218
São Francisco	938	2,914	875
East Atlantic	940	1,556	271
Southeast Atlantic	1,400	4,843	1,325
South Atlantic	1,573	2,869	513
Uruguay	1,689	4,906	550
Parana	1,490	12,398	4,390
Paraguay	1,342	2,836	1,023

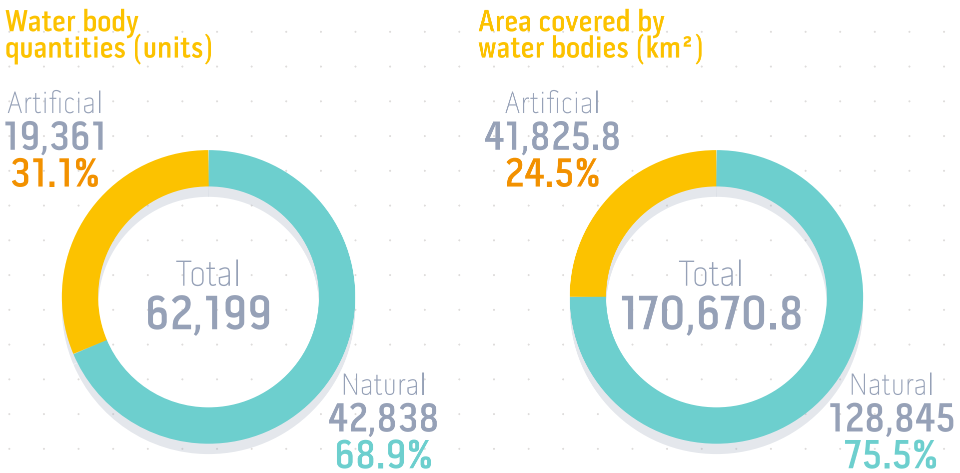
Man-made reservoirs increase surface water availability. In addition to storing water during wet seasons, these artificial reservoirs can also release some of their stored volumes during dry seasons, regulating and reducing seasonal fluctuations in streamflows. However, volume recovery depends on river inflows during wet seasons, which in turn depend heavily on rainfall regime.

Brazil had 19,361 **artificial reservoirs mapped** in 2016. The expansion of its water storage facilities was stepped up from 1950 onwards, particularly through hydropower dams with massive volumes, compared to total storage capacities.

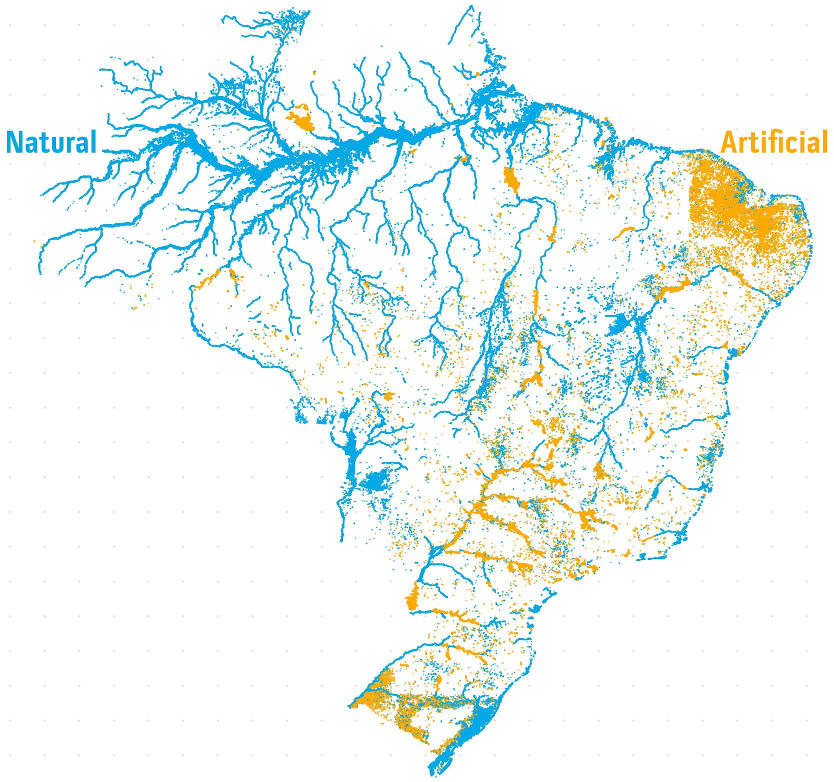
Encompassing lakes and reservoirs, Brazil's water bodies data base maybe accessed through the ANA Metadata Portal at ***goo.gl/n59S6X***.

Water availability in a storage system is a function of rainfall and the regularization capacity of each basin, which together define inflows to reservoirs. Furthermore, reservoir topography is also a determining factor, particularly in areas with high evaporation rates, compared to rainfall directly on the water surface.

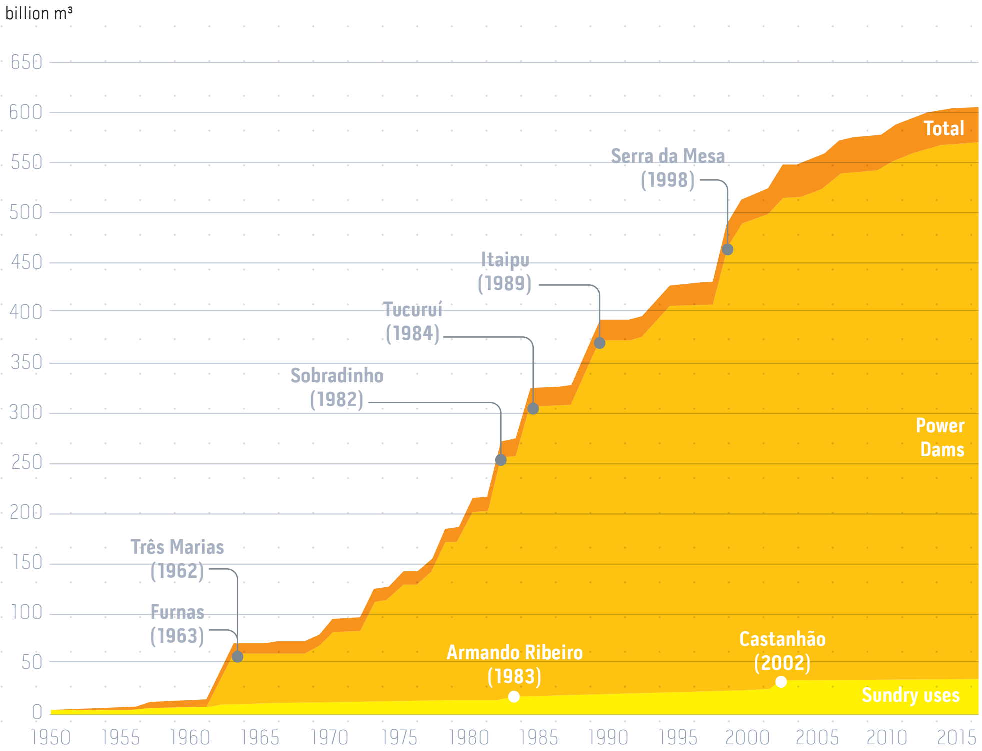
WATER BODY AREAS AND QUANTITIES BY CLASSIFICATION TYPOLOGY



TYPOLOGY OF WATER BODIES IN BRAZIL



EXPANSION OF WATER STORAGE CAPACITY IN BRAZIL



The largest water storage capacity by total **active storage** of the 151 reservoirs in Brazil's **Interconnected National System** (SIN), is located in three Hydrographic Regions: Paraná, Tocantins-Araguaia and São Francisco. These three re gions hold more than 266 billion m³, constituting some 88% of the active storage capacity of this System.

The active storage or volume of a reservoir lies between its maximum and minimum operating levels. It is the amount of its total volume that is effectively used to regulate flows, as water below the minimum operating level of a reservoir Known as dead storage. The inactive or dead storage is usually not available for removal through gravity.

Northeast Brazil is a region where water supplies require special attention, especially in its Northern Segment (Ceará, Rio Grande do Norte, Paraíba and Pernambuco States), where 87.8% consists of Semiarid territory. Low and irregular rainfall figures with high temperatures throughout the year, narrow temperature variations (between 2°C and 3°C), high insolation and evapotranspiration rates or reduce water availability, underpinned by hydro-geological characteristics, such as the relevant presence of intermittent rivers.

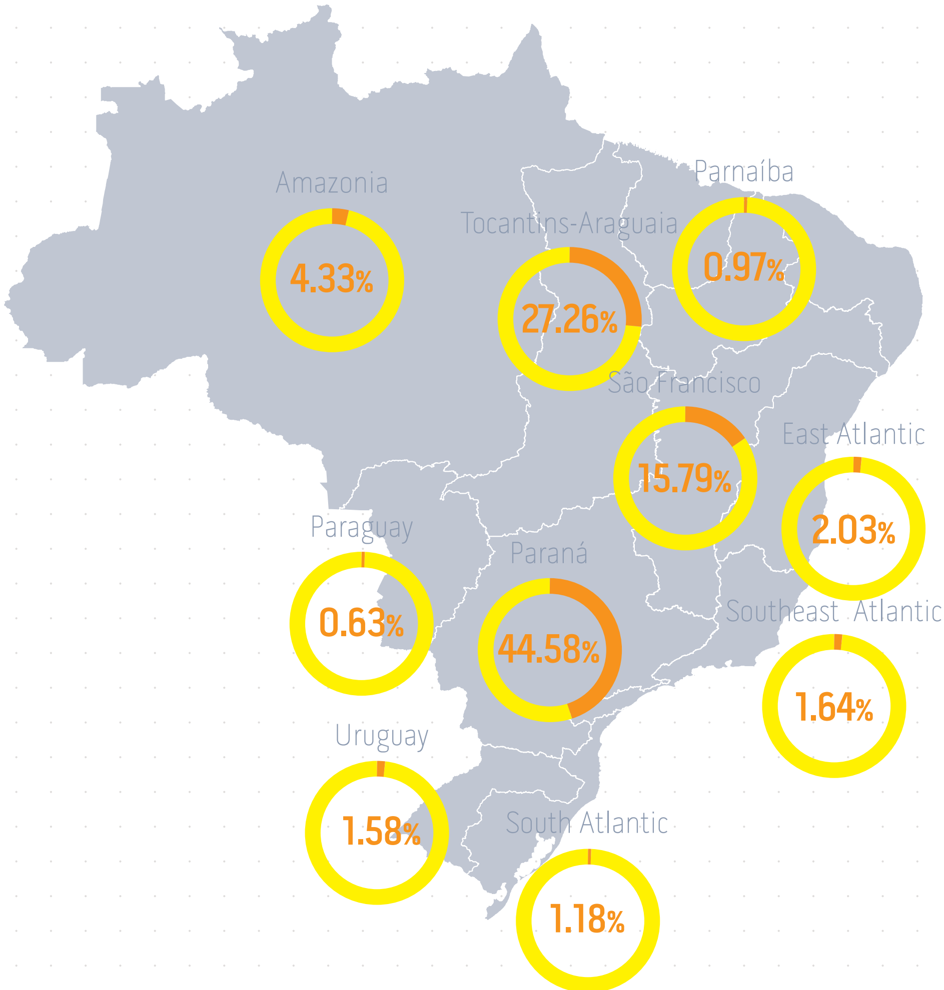
Brazil's Interconnected National System (SIN) Is the hydro-thermal-wind power generation and transmission, operating nation wide. Its installed generation capacity consists mainly of hydropower plants scattered throughout the country, and are addressed in Chapter 3.

Steady water supplies can be ensured in most of these rivers only through the use of reservoirs as they naturally vanish during the dry season, due to low rainfall and thin soil. In other parts of Brazil, dams are used to underpin guaranteed supplies for ongoing demands including human uses.

There are 133 reservoirs in the Northern part of Northeast Brazil that are rated as strategic, with storage capacities hovering around 10 million m³, meaning that they are inter-annual reservoirs. The main purposed served by smaller reservoirs is to store water after the rainy season, for use during the subsequent dry season. In all, there are 398 reservoirs used to supply urban water in this region, with a total storable volume of over 23 million m³, with ANA monitoring some 63% of them.

The Drought Monitor pilot program encompasses proactive drought management strategies and tools designed for Northeast Brazil. Regularly monitoring drought status, it consolidates and releases its findings through maps indicating rought severity and its expansion in terms of space and time, together with impacts on the many different sectors involved. Further information is available from: **goo.gl/ad4jGw**.

PARTICIPATION OF TOTAL ACTIVE STORAGE OF THE INTERCONNECTED NATIONAL SYSTEM BY HYDROGRAPHIC REGION

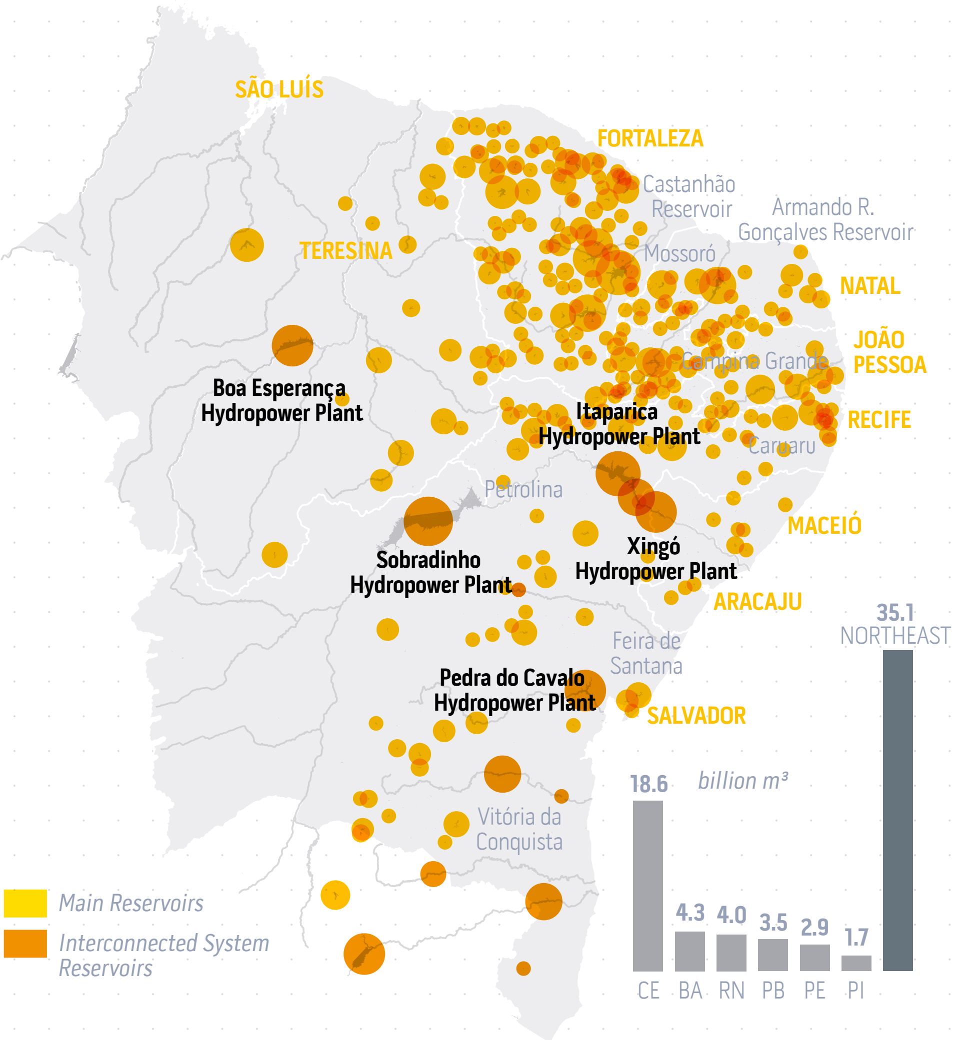


Some 67% of public urban water supplies in the Northern segment of Northeast Brazil comes from runoffs stored in reservoirs.

In historical terms, the reservoir is the main solution adopted by government entities for dealing with the **problem of drought in Northeast Brazil**, with adductor systems transporting water.

The Integration Project linking the São Francisco River to the Northern Northeast River Basins (PISF) is intended to increase guaranteed water supplies in these reservoirs. Water flows are also transferred in river basins in other parts of Brazil, including the Cantareira and Paraíba do Sul systems that supply the São Paulo and Rio de Janeiro Metropolitan Regions respectively.

MAIN RESERVOIRS IN NORTHEAST BRAZIL AND THEIR CAPACITIES



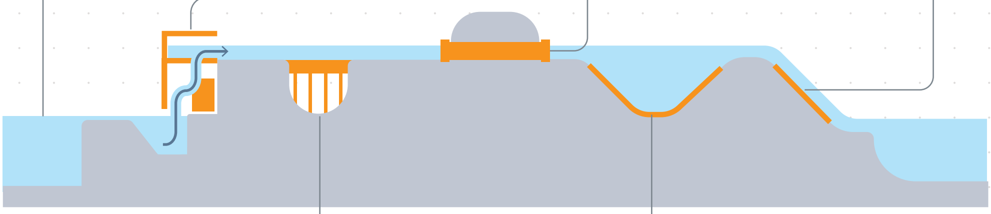
When analyzing the situation for rainfall, streamflows and **water stored in reservoirs** from 2012 to 2016, an exceptional drought was noted in Rio Grande do Sul State during 2012, prompting several municipalities to declare states of emergency. A drought in the Uruguay River was recorded at Uruguaiana city, with a average streamflow during 2012 reaching 54% of its long-term annual mean. Furthermore, droughts have **affected the Semiarid** region since 2012, with a sharp reduction in water volumes stored in the **Northeast Equivalent Reservoir**, principally in States in the Northern part of this region.

Water storages in 677 Brazilian reservoirs are monitored by ANA, working closely with States and government entities in charge of their operation. Disclosed through the Reservoirs Monitoring System (SAR), data are available at: ***goo.gl/HeSyHS***.

The effects of the drought in Northeast Brazil during this period dramatically impacted water supplies to municipalities in this region, with this issue addressed in detail in Chapter 5.

Equivalent reservoir: *corresponds to the sum of the storage in the main reservoirs of a region. In Northeast Brazil, this encompasses a set of 272 reservoirs with a storage capacity of at least 10 million m³, monitored by ANA jointly with the States and entities in charge of their operation. In addition to the Equivalent Reservoir, a further 236 reservoirs are also monitored in Northeast Brazil.*

WATER TRANSFER INFRASTRUCTURE FROM THE SÃO FRANCISCO RIVER TO HYDROGRAPHIC BASINS IN NORTHERN NORTHEAST BRAZIL



The special Water Crisis Supplement, which was an integral part of the 2014 Annual Brazilian Water Resources Report in Brazil provides a detailed description of the events and the steps taken, available at: ***goo.gl/5PkgVW***

A severe drought scourged Southeast Brazil in 2014, when several river streamflows dropped in Minas Gerais, São Paulo and Rio de Janeiro States through to 2015. Worsened by uncertain water management, this forced São Paulo State into an unprecedented **Water Crisis** that significantly undermined local water supplies, particularly in the São Paulo Metropolitan Region. On the Paraíba do Sul River, streamflows at the Ilha dos Pombos hydropower plant were below average from 2012 to 2016, reaching only 54% of the mean in 2015. A similar effect was noted at the Furnas hydropower plant on the Grande River, which flows into the Paraná River, where streamflows decreased by almost 60% in 2014 and 2015. There was less than a 1% chance (or a 100-year **recurrence interval**) of such extremely low annual rainfall rates and streamflows occurring at these locations.

Recurrence Interval or return period is an expression commonly used in hydrology that reflects the inverse of probability. If an event has a recurrence interval of 100 years, this means that there is one chance in a hundred of this event happening in any given year.

The 2014 drought decreased water volumes stored in most of the Interconnected National Grid Reservoirs, with storage increasing only in the Amazon and Paraguay hydrographic regions. There was a severe flood on the Madeira River in Northern Brazil in 2014, recorded at the Santo Antônio hydropower plant in Porto Velho. Floods in Rondônia State cut off entire towns leaving people trapped.

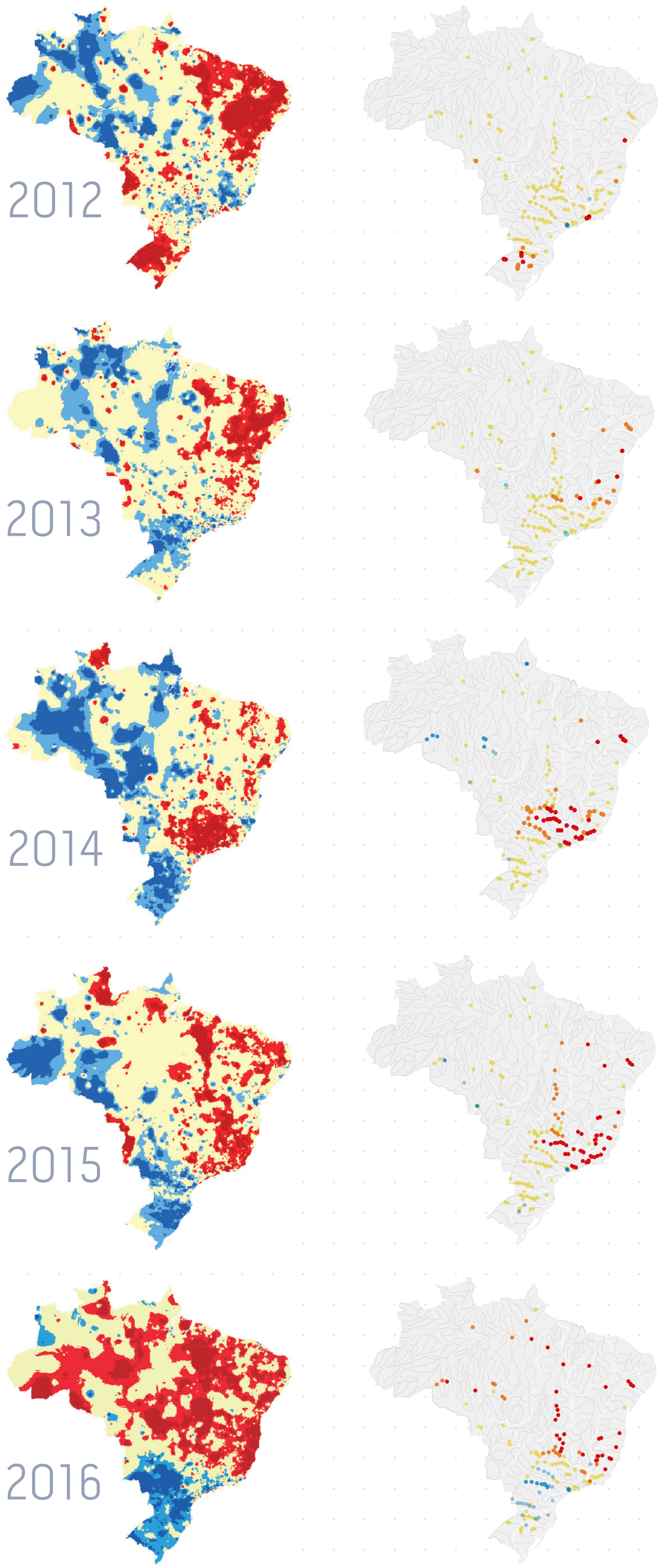
From 2015 onwards, more severe rainfall anomalies were noted over much of Brazil, although heavier rain was recorded in the South, increasing water volumes stored in reservoirs in the Paraná, South Atlantic, Southeast Atlantic and Uruguay Regions. In 2015, the Guaíba River recorded the second-highest flood in its history, in Rio Grande do Sul State, with flooding in midwest São Paulo, Paraná and Mato Grosso States the following year.

Nevertheless, 2016 was a year that was dry to extremely dry over much of Brazil, with a 13% decrease in rainfall overall. Severe droughts occurred in southeast Pará and southern Maranhão States, as well as southeast Tocantins State and the Federal District, southeast and southern Bahia State and other areas. There was a 1.71% drop in stored volumes between January to December 2016 in the Equivalent Reservoir for the Northeast Region. An aftermath of four consecutive dry years, by December 2016, 65% of the reservoirs providing water to the public were dry, with water volumes reaching only 11.5% of total storage capacity.

In Espírito Santo State, the lack of rain caused problems for human water supplies, with adverse effects for the agricultural and livestock sectors. One of the worse-ever droughts was recorded in Acre State, which had experienced the greatest flood ever registered in its history just a year before, in 2015. Along the São Francisco River, average annual streamflows have remained below long-term mean since the mid-1990s. With less rainfall in this basin, reservoir levels are dropping year by year, meaning that several wet years will be needed to restore water volumes in these reservoirs. The historical dataset for the São Francisco River has never recorded such low annual streamflows as those noted over the past few years (61% of the mean in 2016). The chances of an annual streamflow of this magnitude are less than 1%.

CLASSIFICATION OF ANNUAL RAINFALL AND STREAMFLOWS BETWEEN 2012 AND 2016

The maps on the left show the classification regarding rainfall amount. The maps on the right show the recurrence intervals for annual natural streamflows in Brazilian hydropower plants.



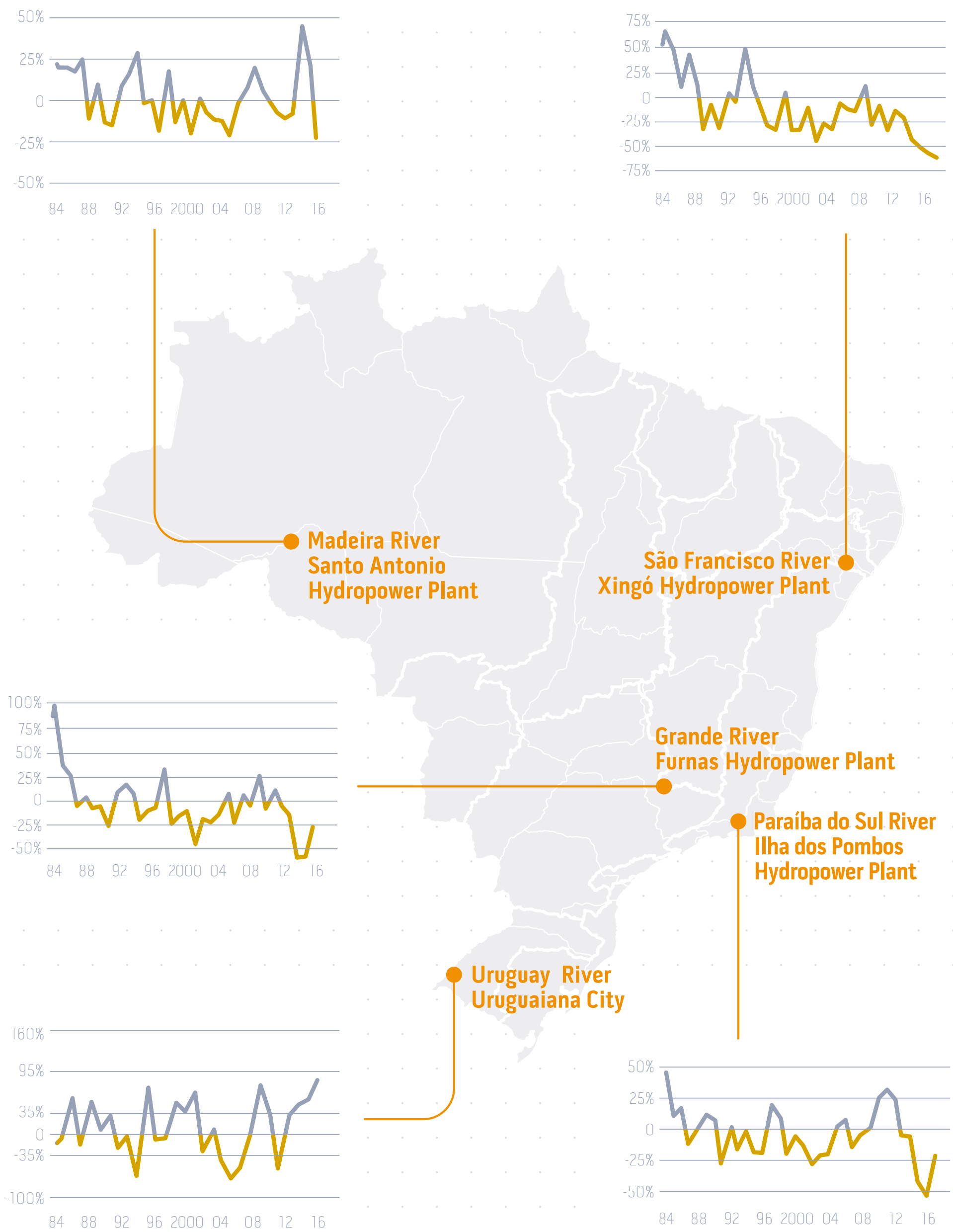
Rainfall classification

- *Extremely dry*
- *Dry*
- *Normal*
- *Wet*
- *Extremely wet*

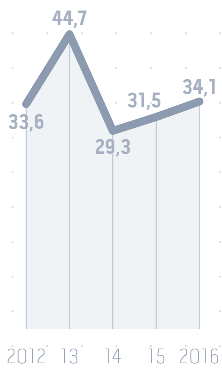
Recurrence Interval

- *Drought more than 50 years*
- *Drought between 10 and 49 years*
- *Close to mean*
- *Flood between 10 and 49 years*
- *Flood more than 50 years*

ANNUAL MEAN AND LONG-TERM ANNUAL MEAN STREAMFLOW AT LOCATIONS IN BRAZIL

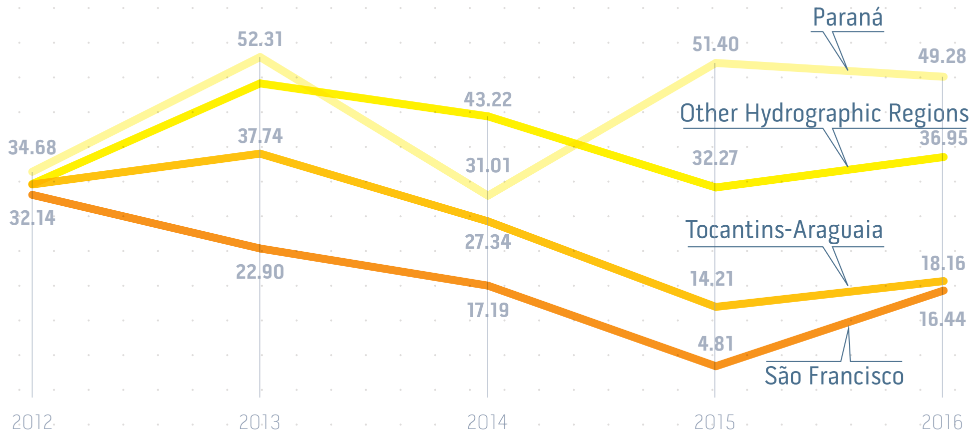


TOTAL

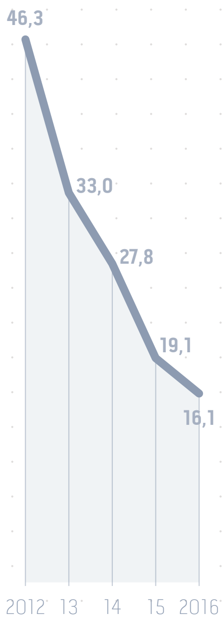


WATER VOLUMES STORED IN THE RESERVOIRS OF THE INTERCONNECTED NATIONAL SYSTEM BETWEEN 2012 AND 2016

% volume stored with reference to active reservoir volume

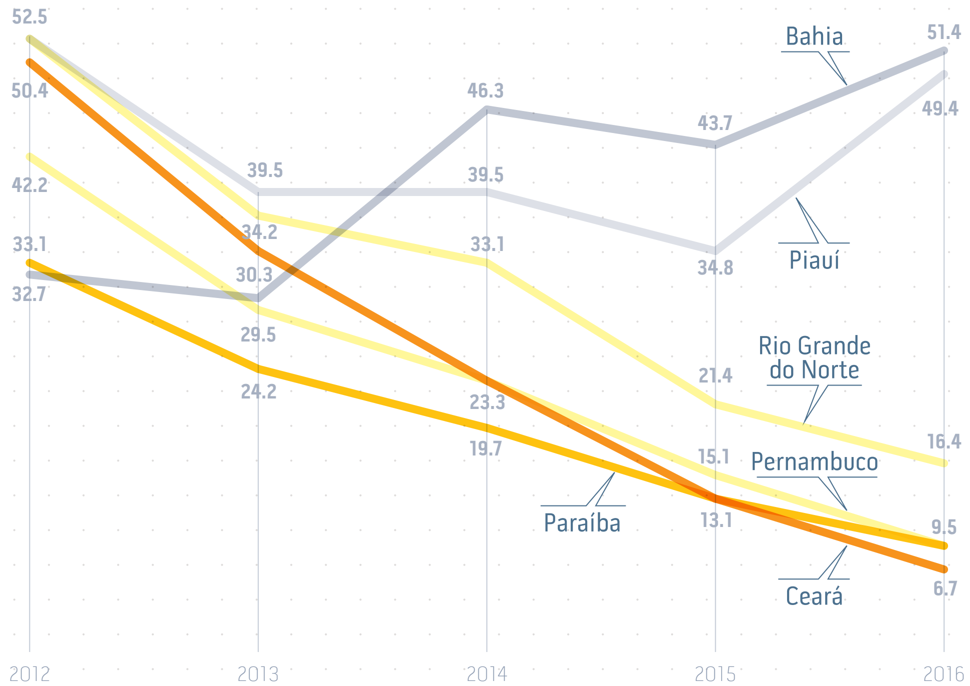


NORTHEAST



WATER VOLUMES STORED IN THE NORTHEAST EQUIVALENT RESERVOIR FROM 2012 TO 2016

% volume stored with reference to reservoir capacities (total storage)

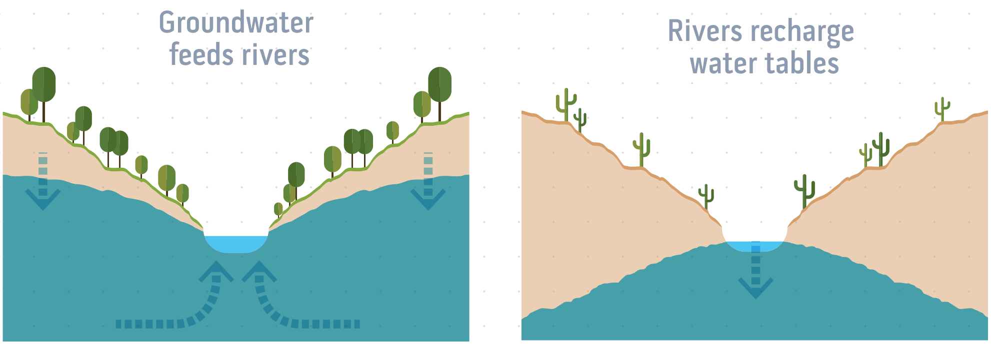


In addition to surface water, **groundwater** plays an important role as a source of water for a wide variety of uses. Ample storage capacity and the resilience to withstand lengthy droughts resulting from climate variability makes ground water an alternative for coping with dry periods.

Water outflows from aquifers underpin an even ecological balance while ensuring the perennial status of most rivers, lakes and wetlands in Brazil through contributions to baseline flows in watercourses.

In some 90% of Brazilian rivers, baseline flows from aquifers feed rivers, keeping them perennial during dry seasons. An exception is found in the semi-arid crystalline basement of Northeast Brazil, which are unable to regularize their rivers, leaving them intermittent.

LINKS BETWEEN RIVERS AND AQUIFERS



Groundwater reserves in Brazil are calculated for the main aquifers in each Hydrographic Region, as well as for those rated as strategic, whose volumes respond to major water demands. The extent of the area draining eastward in Brazil and the storage capacity of the Urucuia Aquifer System highlight the importance of groundwater contributions to baseline flows into the São Francisco river, estimated at 730 m³/s, for example. This accounts for an average of 30% of its streamflow, reaching 80% to 90% during dry seasons in this basin. The westward contribution flowing into the Tocantins basin is estimated at 215 m³/s.

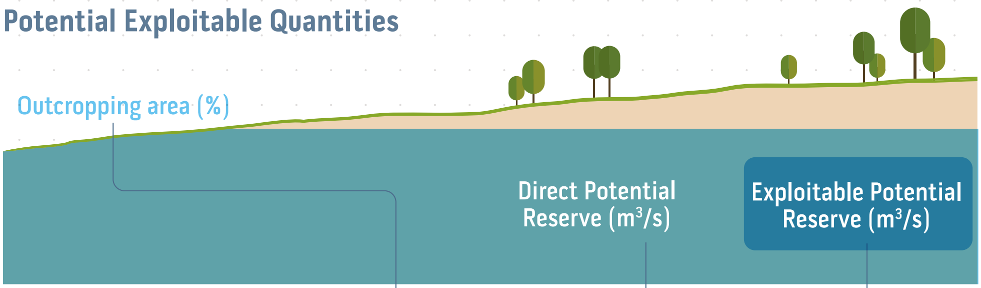
Direct recharge or potential direct reserves (PDR) are estimated for aquifer outcrop areas, updated through studies conducted by ANA and bibliographic data. Major studies conducted between 2013 and 2016 include: Hydrogeological Studies of the Urucuia Aquifer System; a Study of Natural Vulnerability to Contamination; and Protection Strategies for the Guarani Aquifer System; and an Aquifer Assessment in the Amazon Hydrogeological Province, Brazil.

POTENTIAL EXPLOITABLE RESERVES IN OUTCROP AREAS OF MAJOR AQUIFERS BY HYDROGRAPHIC REGION

An outcrop area of an aquifer and aquifer system is the part that breaches the earth's surface, potentially able to be recharged directly through percolation, fed by rain and surface-water bodies. Several aquifers and aquifer systems extend beyond the boundaries of the Hydrographic Regions as well as Brazil's national borders.

The Direct Potential Reserve (DPR) consists of the amount of rainfall seeping into the ground and effectively reaching free aquifers. The exploitable potential reserve is the part of the DPR that can be used sustainably.

Potential Exploitable Quantities



Hydrographic Region	Outcropping area (%)	Direct Potential Reserve (m³/s)	Exploitable Potential Reserve (m³/s)
Amazonia	92.3	27898	9809
Tocantins-Araguaia	82.4	3702	1064
Western Northeast Atlantic	83.7	1064	223
Parnaíba	64.3	537	218
Eastern Northeast Atlantic	95.1	213	79
São Francisco	96.6	1194	334
East Atlantic	96.3	388	137
Southeast Atlantic	96.6	402	148
South Atlantic	84.7	746	272
Uruguay	89.7	1082	433
Parana	94.3	3388	1479
Paraguay	89.8	2036	450

The mapping presented in the 2013 Brazilian Water Resources Report was simplified and updated in 2016 for 37 aquifers and outcrop aquifer systems, compared to the 181 addressed previously. The Fractured (Fraturado) System was grouped and classified into four major segments; the Porous System was divided into 29 areas; and the Karstic System was classified into four sections. Several aquifers and aquifer systems are not shown on the map, as their outcrop areas are not represented at the scale of work or because they occur only as confined rather than outcropped aquifers.

It is estimated that there is around 14,650 m³/s of groundwater availability in Brazil. Similar to surface water, it is not distributed uniformly nationwide, with aquifer productivity being variable, with shortages in some of the regions and relative abundance in others. In order to reach a specific aquifer, drilling at different depths is required, depending on the location. The **aquifer systems** located in sedimentary ground, which covers **48% of the land area of Brazil**, are endowed with ample water storage potential, as they are generally found in regions with favorable climate conditions. Regions with limited water availability coincide with the areas where fractured aquifers are located.

Brazilian aquifers and aquifer systems are classified into three domains:

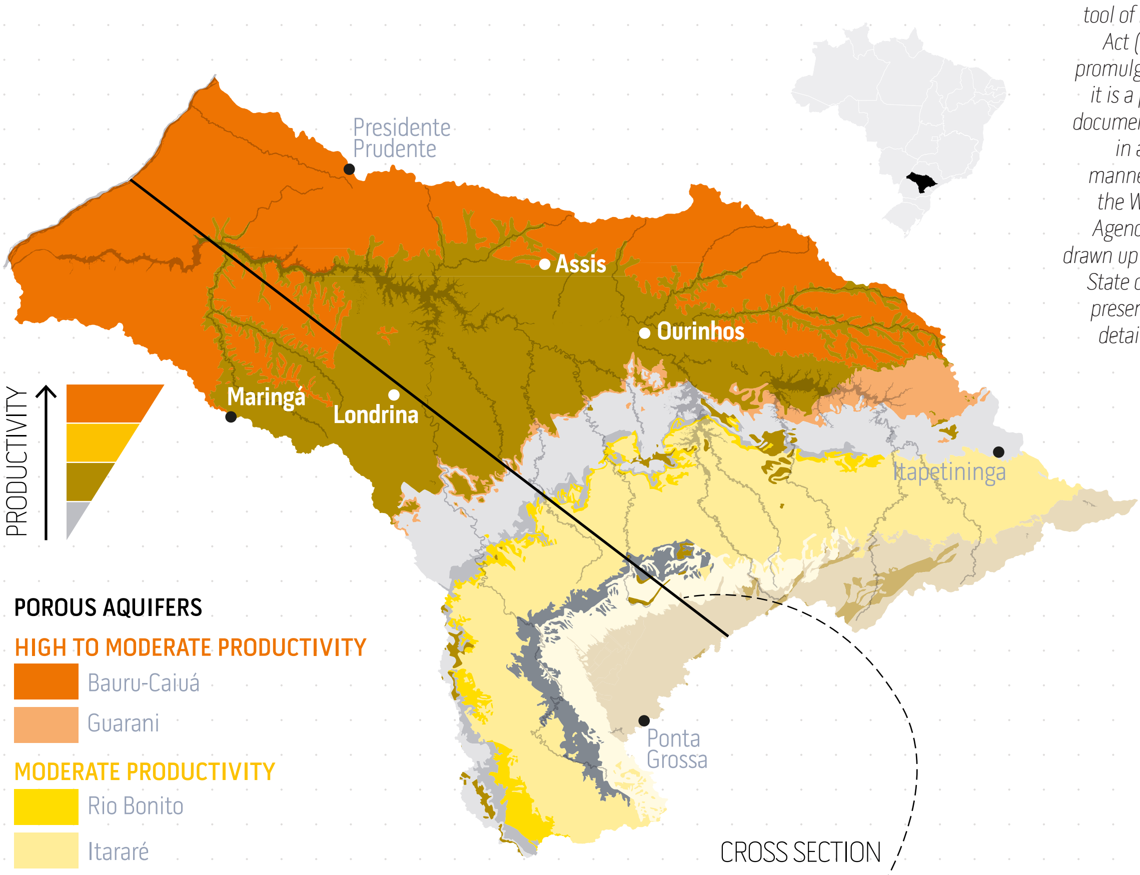
Fractured:
where the groundwater is stored and circulates through cracks in rocks, called secondary porosity

Porous:
where water circulates and is stored in rock pores, called primary porosity

Karstic:
where water storage and circulation depends mainly on dissolution, following cracks in carbonate rocks, also known as secondary porosity

OUTCROP AREAS OF AQUIFERS AND AQUIFER SYSTEMS BASED ON THE WATER RESOURCES PLAN OF THE PARANAPANEMA BASIN

The Water Resources Plan is a tool of Brazil's Waters Act (Law Nº 9433) promulgated in 1997; it is a programmatic document constructed in a participatory manner that defines the Water Resource Agenda and may be drawn up by river basin, State or country. It is presented in greater detail in Chapter 4.



POROUS AQUIFERS

HIGH TO MODERATE PRODUCTIVITY
- Bauru-Caiuá
- Guarani

MODERATE PRODUCTIVITY
- Rio Bonito
- Itararé
- Furnas

FRACTURED AQUIFERS

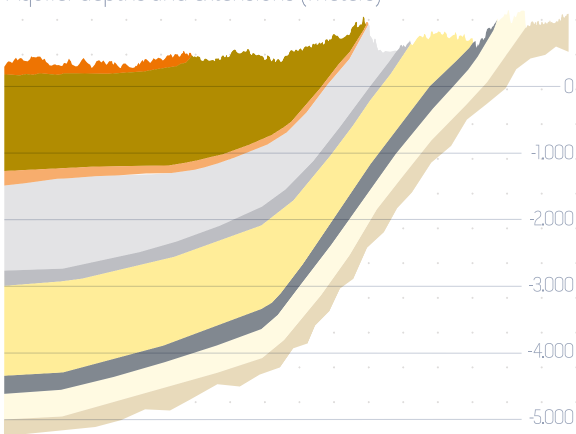
VARIABLE PRODUCTIVITY
- Serra Geral
- Paraná Basin Karst

LOW PRODUCTIVITY
- Center South Fractured

VERY LOW PRODUCTIVITY
- Passa Dois
- Palermo
- Ponta Grossa

HYDROGEOLOGICAL PROFILE

Aquifer depths and extensions (meters)



Access to groundwater data is provided through the **Groundwater Information System** (SIAGAS), which registers some of the wells located in Brazil.

SIAGAS was developed and is operated by the CPRM, which stores and provides access to geo-referenced data and information on wells in Brazil, accessible at: ***goo.gl/kGJAHT***.

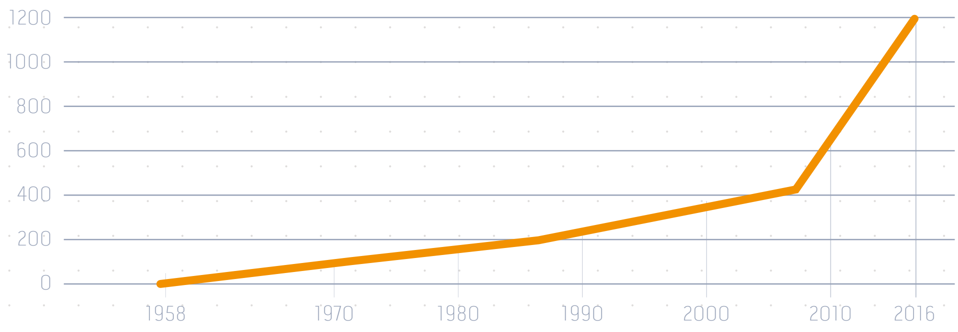
A survey conducted by the CPRM showed that some 40% of tubular wells were out of operation in Northeast Brazil in 2005, except in Maranhão State and including Northern Minas Gerais and Espírito Santo States. It is calculated that 15% of Brazil's tubular wells are out of operation, as the economic and hydro-geological contexts are generally more favorable than those found in the Northeast. As 1.2 million tubular wells were drilled after 1958, and assuming that percentage is correct, it is possible that around 180,000 wells are out of operation in the current well universe.

By January 2008, some 145,000 groundwater supply sources had been registered, almost all consisting of tubular wells. By October 2016, there were more than 278,000 registered wells. A new estimate of the number of tubular wells in Brazil hovers around 1.2 million, reflecting an annual increase of more than 22% over the 2008 estimates.

The significant upsurge in the number of wells drilled in Brazil is influenced, among other factors, by water shortages over the past few years, as well as reviews of the 2008 estimates by the States. It must be stressed that the construction of tubular wells does not necessarily indicate that they are actually **in use.**

INCREASE IN THE ESTIMATED NUMBER OF WELLS IN BRAZIL

In million



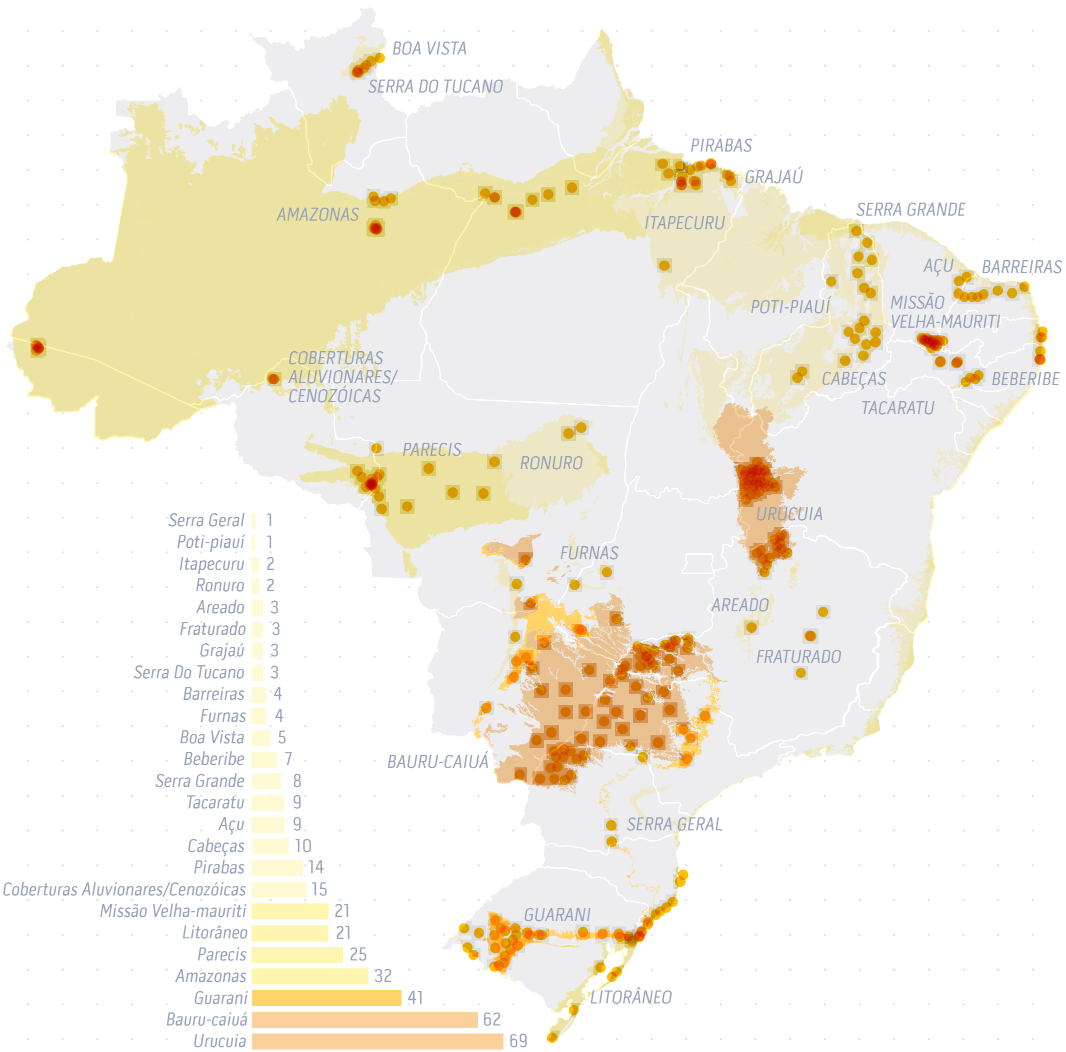
Some States have **groundwater monitoring networks**, particularly São Paulo, where these activities began in 1990. Its network encompasses 180 wells, where forty physical, chemical and biological parameters are monitored half-yearly. In Rio Grande do Norte State, groundwater has been monitored since 2010, with the number of wells ranging between 100 (when monitoring began) to 81, underpinned by field experience, prioritizing aspects related to aquifers, access, on-site structures and well types. Monitoring began in the Distrito Federal in 2013, with half-yearly static level metering and measurements of eleven water quality parameters. The network consists of 42 pairs of wells, one of which is always shallow (up to 30 meters) alongside a deep well (up to 150 meters). In the Verde Grande, Riachão and Jequitaí River basins in Minas Gerais State, a water quality monitoring network was implemented in 2004, with 74 parameters measured half-yearly, and plans to install forty monitoring points in the Velhas River basin. There have been five monitoring points in the Guarani Aquifer since 2008.

The CPRM has been implementing the **Integrated Groundwater Monitoring Network** (RIMAS), which may in future be upgraded to a national network, through integrated action among different institutions. In general, **groundwater monitoring** in Brazil is still fairly incipient. It is important for current monitoring programs to continue, with new wells being included, in order to upgrade data quality. At the regional level, there is a proposal for a specific monitoring network with 180 points in the Guarani Aquifer System, under the aegis of the Environmental Protection and Sustainable Development Project for this aquifer (PSAG), which has not yet been implemented.

The Integrated Groundwater Monitoring System is essentially quantitative, measuring water levels daily with quarterly measurements of electrical conductivity and temperature, with chemical analyses for the other 43 parameters conducted over five years. By 2016, this Network had collected seven years of data on 379 wells.

In 2010, the CNRH approved the guidelines for setting up the National Integrated Qualitative and Quantitative Groundwater Monitoring Network, with jurisdiction shared out between ANA, CPRM and States. The initial planning for this network took place on 2011, but its implementation has not yet moved ahead.

DISTRIBUTION OF 374 RIMAS MONITORING STATIONS BY AQUIFER



An example is the study evaluating aquifers in the Amazonas Hydro-Geological Province, Coordinated by ANA in the Macapá, Porto Velho, Rio Branco, Santarém and Tabatinga urban areas, estimating reserves in the aquifers supplying these areas and analyzing water quality. In some samples, nitrate levels exceeded drinking water limits, together with total coliforms and Escherichia Coli, indicating contamination, due mainly to the lack of basic sanitation.

The manner in which rocks store and convey water directly influences **groundwater quality**. In general, groundwater is of good quality in Brazil, with physical, chemical and bacteriological properties that are appropriate for a wide variety of uses, including mineral water consumption. However, human activities have adversely affected some aquifers to a significant extent. Although there are no systematized projects assessing water quality and contamination in Brazil, **published papers** have attempted to categorize contaminated areas, indicating that the main pollutants are nitrate (the most common), oil products (particularly gasoline and chlorinated solvents) and heavy metals, together with pathogenic bacteria and viruses.

The widespread occurrence of nitrate is blamed on the lack of sewage networks in urban areas and the use of nitrogenated fertilizers in rural zones. Nitrates are highly mobile in groundwater and may contaminate extensive areas. Pesticides may also pollute groundwater, particularly when agricultural activities are intensive in aquifer replenishment areas. Oil products come mainly from leaking fuel tanks in gas stations, while chlorinated solvents and heavy metals are due to the improper disposal of solid wastes in garbage dumps all over Brazil. The presence of viruses and bacteria is also quite common in wells that have been badly built and/or poorly maintained.

Off-standard wells bored at unsuitable locations may open up connecting cracks between shallow waters that are susceptible to contamination and deeper waters that are less vulnerable to pollution. This is a matter of great concern in outlying urban areas where the absence of basic sanitation results in supply wells alongside cesspits. Abandoned and deactivated wells must be properly sealed, thus avoiding aquifer contamination.

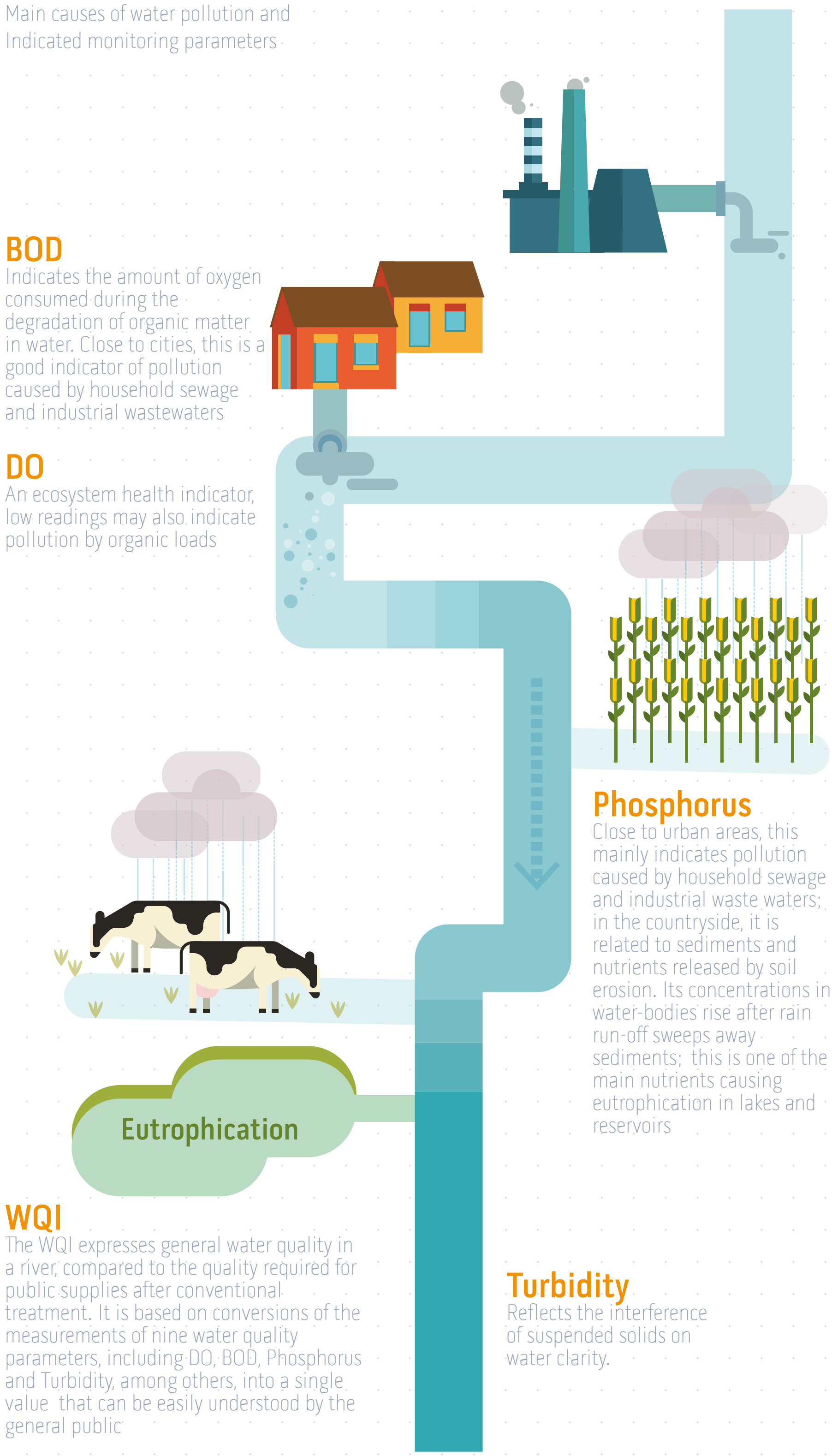
Specific sources of contamination may be identified individually, such as discharges of industrial wastewaters or domestic sewage. Nonpoint sources are harder to quantify, due to their broadly-dispersed origins, in addition to varying widely over time. Load dynamics are closely linked to rainfall regimes and are generally associated with water pollution caused by rainfall run-off in urban settings, or soil erosion and swept-away sediments carrying potential pollutants in rural areas.

Similar to groundwater, **surface water quality** in rivers, streams and lakes is a determining factor in its availability for a wide variety of uses, including human supplies, recreation, food production and industrial purposes. Surface and groundwater quality is also dependent on natural variables linked to rainfall regimes, for example, as well as surface run-off, geology and vegetation cover, as well as anthropic impacts such as discharges of liquid wastes from **point and nonpoint sources**, soil management and other aspects.

Water quality has massive effects on public health and, in a broader sense, on the quality of life of the population. Good quality water is essential for ensuring ecosystem health. During the hydrological cycle, water flows through water-bodies in a river basin, becoming available to human beings and acquiring the characteristics that define its quality. The conservation status of water sources and their surrounding ecosystems is a determining factor for water quality.

MAIN CAUSES OF WATER POLLUTION AND INDICATED MONITORING PARAMETERS

Main causes of water pollution and Indicated monitoring parameters



The classification of water bodies according to water quality objectives is among the instruments established in the Waters Act (Law Nº 9,433 promulgated in 1997) for ensuring water quality compatible with their diverse intended uses and controlling water pollution through permanent preventive actions. This instrument is addressed in detail in Chapter 4.

Monitoring water quality allows the identification and evaluation of trends in river basins. There are several ways of evaluating water-body quality. Physicochemical and biological parameters in surface water samples collected from rivers and reservoirs are widely used as **water quality indicators**. In Brazil, the levels and concentrations of several indicators are used as standard benchmarks for **classifying water-bodies according to water quality objectives**. The States and ANA operate monitoring networks based on these indicators.

In 2016, Brazil's National Water Monitoring Network encompassed 1,652 water quality monitoring stations in all States. This network monitors basic quality parameters such as pH, temperature, DO, turbidity and conductivity.

In addition to the National Water Monitoring Network, there are also State monitoring networks set up specifically to monitor water quality. Most of other them were designed to detect trends at strategic locations and/or with current or potential quality problems.

This report uses data from 118,457 water quality samples collected between 2001 and 2015 in the States. The following parameters were analyzed individually: Phosphorus (P), Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO) and Turbidity. These analyses were based on the mean values obtained for the years between 2001 and 2015, together with the Water Quality Index (WQI), which clusters several indicators together. Trend analyses are based on the mean annual values of this Index.

In 2015, there were more than 2,700 water quality monitoring points in operation in seventeen States. The monitoring networks operated by the States function independently, producing essential information with their own specific sampling frequencies and parameter sets.

In general, at monitored locations, degraded water quality hotspots are particularly noteworthy in major urban hubs and reservoirs in Northeast Brazil, which are rated as top priority for water pollution control and water sources protection.

In spite of the large number of water quality monitoring sites, there are still huge information gaps in Brazil. Some States have not implemented their water quality monitoring networks and, in some cases, the existing monitoring present problems in terms of spatial and temporal representativity. Nationwide, there are striking differences among the States in terms of operating capacities, as well as the ability to disclose and provide monitoring results. Some actions have been taken in order to solve these problems, such as the **National Water Quality Assessment Program** (PNQA), **the National Water Quality Monitoring Network** (RNQA) **and the Water Quality Data Disclosure Incentive Program** (Qualiágua).

The PNQA strives to build up knowledge of surface water quality in Brazil. In addition to ANA, it involves other institutions engaged in monitoring activities, especially State water resource and environmental entities.

Launched by ANA in July 2014, the Qualiágua - Water Quality Data Disclosure Incentive Program embodies all the components of Brazil's National Water Quality Assessment Program: the National Water Quality Network (RNQA); Standardization; Laboratories and Training; and Data Assessment. This Program is intended to ensure the financial sustainability of RNQA operations in the States through rewards for attaining goals related to the monitoring network evolution goals.. Its activities must be implemented without adversely affecting monitoring activities already in place. By 2016, 23 States and the Distrito Federal had already applied to sign up with this Program.

The National Water Quality Network was based on a methodology developed by ANA, defining the allocation of monitoring points according to streamflows and significant point sources of effluents, in order to define the most appropriate point density and monitoring frequency.

Biochemical Oxygen Demand (BOD) indicates the amount of oxygen consumed in biological processes that decompose organic matter in water. This is consequently an indicator of organic loads in water-bodies. Organic loads resulting from untreated domestic effluents strongly influence the BOD, particularly in small streams and rivers with reduced self-cleansing capacity. Industrial wastewaters may also contain high organic loads, depending on the processes involved. In both situations, BOD levels may be lowered through appropriate liquid wastes treatment and control.

BOD is generally measured in the laboratory. The amount of organic matter is estimated on the basis of oxygen consumption by microorganisms in samples under controlled conditions.

In urban areas, leachate – a liquid effluent that drains from a landfill – also may increase BOD in contaminated water-bodies through the interface between surface and groundwaters. In the countryside, agricultural activities may also produce significant organic loads. Where livestock is raised in confinement, the resulting organic loads can be controlled through treatment or recycling to produce fertilizers.

BOD data obtained through water monitoring between 2001 and 2015 indicate that the highest concentrations are found mainly in metropolitan regions. Locations with increased BOD may also be noted at reservoirs in Northeast Brazil. Farming activities without proper management and discharge of domestic effluents may be associated with high BOD levels.

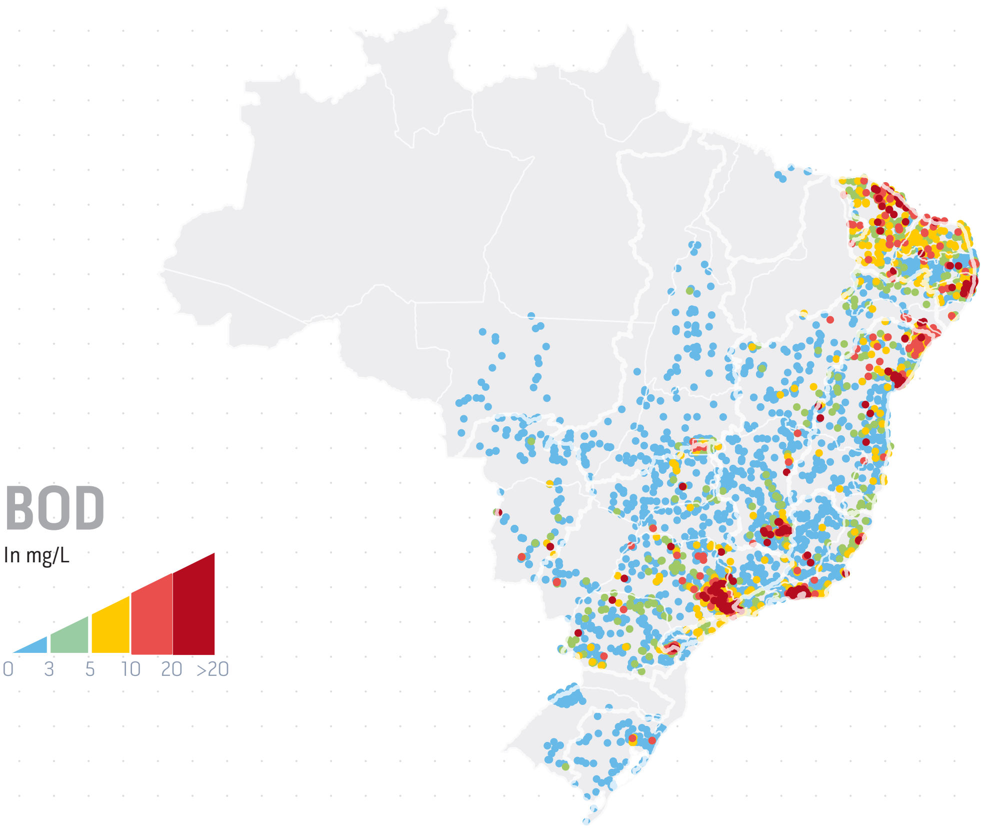
The concentration of **Dissolved Oxygen** (DO) in water is essential for the life cycles of fish and other aquatic organisms, as well as the proper functioning of aquatic ecosystems. DO levels indicate the health of these ecosystems, as oxygen is involved in practically all chemical and biological processes. Extreme DO deficits may lead to what are known as "dead rivers", where apparently no forms of life can observed any more. DO levels and water also indicate contamination by organic loads, which is why they are generally linked to BOD. Organic load discharges boost DO consumption by aerobic microorganisms during organic matter stabilization processes.

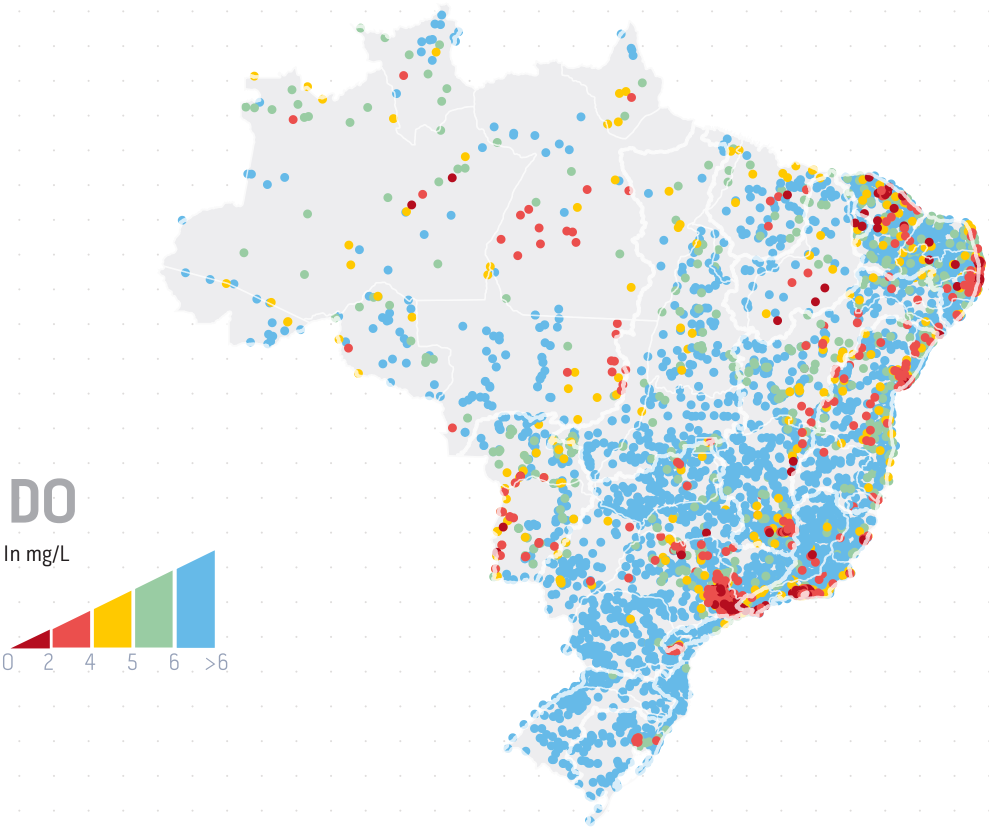
Mean DO concentrations in 2015 also highlight critical situations in metropolitan regions. The self-cleansing capacity of urban rivers absorbing massive inflows of organic matter from either industrial or domestic sources can be exceeded, sometimes causing large-scale **fish kills.** This phenomenon may also occur naturally, due to the decomposition of large amounts of organic matter.

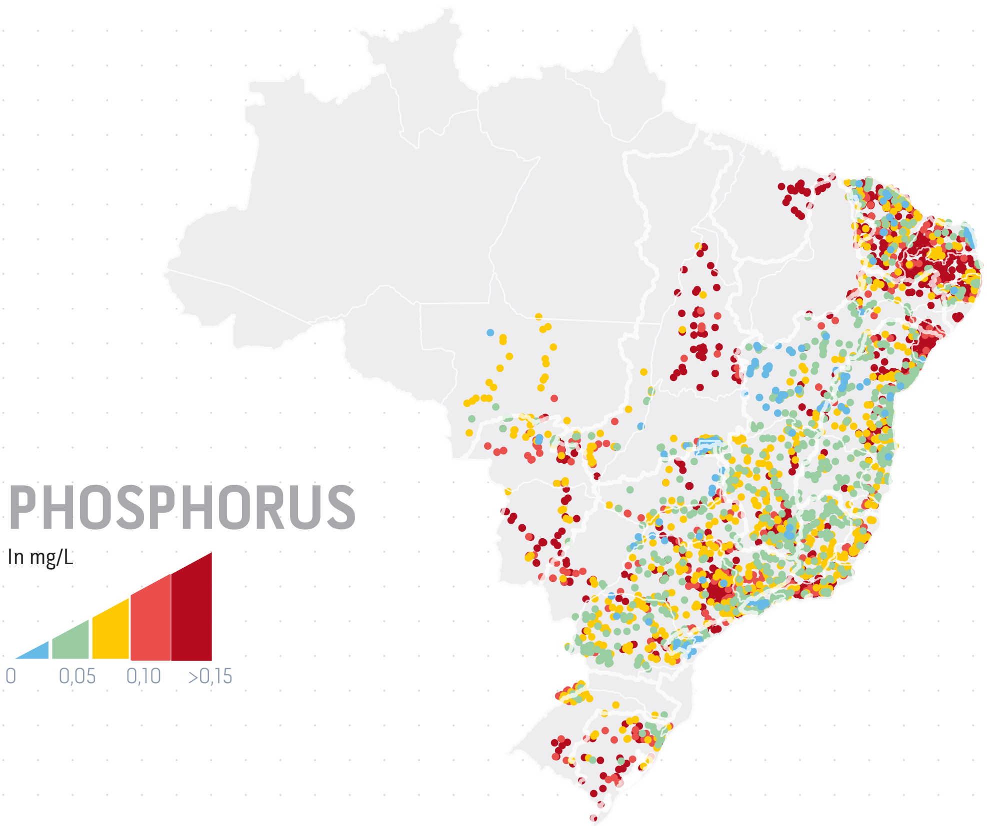
In the Pantanal wetlands of Mato Grosso do Sul States, monitoring points located along the Paraguay River indicate low DO concentrations, caused by a natural phenomenon locally known as the decoada. During this phenomenon, DO drops due to the decomposition of submerged vegetation during the lengthy flood season on this wetlands plain, which may result in wide-spread fish kills. Low DO concentrations resulting from the oxidation of organic matter may also be observed in the large rivers of Amazonia during the high-water season.

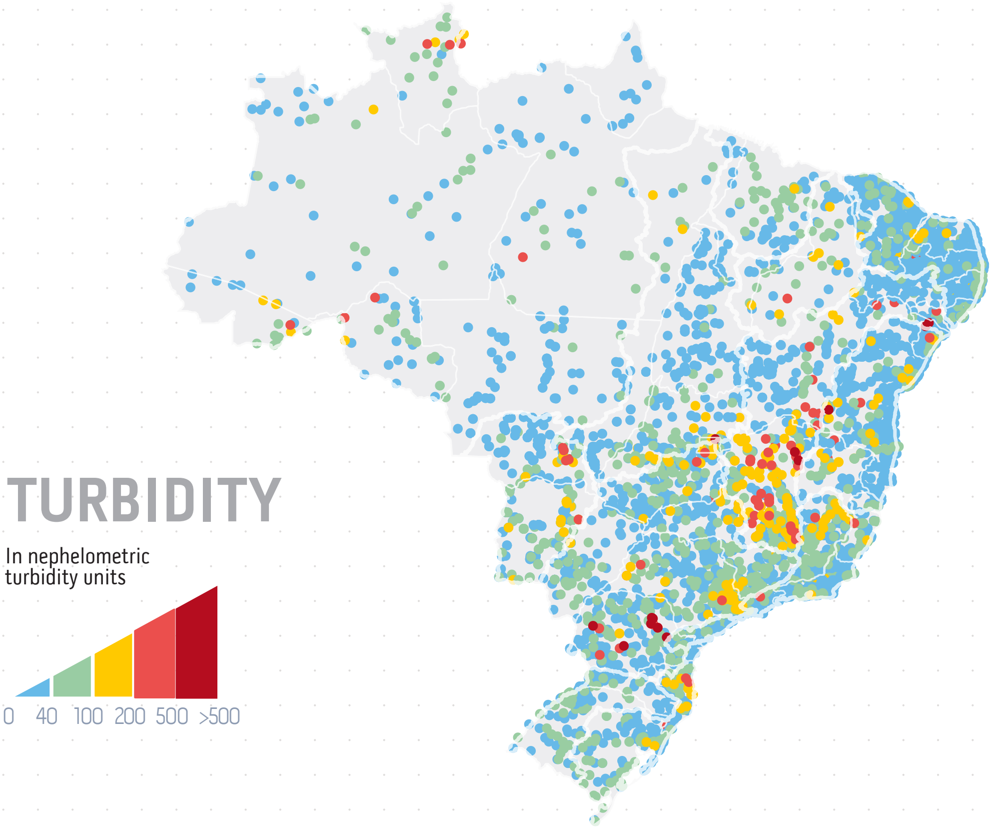
In urban areas, phosphorus concentrations in water indicate pollution caused mainly by domestic and industrial effluents, depending on the type of industry. In the countryside, **phosphorus** concentrations are generally associated with inflows of sediments and nutrients originating from erosion caused by inadequate soil management and the excess of fertilizers. In the latter case, phosphorus concentrations tend to rise after rain, when matter is swept away into water bodies.

Mean concentration between 2001 and 2015, at monitored points






PHOSPHORUS
In mg/L
0
0,05
0,10
>0,15


TURBIDITY
In nephelometric turbidity units
0
40
100
200
500
>500

Total phosphorus quality standards are different for running waters (lotic) ecosystems such as rivers and streams; still (lentic) waters such as lakes and reservoirs; and intermediate water-bodies that form transition zones between these two systems. Phosphorus standards are more stringent for lentic water, due to higher risks of eutrophication.

Eutrophication degrades water supplies intended for human use, with adverse effects on human health, as well as the use of inland waterways, hydropower generation, fishing and recreation.

Phosphorus tends to accumulate and cause problems in lentic **water-bodies** such as lakes and reservoirs. Plant and algae growth is normally limited by phosphorus concentrations under natural conditions. Excessive inflows of this nutrient may trigger excessive growth of aquatic flora, leading to ecosystem imbalance through **eutrophication**.

Total phosphorus concentrations were high between 2001 and 2015 at most monitoring points in metropolitan regions, due mainly to household sewage discharges. Even if treated, phosphorus reduction rates at sewage treatment stations generally tend to below in Brazil.

Phosphorus intakes from nonpoint sources in rural zones are associated with rainfall and surface run-off. The inflow of nutrients loads resulting from agricultural activities varies depending on the fertilizer application, which hampers the monitoring of into rivers and reservoirs. Consequently, detecting increases of phosphorus concentrations from these sources are highly dependent on sampling design and frequency.

Located mainly in reservoirs that are strategically important for public water supplies, monitoring points in the semi-arid region indicate high phosphorus levels, representing severe risks of eutrophication, particularly during lengthy dry periods, when phosphorus levels become more critical, such as during the drought assailing this region since 2012.

Turbidity reflects the interference of suspended solids on water transparency. It is thus a good indicator of the quantity of solids in suspension and, consequently, the erosion processes in a river basin. In towns and cities, rising turbidity usually reflects the discharge of domestic and industrial effluents from point sources, often associated with drainage infrastructures or loads originating from non-point sources. In rural areas, illegal occupancy of areas set aside to protect water resources, such as Permanent Preservation Areas, may result in higher turbidity. The transport of suspended solids and the resulting increases in turbidity are generally associated with rainfall and surface water run-off conditions. Turbidity may also indirectly indicate flows of nutrients into rivers, which are generally associated with sediments in suspension.

The natural color patterns of the water varies widely among different water-bodies, affecting water turbidity. This situation is particularly notable in the Amazon Region, where geology and vegetation endow water with different natural turbidity levels. In such cases, turbidity may not constitute a real problem for water quality.Where monitoring takes place, the mean turbidity results indicate some level of impairment in the upper São Francisco river basin. Most monitoring points indicate water that was less turbid in 2015, compared to the mean figures for the period between 2001 and 2015.

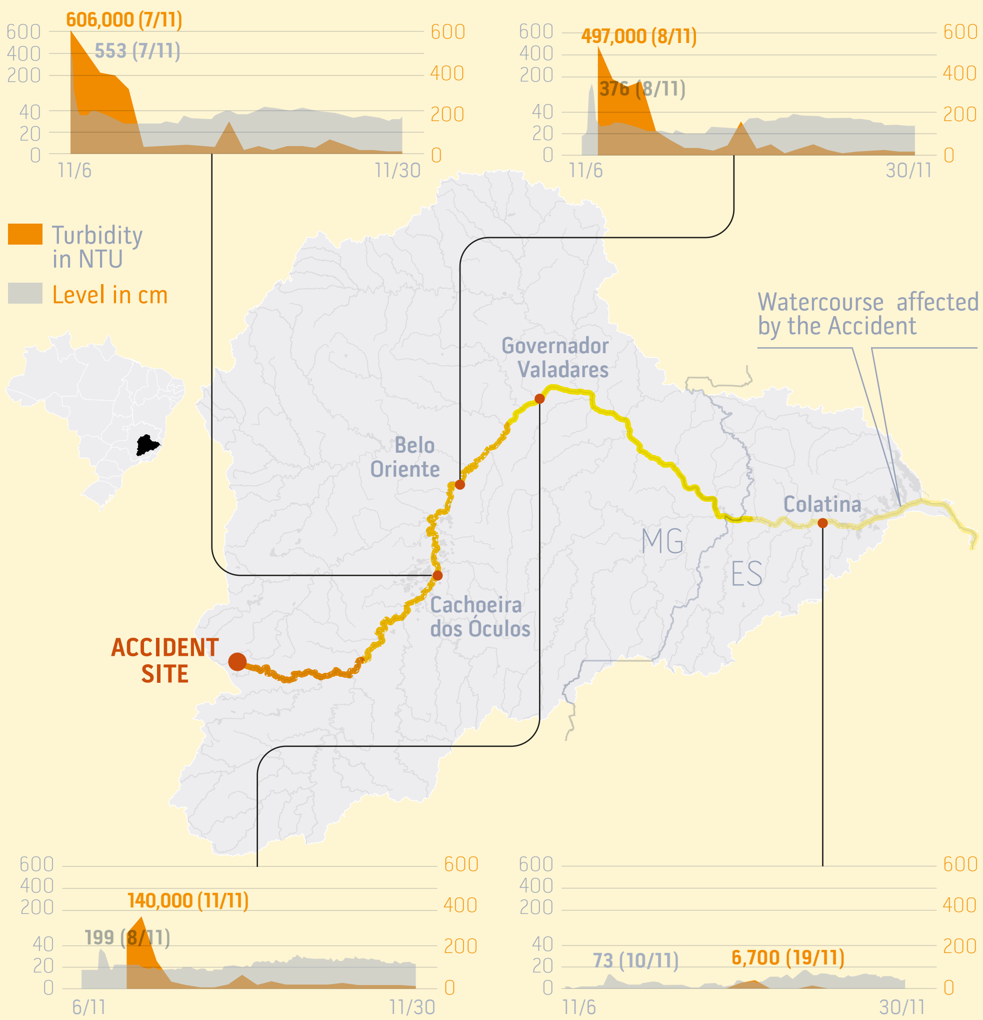
DISASTER AT MARIANA, MINAS GERAIS STATE

The breach of the **Fundão Dam** in Mariana, Minas Gerais State on November 5, 2015 released an estimated volume of 34 million m³ of tailings, with human lives lost and a wide variety of social, economic and environmental impacts in the Doce river basin. Torrents of mud and flooding caused by this collapse surged more than 650 kilometers to the mouth of the river on the Espírito Santo State coast. Heavy loads of sediments flowing into water-bodies in this basin halted water supplies to communities serviced by the Doce river, in addition to hampering water use for other purposes.

The special Supplement on the Mariana Dam Breach in the Doce River Basin, Minas Gerais State, was an integral part of the 2015 Brazilian Water Resources Report, describing the impacts of this event in detail. It is available at: ***bit.ly/2wqWKTB****. Special monitoring data for the Doce River are disclosed systematically by ANA at:* ***bit.ly/2vjg9pq***

The magnitude and dynamics of changes in quality were assessed by variations in the physical, chemical and biological parameters, measured by monitoring the affected water-bodies. Peak figures for turbidity and solids (dissolved, in suspension and total), together with dissolved iron, total manganese and heavy metals were recorded as the wave of tailings surged down the water-course. These peaks significantly exceeded the maximum figures for all these parameters in long-term monitoring datasets.

MONITORING TURBIDITY AND WATER LEVELS IN THE DOCE RIVER AFTER THE FUNDÃO DAM BREACH



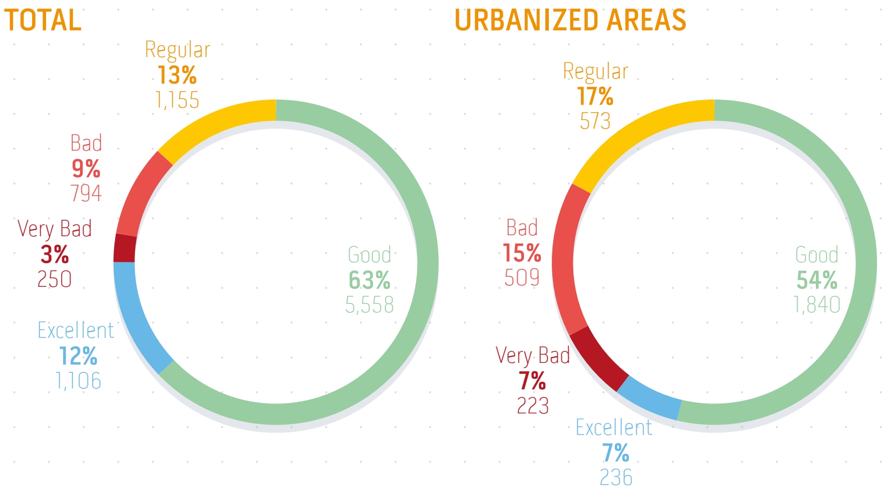
The Water Quality Index was developed in the USA in 1970, order to assess raw water intended for public supplies, after treatment. The São Paulo State Environment Company (CETESB) adapted this Index, used in its water quality analyses since 1975. In contrast, ANA has its own methodology, which is available at ***bit.ly/2umb52h***

Water Quality Index (WQI) is an indicator that simultaneously analyses **nine physical, chemical and biological parameters** rated as important for water-quality assessments, some of which have already been discussed: water temperature, pH, DO, BOD, heat-tolerant coliforms, total nitrogen, total phosphorus, total solids and turbidity.

Between 2001 and 2015, most monitoring points were rated as "Good" under this Index, with "Bad" or "Very Bad" scores for locations in water-bodies in major urban hubs. The São Francisco river has several monitoring points with "Regular" scores. In the Semi-arid region, several reservoirs also show some level of degradation, although this Index presents relatively better results in reservoirs due to pollutant dilution conditions.

The Water Quality Index is less useful when monitoring activities do not encompass all the parameters used in the calculation, curtailing the spatial scope of these analyses. Moreover, a parameter with very good results may conceal the poor results of another, masking a possible problem.

DISTRIBUTION OF WQI CLASSES



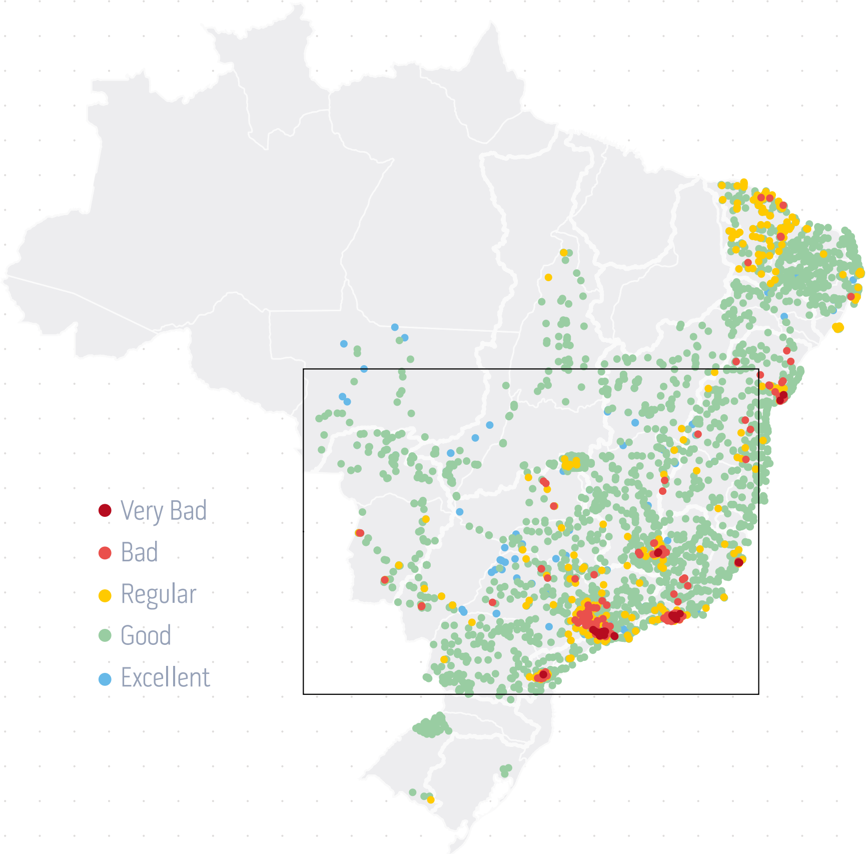
Water Quality Index values present an **uptrend** of increase at several monitoring points in Minas Gerais, Espírito Santos, Mato Grosso do Sul and principally São Paulo States. In counterpart, the WQI indicates downtrends in water quality scores in some parts of these States and, mainly, Mato Grosso.

Trend analyses were conducted in order to assess the progress of the WQI between 2001 and 2015. The statistical analysis used the Mann-Kendall test and included only monitoring points with ten or more annual mean figures for this Index.

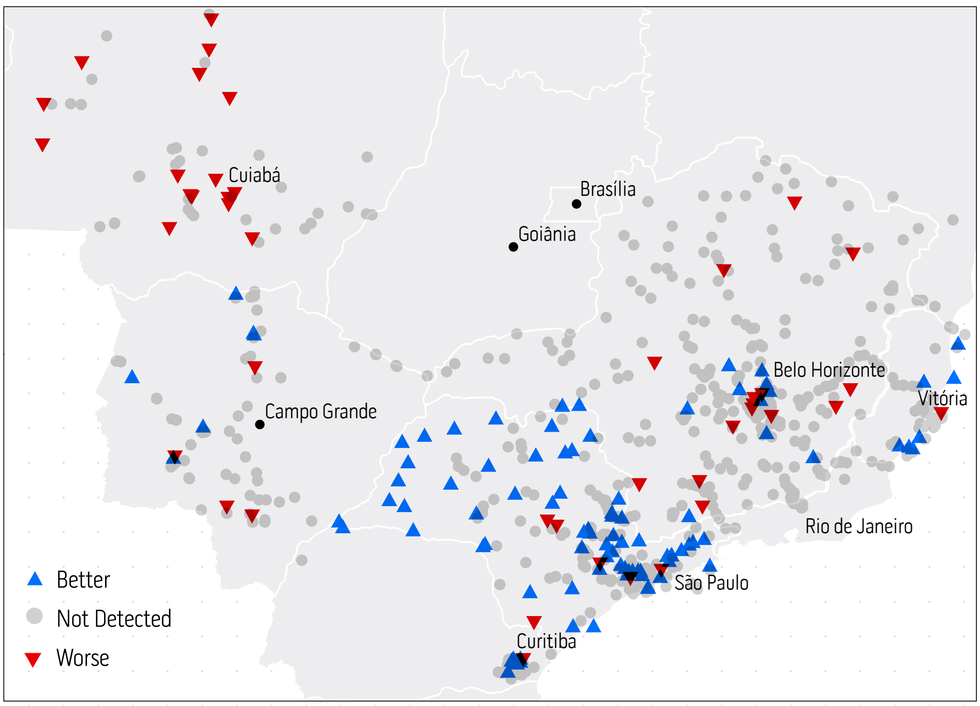
Several factors may help upgrade water quality. Advances in water pollution control, particularly through sewage treatment, drive better WQI scores, as this Index is relatively sensitive to pollution by household wastewaters. The same applies to fine-tuning industrial and agricultural pollution control, particularly in terms of soil management and pesticide use.

Climate variables such as prolonged changes in rainfall regimes and surface run-off may also affect this indicator, either positively or negatively, depending on the characteristics of the water-bodies in river basins. Regional economic dynamics are also associated with WQI trends over time. The expansion of potentially polluting activities without adequate control over water pollution may degrade water quality. On the other hand, improved water quality may reflect shrinkage in these activities, with resulting reductions in their pollutive potential.

WATER QUALITY INDEX: 2001 – 2015



WATER QUALITY INDEX: TRENDS



Brazilian Water Resources Report 2017

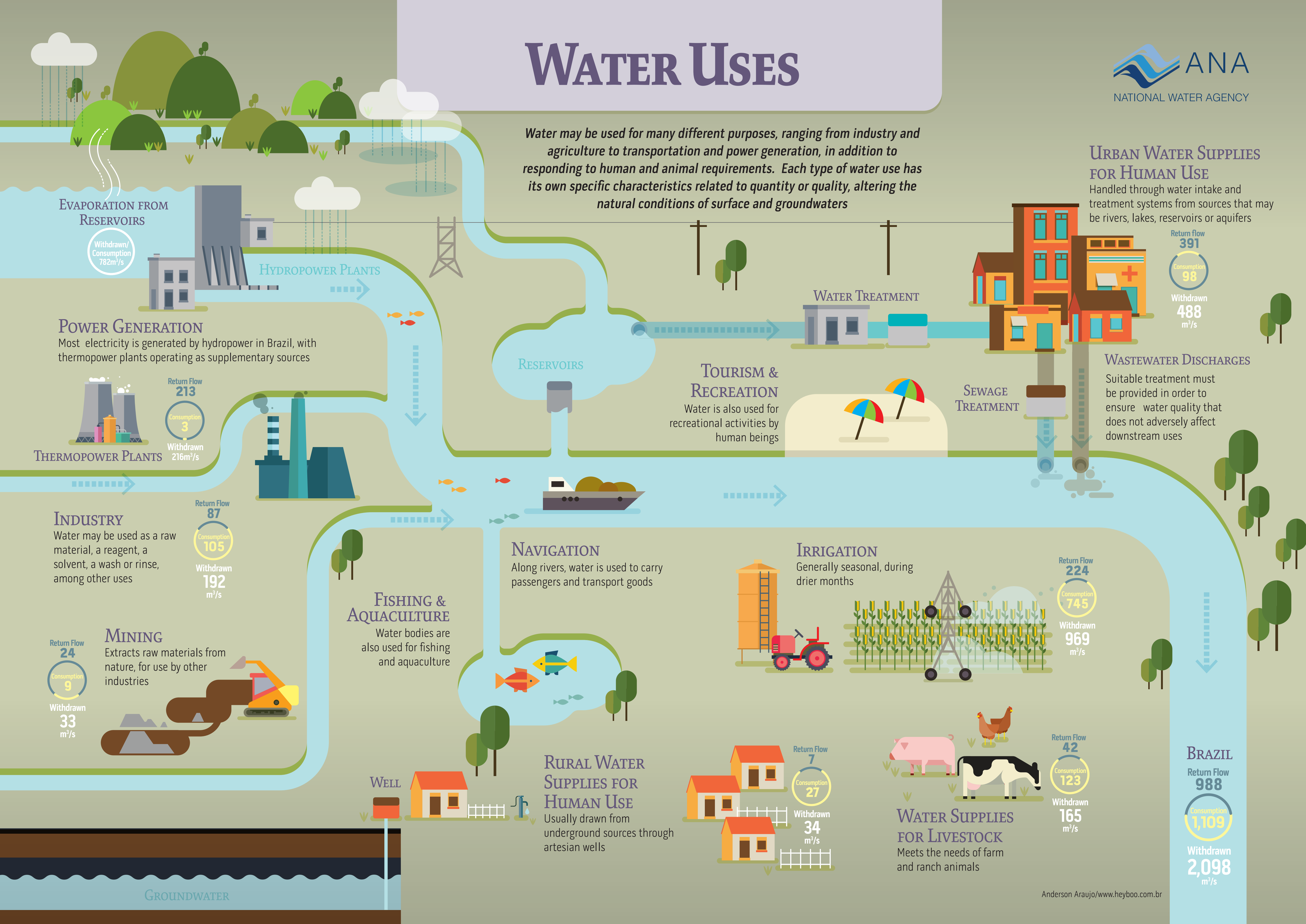
Chapter 3
Water Uses

Human activities and the modern economy require water resources, using water in a wide variety of ways.

After use, wastewaters are discharged at many different levels, in terms of quantity and quality.

Click on this tab to see the infographic that we have prepared for you to understand this, quite simply!

Open here



Water Uses
ANA
NATIONAL WATER AGENCY
Water may be used for many different purposes, ranging from industry and agriculture to transportation and power generation, in addition to responding to human and animal requirements. Each type of water use has its own specific characteristics related to quantity or quality, altering the natural conditions of surface and groundwaters
Evaporation from Reservoirs
Withdrawn/ Consumption 782m³/s
Hydropower Plants
Power Generation
Most electricity is generated by hydropower in Brazil, with thermopower plants operating as supplementary sources
Thermopower Plants
Return Flow 213
Consumption 3
Withdrawn 216m³/s
Reservoirs
Water Treatment
Urban Water Supplies for Human Use
Handled through water intake and treatment systems from sources that may be rivers, lakes, reservoirs or aquifers
Return flow 391
Consumption 98
Withdrawn 488 m³/s
Tourism & Recreation
Water is also used for recreational activities by human beings
Sewage Treatment
Wastewater Discharges
Suitable treatment must be provided in order to ensure water quality that does not adversely affect downstream uses
Industry
Water may be used as a raw material, a reagent, a solvent, a wash or rinse, among other uses
Return Flow 87
Consumption 105
Withdrawn 192 m³/s
Navigation
Along rivers, water is used to carry passengers and transport goods
Irrigation
Generally seasonal, during drier months
Return Flow 224
Consumption 745
Withdrawn 969 m³/s
Fishing & Aquaculture
Water bodies are also used for fishing and aquaculture
Mining
Extracts raw materials from nature, for use by other industries
Return Flow 24
Consumption 9
Withdrawn 33 m³/s
Well
Rural Water Supplies for Human Use
Usually drawn from underground sources through artesian wells
Return Flow 7
Consumption 27
Withdrawn 34 m³/s
Water Supplies for Livestock
Meets the needs of farm and ranch animals
Return Flow 42
Consumption 123
Withdrawn 165 m³/s
Brazil
Return Flow 988
Consumption 1,109
Withdrawn 2,098 m³/s
Groundwater
Anderson Araujo/www.heyboo.com.br

Water Uses

In Brazil, water is used mainly for irrigation, human and animal consumption, industrial purposes, power generation, mining, aquaculture, navigation, tourism and recreation. Knowledge of these uses is constantly extended through direct surveys, sectoral studies and user registrations.

Multiple water use compatibilization must take specific characteristics into account, as well as the different needs imposed by each type of use. For example, water quality is not important for navigation, but it requires minimum depths in order to ensure its feasibility. On the other hand, good water quality is essential for human supplies and also for recreational activities such as watersports, among other uses. The amounts of water used may be classified into:

Withdrawal: *means the total amount of water uptake for a specific use, such as water withdrawn for urban supplies.*

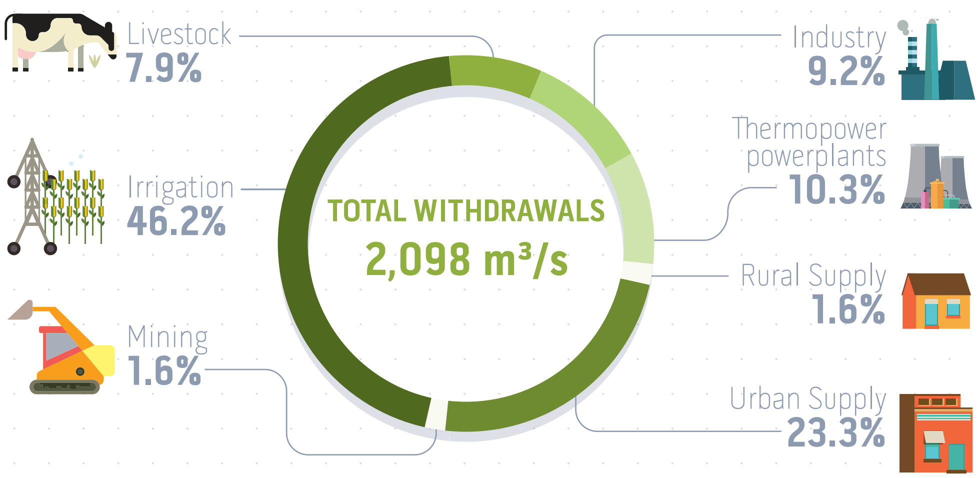
Consumption: *means withdrawn water that does not flow back directly into waterbodies. In a simplified manner, this is the difference between withdrawn water and return flows. For example: water withdrawn for urban supplies less water flowing back as sewage.*

Return flow: *this is the portion of water withdrawn for a specific use that returns to waterbodies. For example: sewage deriving from water use for urban supplies.*

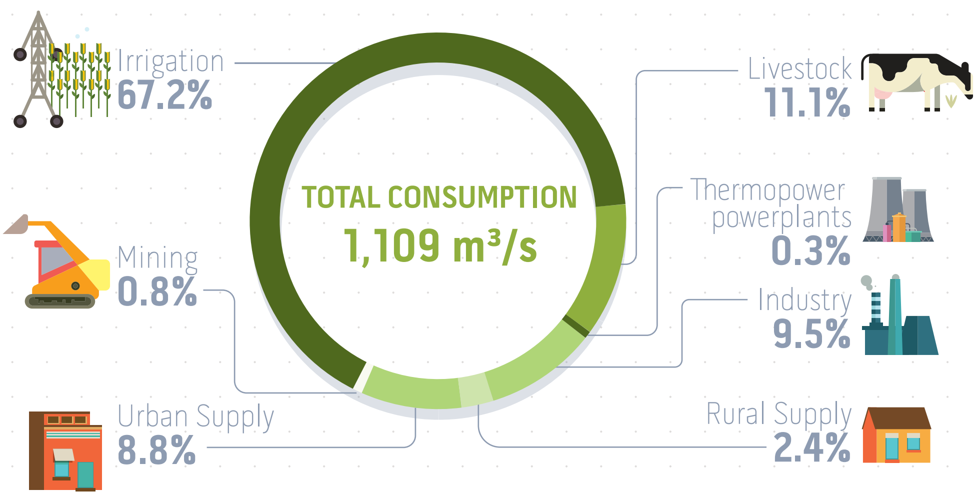
DEMANDS BY PURPOSE
(WITHDRAWAL, CONSUMPTION AND RETURN FLOW) IN BRAZIL IN 2016

Uses (m³/s)	Withdrawal	Consumption	Return
Irrigation	969.0	745	224
Urban Supply	488.3	97.7	390.6
Industry	192.4	104.9	87.4
Rural Supply	34	27	7
Mining	32.8	8.9	24.0
Thermopower	216.3	2.9	213.4
Livestock	165.1	123.0	42.2

TOTAL WATER WITHDRAWN IN BRAZIL (ANNUAL MEAN)



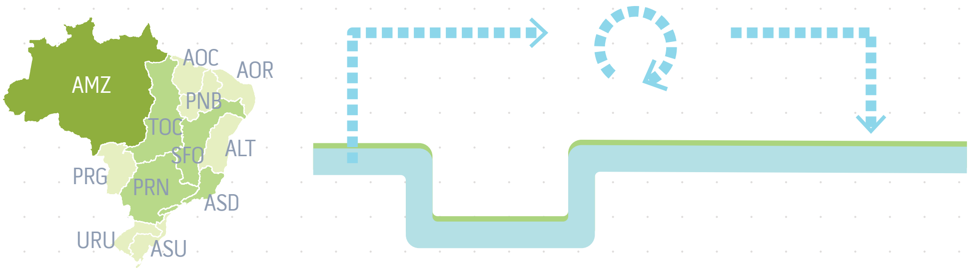
TOTAL WATER CONSUMED IN BRAZIL (ANNUAL MEAN)



Drawn up by ANA, the study of Water Consumption Uses in Brazil (Usos Consuntivos de Água no Brasil) prepared estimates of the main water uses over time (in the past and future projections) for all municipalities in Brazil.

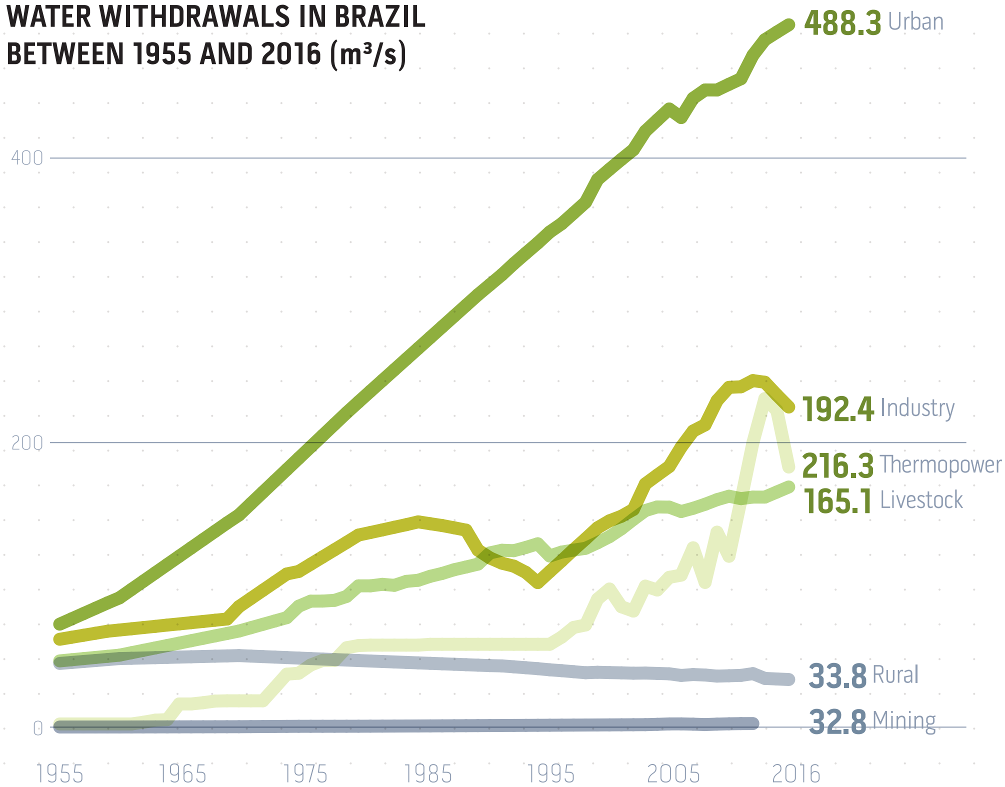
Water use demands in Brazil are rising, with an estimated increase of around 80% in total water withdrawals over the past two decades. The forecast is that withdrawals will increase by 30% through to 2030. The **track-record** of water use development is directly related to economic progress and Brazil's urbanization process.

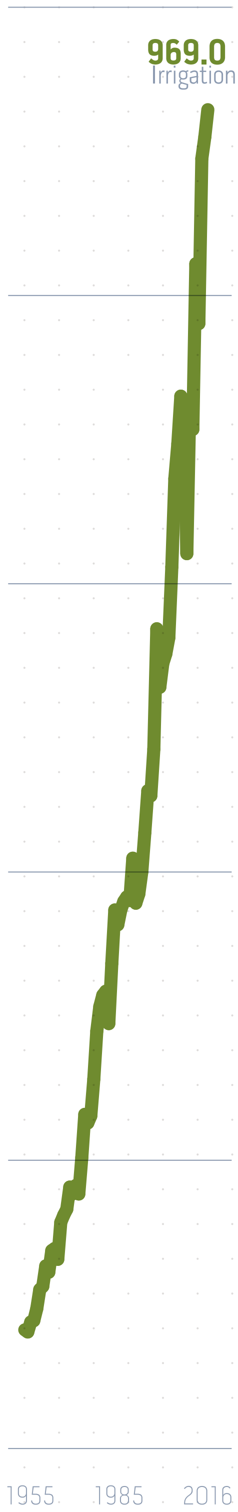
WATER WITHDRAWN, CONSUMED AND RETURNED BY HYDROGRAPHIC REGION IN 2016



Hydrographic Region	Withdrawal	Consumption	Return flow
Amazonia	124.77	44.55	75.32
East Atlantic	128.95	73.56	52.26
West Northeast Atlantic	27.58	11.72	14.91
East Northeast Atlantic	190.71	103.57	82.14
Southeast Atlantic	218.95	63.49	145.82
South Atlantic	333.43	175.10	175.50
Paraguay	31.86	15.68	15.23
Paraná	484.25	252.68	218.14
Parnaíba	23.22	13.84	8.85
São Francisco	226.66	164.06	59.54
Tocantins-Araguaia	126.36	74.11	54.34
Uruguay	181.04	117.05	87.00

WATER WITHDRAWALS IN BRAZIL BETWEEN 1955 AND 2016 (m³/s)



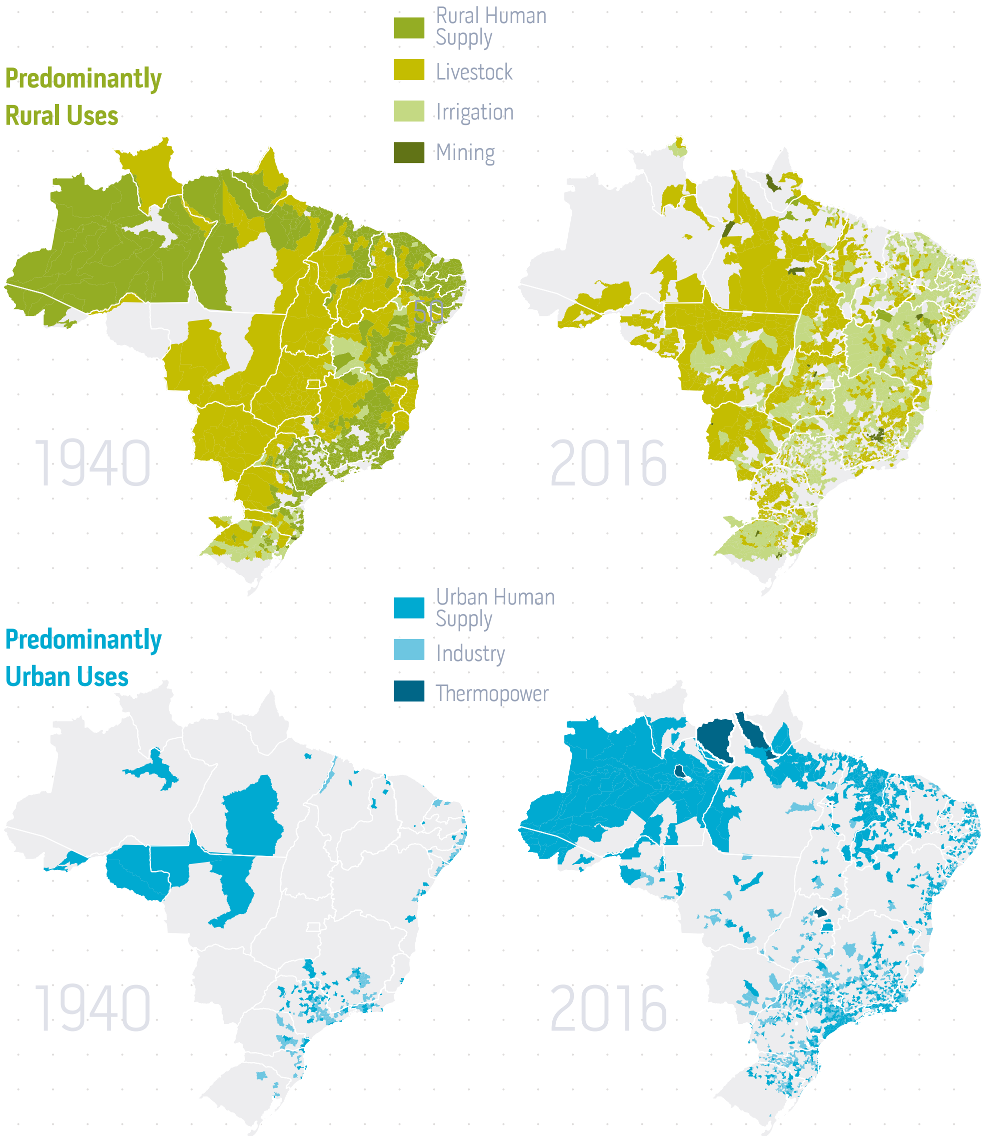


Since 2012, Brazil has been subject to a gradual but intense reduction in rainfall, particularly in the Northeast, the Southeast and, more recently, the Center-West. Other factors related to water demand management and supply guarantees are important, as they can worsen or ease the effects of this crisis. This issue is addressed in detail in Chapter 5.

During the 1940s, the preponderant use for water in all Brazilian States was for human consumption (both rural and urban). From then on, the industrialization process prompted a parallel increase in industrial use through to the mid-1980s, when stagnation held sway, followed by an upswing in expansion during the first decade of the second millennium. A slight dip in growth has been noted since 2012, related to the **water crises** assailing several regions in Brazil, in addition to the slowdown in Brazil's economic progress. From that year onwards, an increase was also noted in water used to generate thermopower, prompted by the need to bring complementary energy sources into operation, due to low water volumes available for hydropower generation in Brazil.

At the moment, **irrigation** is the main use of water in Brazil, in terms of quantities, through a set of agricultural techniques and equipment designed to offset full or partial shortages of water for crops, tailored to soil type, terrain, climate and the needs of each crop, in

PREPONDERANT WATER USES IN BRAZIL (1940 AND 2016)



addition to other variables. Irrigation normally provides additional water to supplement rainfall, allowing crops to be grown in drier regions such as the Semi-arid region or at locations with specific dry seasons, such as central Brazil.

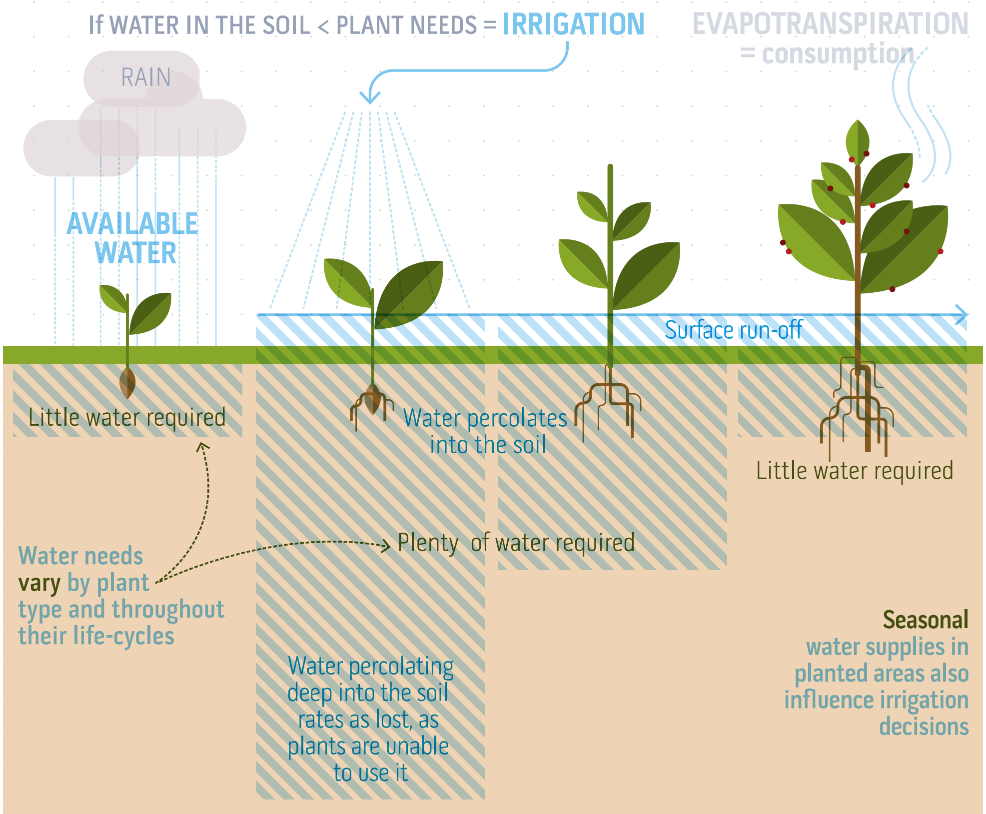
Agriculture initially flourished in Brazil in regions where rainfall distribution could respond to crop water requirements, particularly in terms of time and space. During the early XX century, irrigation was introduced for growing rice in Rio Grande do Sul State, becoming significantly more intensive in other parts of Brazil during the 1970s and 1980s, particularly the Northeast and **Center-West**. During the past few years, agriculture has expanded rapidly in the Cerrado savannas, endowed with appropriate characteristics for this activity.

In the Paranaíba river basin which runs into the Paraná River in parts of Goiás, Minas Gerais and Mato Grosso do Sul States, as well as the Distrito Federal, surveys conducted for the Water Resources Plan identified 608,000 irrigated hectares in 2010, which is twice the irrigated area recorded in 2006 through the Farming and Ranching Census conducted by the Brazilian Institute for Geography and Statistics (IBGE). Scenarios indicate that irrigated areas in this basin could reach 2 million hectares in 2030. These data may be accessed at: ***goo.gl/ncJQa1***

Total demands for water withdrawn for irrigation in Brazil reach 969 m³/s. This use is even more relevant when consumption is considered, as return flows directly into waterbodies are very low, compared to other uses.

This is because some of the water is absorbed by plants, while part evaporates and a portion percolates into the soil, with only minor amounts running off directly into waterbodies.

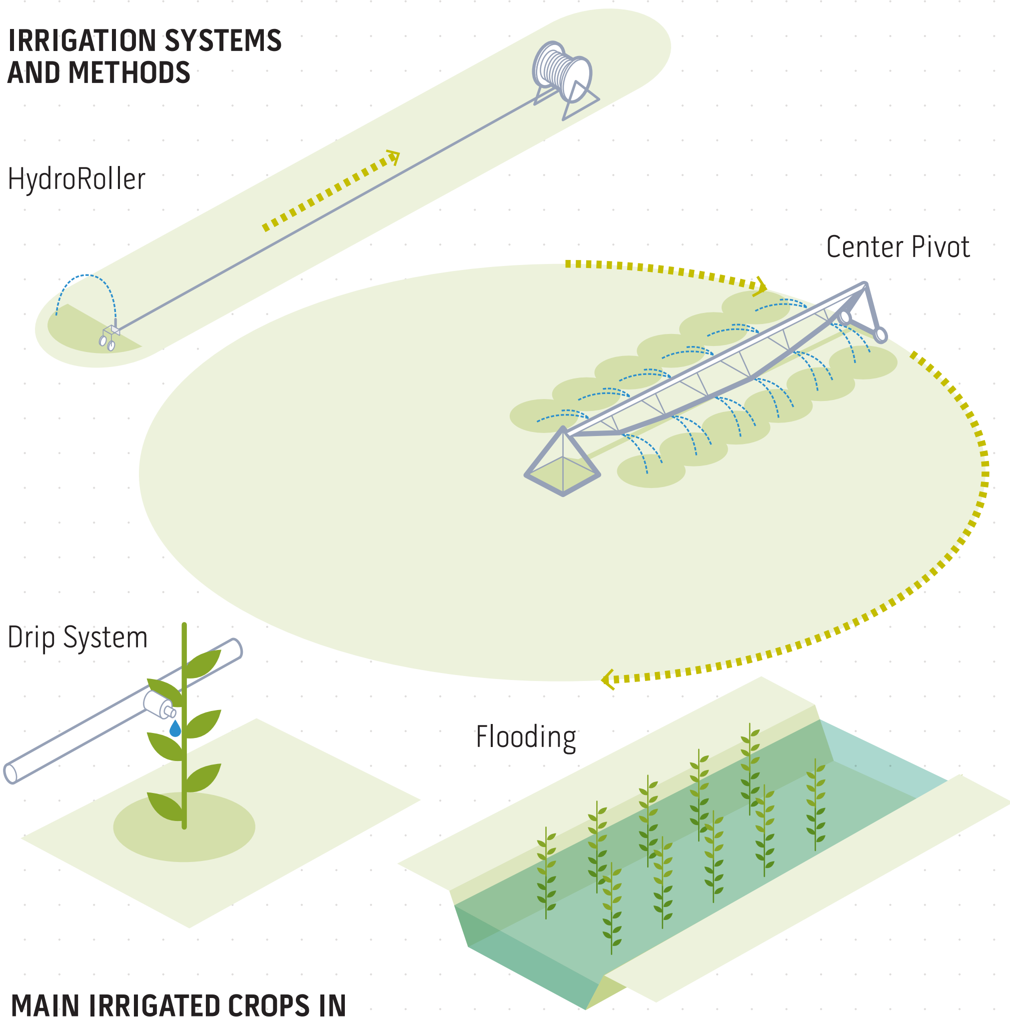
ESTIMATED WATER USE FOR IRRIGATED AGRICULTURE



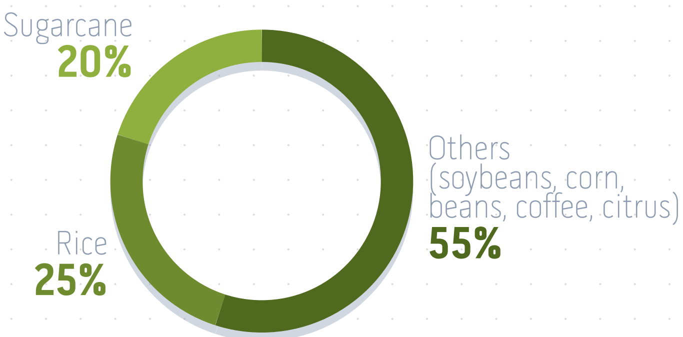
Irrigation methods may be clustered by the manner in which water is deployed, with four main options: surface, underground, sprinkling and localized. There are different systems for each of these methods, such as **center pivots** and Hydrorollers used for sprinkle irrigation, drip systems for localized irrigation, and flooding for surface irrigation. Hydrorollers are used mainly for irrigating sugarcane, while pivots are preferred for growing cereals, and flooding is generally used for rice irrigation.

In 2014, ANA and the Brazilian Agricultural Research Enterprise (EMBRAPA) conducted a joint survey of areas irrigated by center pivots in Brazil, based on satellite images. These data are available at: ***goo.gl/eNEJA9***.

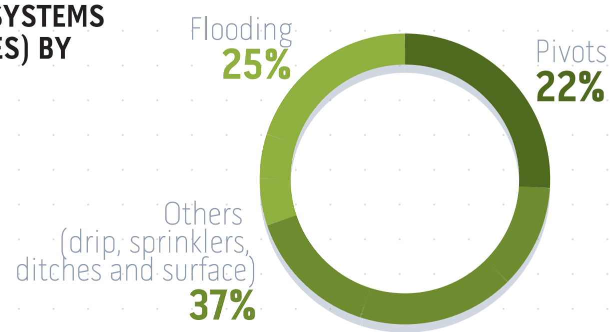
IRRIGATION SYSTEMS AND METHODS

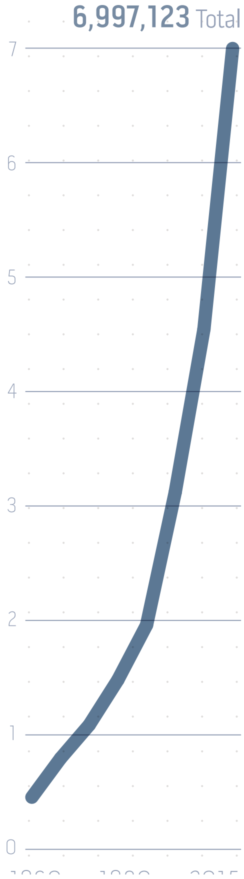


MAIN IRRIGATED CROPS IN BRAZIL (HECTARES)



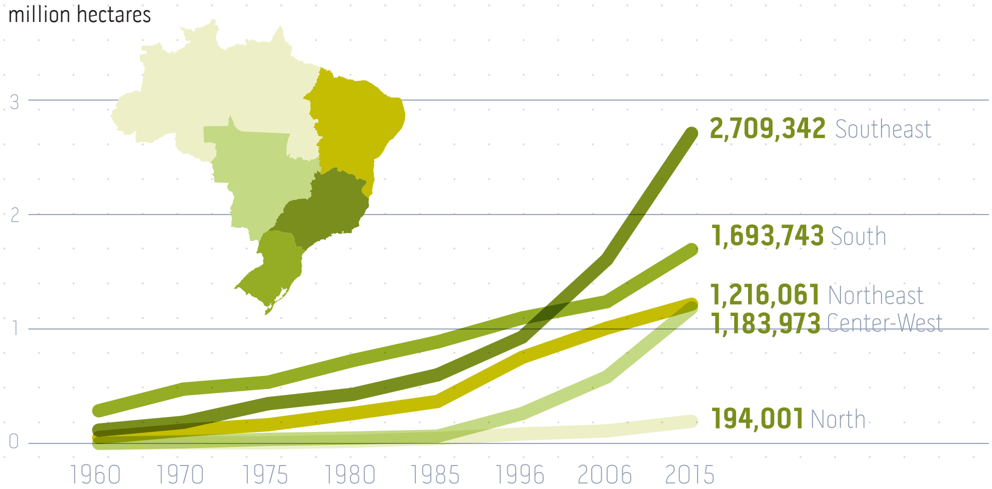
MAIN IRRIGATION SYSTEMS IN BRAZIL (HECTARES) BY IRRIGATED AREA



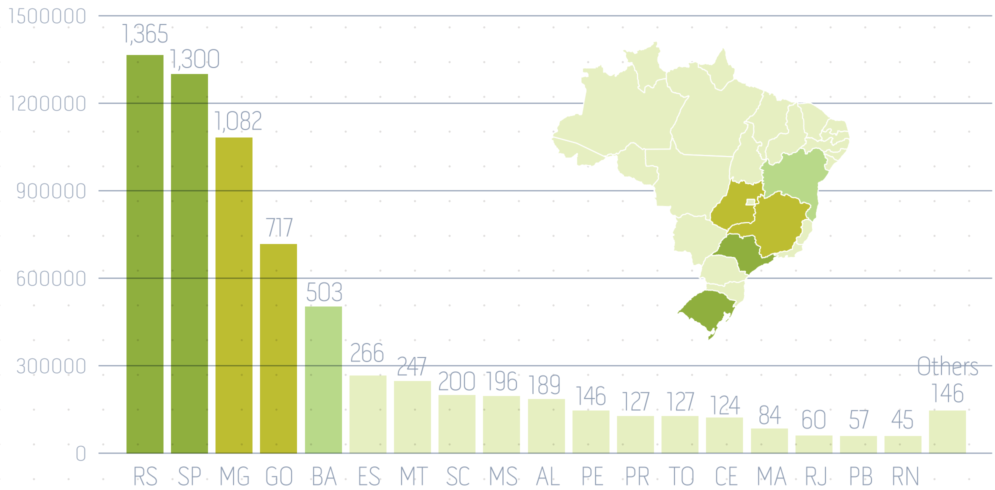


EXPANSION OF TOTAL IRRIGATED AREA BY GEOGRAPHICAL REGION

million hectares



Irrigated areas have been expanding in Brazil at mean rates of more than 4% a year since the 1960s. By 2015, Brazil was estimated to have 6.95 million irrigated hectares.



Irrigation data, including the methodology used to estimate irrigated areas, may be accessed in the Irrigation Atlas: Water Use for Irrigated Agriculture (Atlas Irrigação: Uso da Água na Agricultura Irrigada), available at: ***atlasirrigacao.ana.gov.br.*** *Referenced to 2015, the current diagnosis includes updates of earlier studies conducted by ANA, including studies of center pivot use and irrigated sugarcane, together with more recent data, in addition to reviewing census projections.*

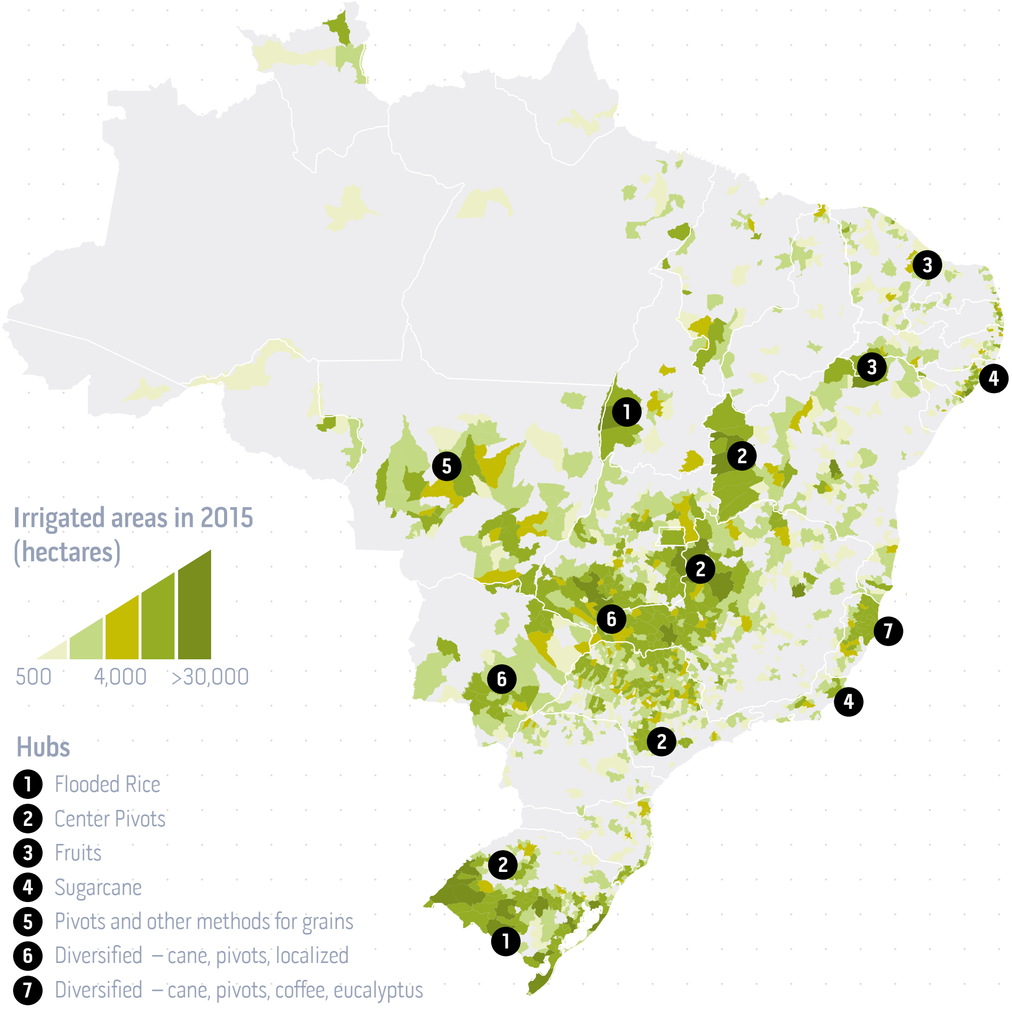
IRRIGATED AREAS IN BRAZIL IN 2015

Irrigated Rice

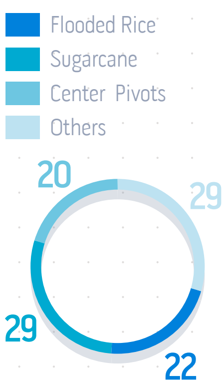
Sugarcane

Center Pivot

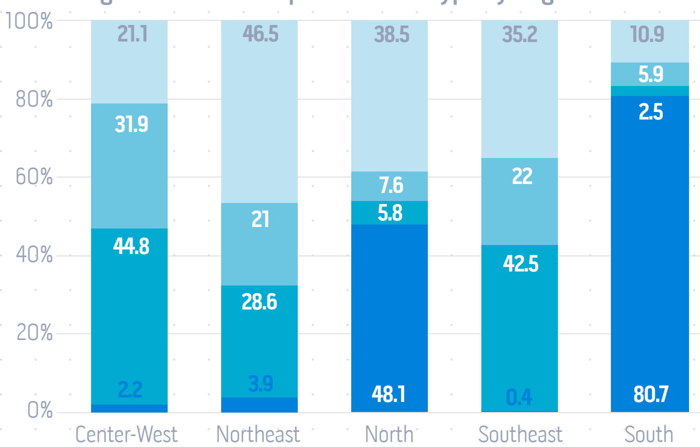
Others



Percentage distribution of predominant type



Percentage distribution of predominant type by Region



AGROCHEMICALS AND FERTILIZERS

Rising agricultural yields is prompting farmers to opt for technological packages that generally include more intensive use of **agrochemicals and fertilizers.** These products affect water resources and downgrade water quality.

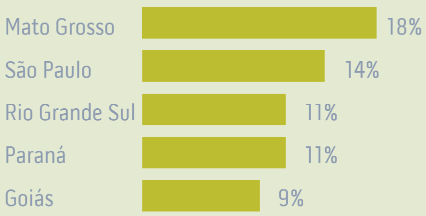
Data on planted areas in Brazil are provided by the Brazilian Institute for Geography and Statistics (IBGE) and are available at: https://sidra.ibge.gov.br. Information on agrochemical sales in 2004 was obtained from Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA) and may be accessed at: ***goo.gl/K7my4d****.*

However, many agricultural regions in Brazil are deploying more sustainable practices, such as no-till farming (minimum cultivation system), crop/pasture rotation, in addition to using biological agents to deal with pests, helping lessen agrochemical and fertilizer use.

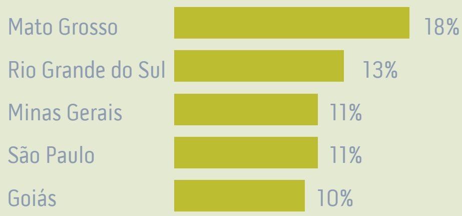
AMOUNT OF AGROCHEMICALS SOLD IN 2014

Planted area in Brazil (million hectares)

Agrochemicals sold
In 2014
508,556 tons

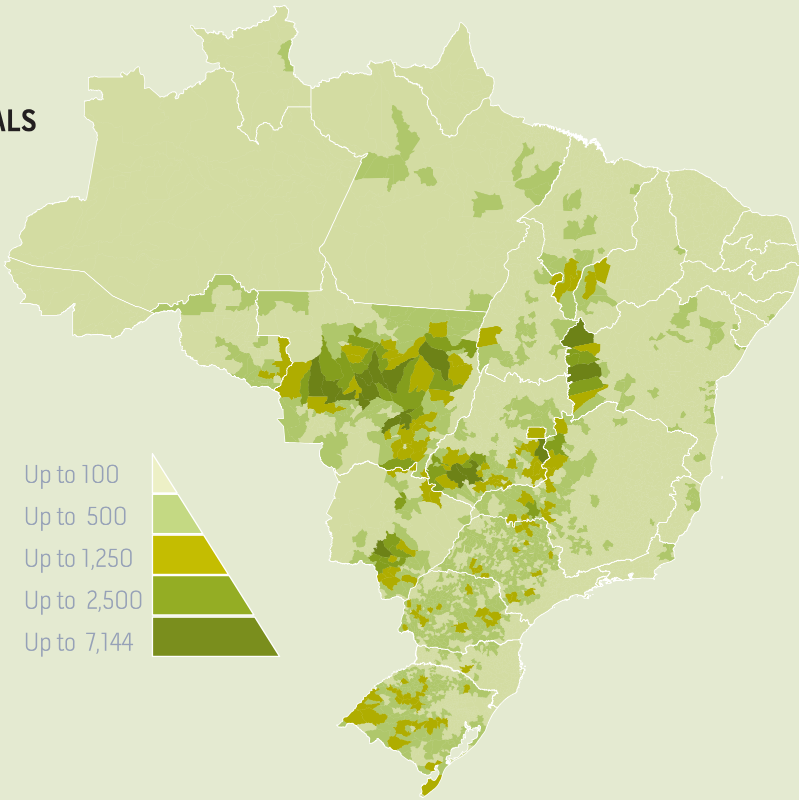


Fertilizers sold
In 2015
13 million tons



AMOUNT OF AGROCHEMICALS SOLD IN 2014

Tons



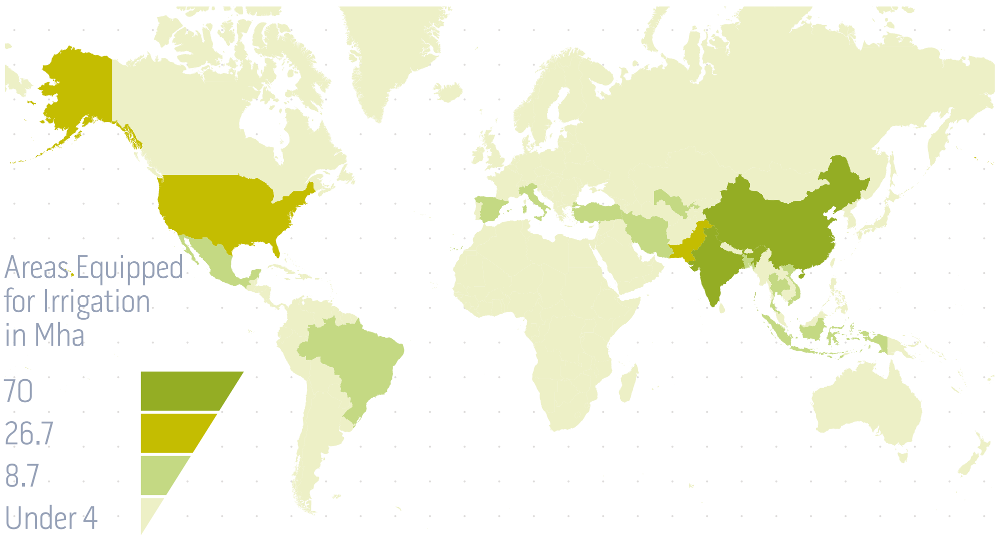
Data on areas equipped for irrigation were published in 2017 by the UN Food and Agriculture Organization (FAO) and are available at: ***goo.gl/EiU9fr***.

In general, the expansion of irrigation steps up water use. On the other hand, investments in the sector also trigger a substantial upsurge in productivity and output value, easing pressures on opening up new croplands.

Brazil is among the ten countries with the world's largest **irrigation-equipped areas**. The global leaders are China and India, each with around 70 million hectares (Mha). In Brazil, irrigation is rated as minor, compared to its estimated potential and total agricultural area, the size of its landmass and a set of favorable physical and climate factors, including ample water availability. This context contrasts with situations in other countries that are leaders in irrigation, which are generally approaching full effective full use of their estimated capacity.

In 2014, the Ministry of National Integration (MI) assessed the irrigable areas that could be added in Brazil, based on water demands from major crops, water balances and areas available for farming and ranching activities. This information is available at: ***goo.gl/WhTw8h***.

AREAS EQUIPPED FOR IRRIGATION WORLDWIDE



A further 76 million irrigated hectares may also be added, when considering the irrigable potential of Brazil. The Center-West Region is noteworthy for holding 43.1% of areas with high irrigation aptitudes, and 34.2% of areas with mid-to-high irrigation aptitudes.

Impairment of water availability resulting from water uses is the outcome of water balance analyses that provide input for defining special-interest management basins, also known as critical basins. This issue is addressed in Chapter 5.

Of this total, it is estimated that the effective potential is 11.2 Mha, encompassing areas with the greatest aptitudes and conditions for developing activities over the medium term. The Irrigation Atlas estimated that 3.14 Mha will be included by 2030.

Historical datasets indicate annual increases for irrigated areas in Brazil over the past few decades, particularly during the last few years, reflecting better use of this potential each year. **This increase requires planning and control actions designed to minimize disputes over water uses.**

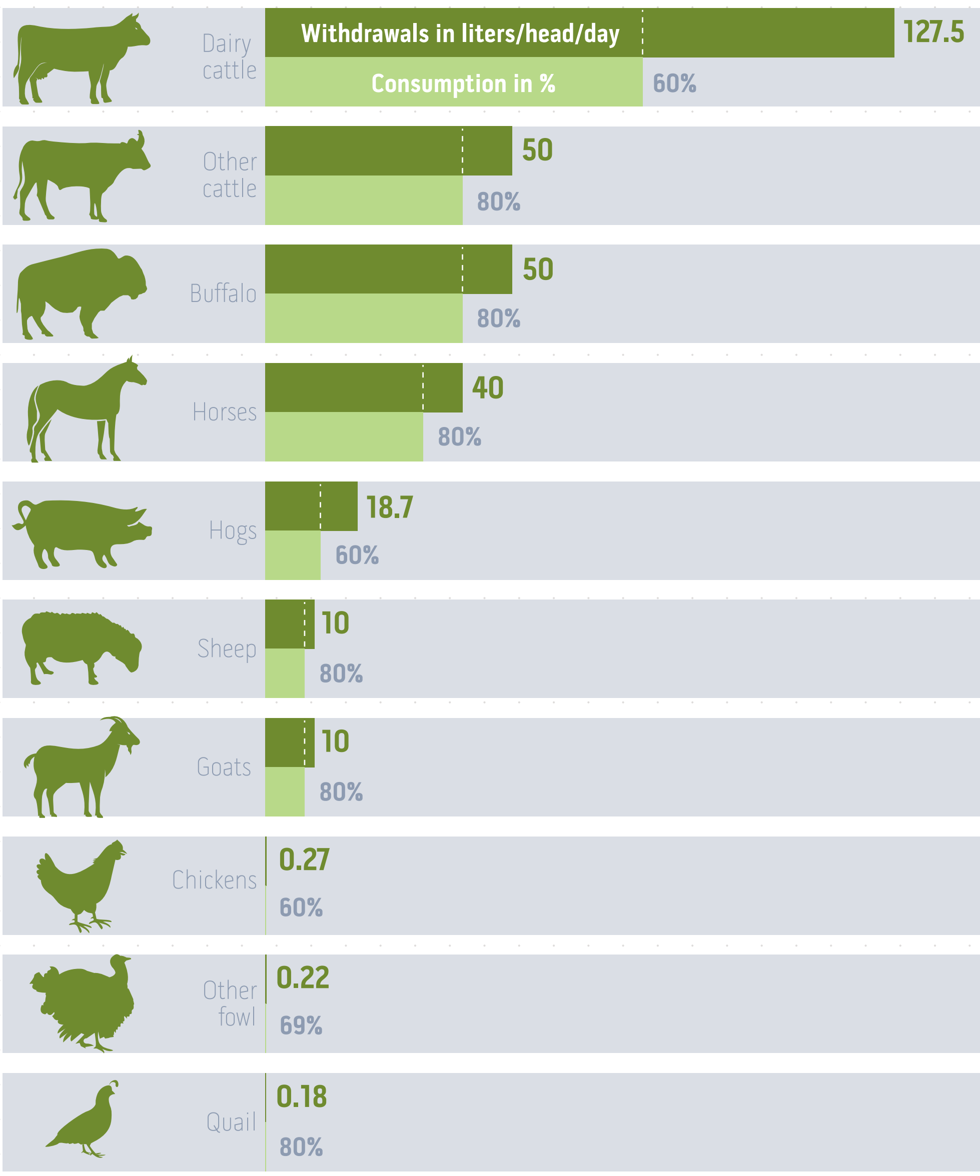
At the global scale, the heaviest water consumption is found in rural areas (farming and ranching activities). In addition to its use for agricultural purposes, these quantities also include **supplies for livestock,** including drinking water, as well breeding and raising facilities, for the management and upkeep of apparatus in livestock confinement facilities.

*According to the United Nations Organization, most water consumed worldwide is generally channeled to ranching and farming activities (70%), followed by industry, including the energy sector (19%) and household use (10%). Data available at:**goo.gl/Wpx5Xi**.*

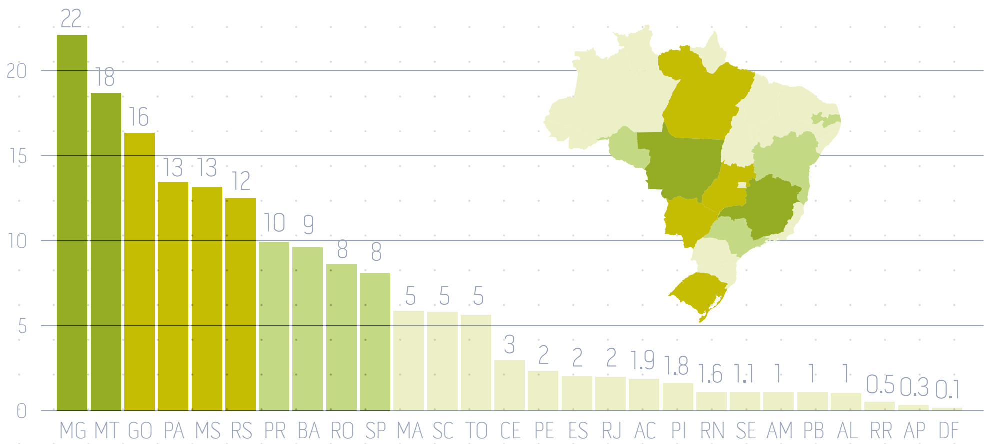
Daily water consumption on cattle ranches varies significantly by species. Sizes and physiological development stages are determining factors in per capita water demands, in addition to being influenced by **stewardship and environmental conditions.**

*Some preventive actions mitigating water consumption by livestock-raising enterprises are recommended by EMBRAPA at: **goo.gl/CFBb4t.** They include correctly-installed and properly-sized drinking troughs, washing systems based on floor scraping, high pressure washing equipment, installing water meters, avoiding leaks, using nutritional technologies and treating liquid wastes according to the profile of each farmer and property.*

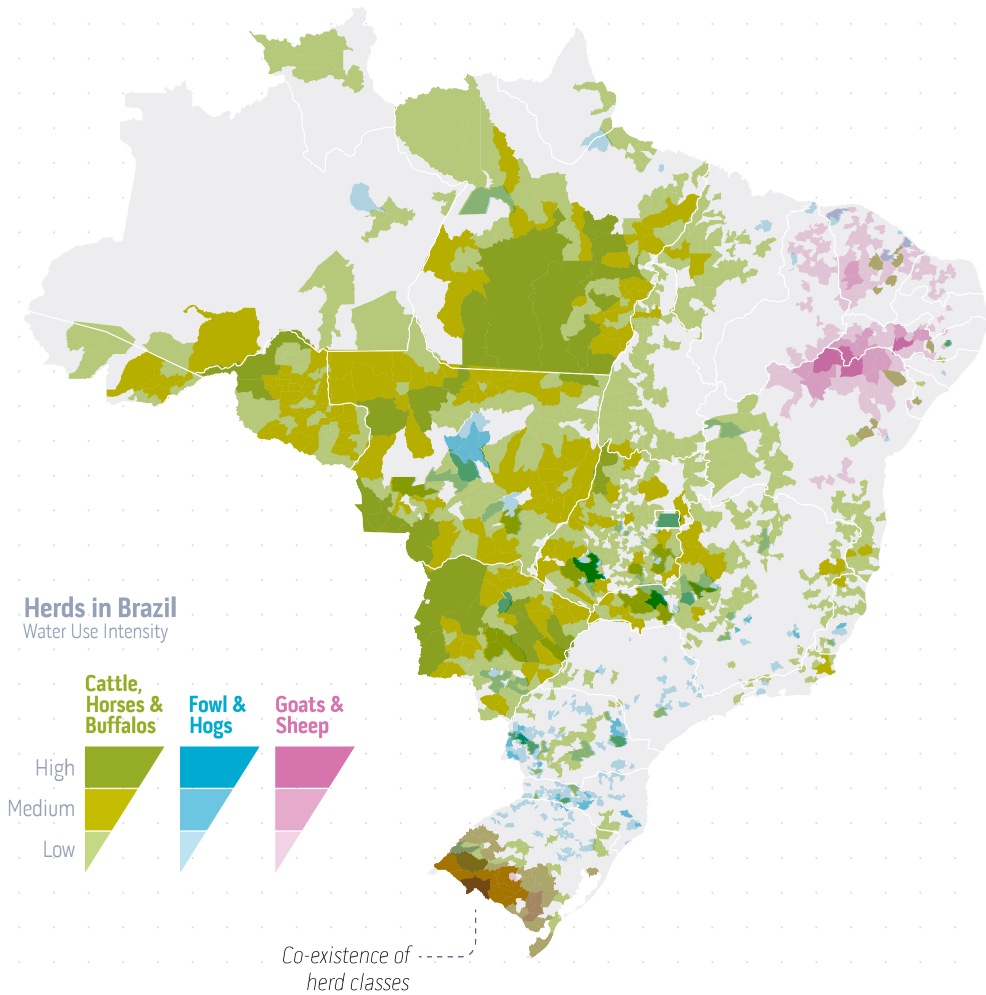
Most water allocated to livestock in Brazil (totaling 123 m³/s nationwide) is consumed by cattle.



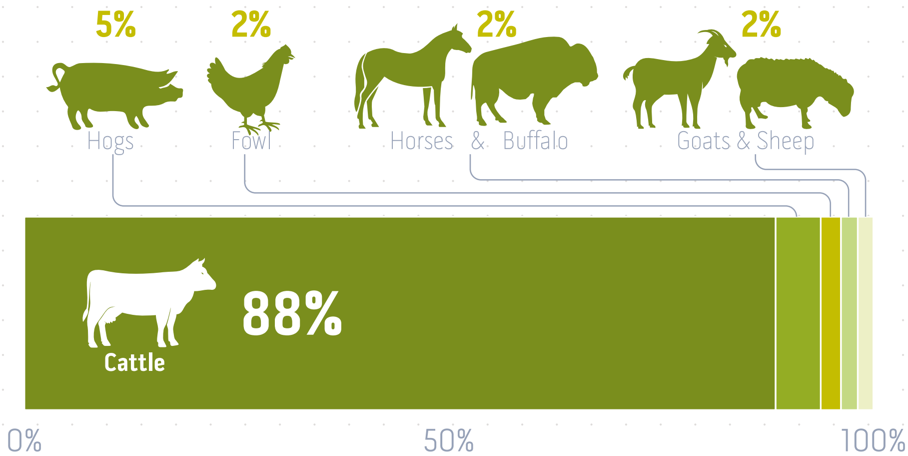
LIVESTOCK DEMANDS BY STATE (m³/s)



LIVESTOCK WATER DEMANDS IN BRAZIL



LIVESTOCK DEMAND DISTRIBUTION BY HERD TYPE (m³/s)



In 2016, 16% of the Brazilian population was living in rural areas, with water supply demands of 33.8 m³/s, generally met through wells, individual uptake facilities or cisterns.

Urban water supplies require 488 m³/s – some fifteen times higher than rural demands. These services – including water production and distribution – are rendered mainly (69% of Brazilian municipalities) by State sanitation enterprises, as well as municipal entities and private companies.

Urban water supply coverage in Brazil has stabilized at around 93% during the past five years.

This high coverage rate indicates access to a water supply system network, but does not necessarily reflect guaranteed water supplies, meaning the availability of water from springs.

Among Brazilian municipalities, 58% draw their water supplies mainly from surface water springs, while 42% use underground springs as their main sources. Surface wellsprings are even more widely tapped by major urban centers in Brazil, rising to 69% for surface water-bodies, with only 31% drawing water from underground sources.

Underground wellsprings may be considered as strategic reserves, often offering important alternatives in critical situations. The use of these wellsprings has been rising over the past few years in Brazil, due mainly to recent water crises, which have affected especially surface water supplies.

Water supplies form a component of basic sanitation which, according to Brazil's National Sanitation Guidelines Act (Law Nº 11,445) promulgated in 2007, also includes sewage, street cleaning and solid wastes management, as well as drainage and rainwater management.

These water supply data were taken from the Brazil Atlas: Urban Water Supplies (Atlas Brasil: Abastecimento Urbano de Água) published in 2010 by ANA, with this information available at: **goo.gl/o2j1Uo**

The number of well-drilling licenses in São Paulo rose 82% during the first two months of 2014, according to data released by the Brazilian Groundwater Association (ABAS). For the disaster caused by the breach in the dam wall at Mariana on November 5, 2015, deep wells were often the only alternative for supplying water to several communities.

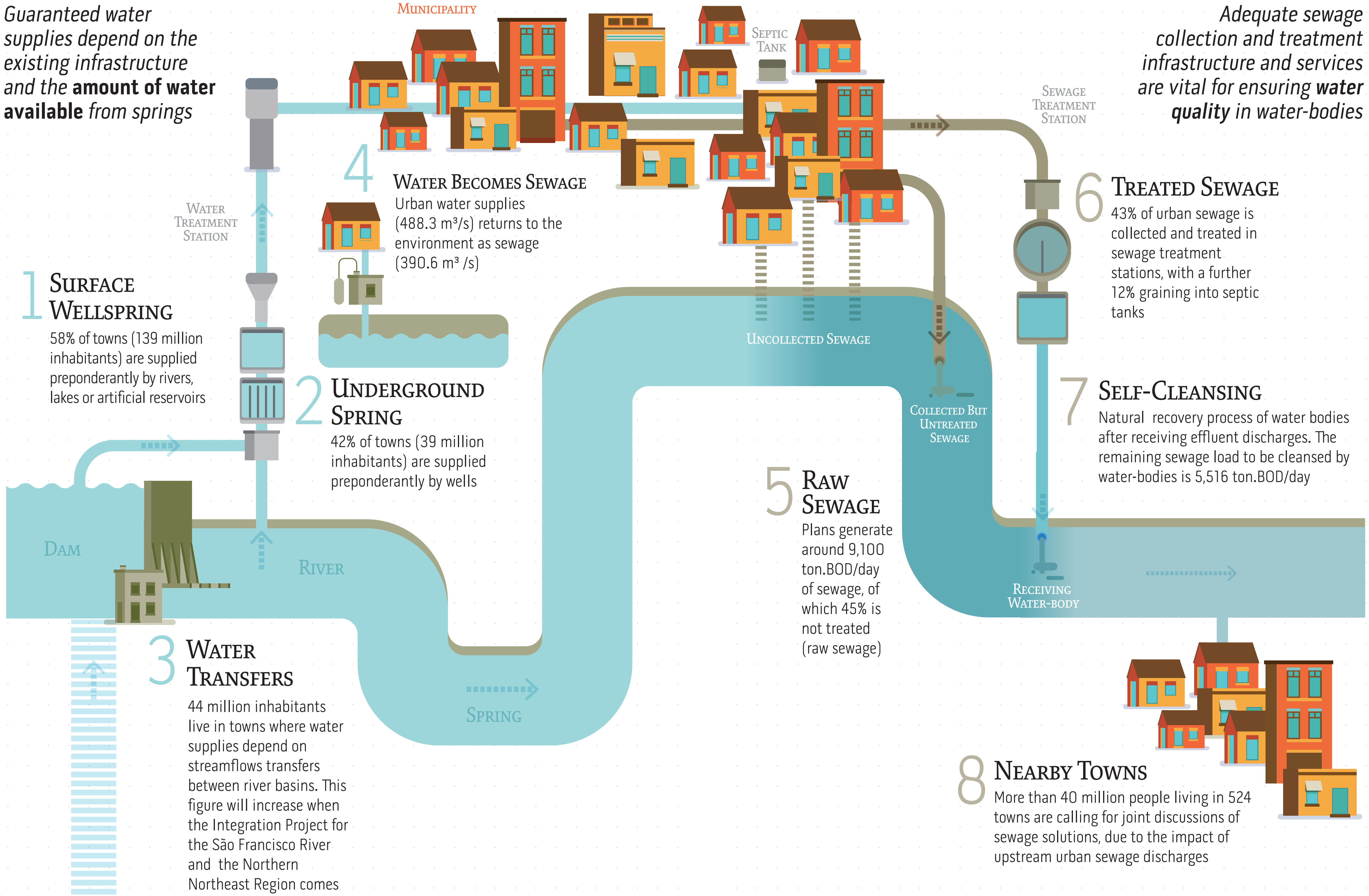
Urban Water Cycle

Water Supplies

Guaranteed water supplies depend on the existing infrastructure and the ***amount of water available*** *from springs*

Sewage Treatment

Adequate sewage collection and treatment infrastructure and services are vital for ensuring ***water quality*** *in water-bodies*



1 Surface Wellspring

58% of towns (139 million inhabitants) are supplied preponderantly by rivers, lakes or artificial reservoirs

2 Underground Spring

42% of towns (39 million inhabitants) are supplied preponderantly by wells

3 Water Transfers

44 million inhabitants live in towns where water supplies depend on streamflows transfers between river basins. This figure will increase when the Integration Project for the São Francisco River and the Northern Northeast Region comes into full operation

4 Water Becomes Sewage

Urban water supplies (488.3 m³/s) returns to the environment as sewage (390.6 m³ /s)

5 Raw Sewage

Plans generate around 9,100 ton.BOD/day of sewage, of which 45% is not treated (raw sewage)

6 Treated Sewage

43% of urban sewage is collected and treated in sewage treatment stations, with a further 12% graining into septic tanks

7 Self-Cleansing

Natural recovery process of water bodies after receiving effluent discharges. The remaining sewage load to be cleansed by water-bodies is 5,516 ton.BOD/day

8 Nearby Towns

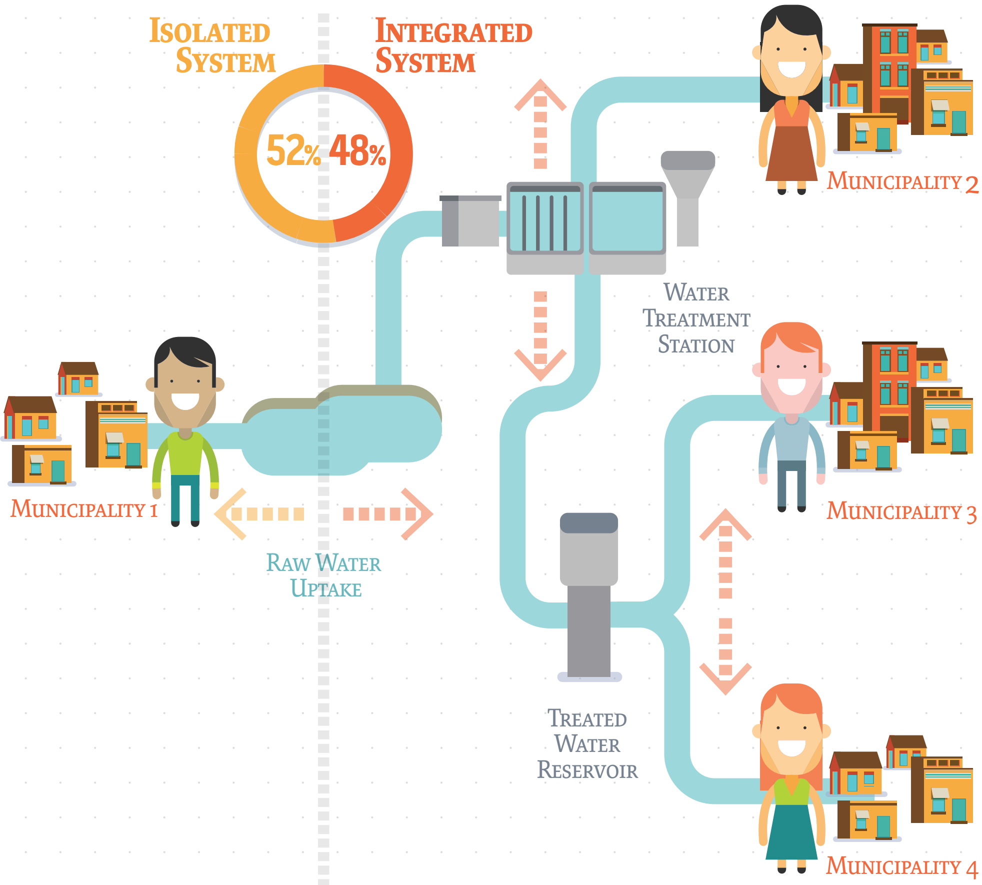
More than 40 million people living in 524 towns are calling for joint discussions of sewage solutions, due to the impact of upstream urban sewage discharges

Water availability at the local level for urban consumption must often be buttressed by reservoir construction and streamflow transfers from neighboring river basins, requiring the operation of complex infrastructure in order to ensure water supplies. The most notable situations in Brazil consist of water supplies to two Metropolitan Regions: São Paulo, where streamflows are channeled from the Piracicaba, Capivari and Jundiaí (PCJ) river basins to the Upper Tietê through the Cantareira system; and Rio de Janeiro, with water transferred from the Paraíba do Sul river to the Guandu system.

These metropolitan regions are supplied through integrated systems where a cluster of municipalities share the same water production scheme. Integrated systems also used to supply water in other major urban hubs throughout Brazil, including Belo Horizonte, Recife, Fortaleza, Curitiba, Salvador, Vitória, Brasília, Goiânia and Belém, as well as several municipalities in the Semi-arid drylands, due to limited water supplies available from local springs.

In all, 48% of the Brazilian population is serviced by integrated systems, and 52% by isolated systems. In **urban hubs, 14.4%** are connected to integrated systems.

URBAN WATER SUPPLY SYSTEMS IN BRAZIL

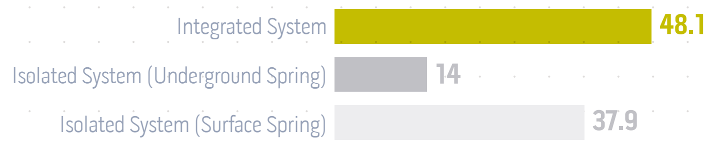


URBAN WATER SUPPLIES IN BRAZIL

Main Integrated Metropolitan Systems

1. Bolonha-Utinga in the Belém Metropolitan Region
2. Gavião in the Fortaleza Metropolitan Region
3. Tapacura, Botafogo & Gurjaú, interconnected in the Recife Metropolitan Region
4. Salvador-Lauro de Freitas I & II in the Salvador Metropolitan Region
5. Jucu & Santa Maria in the Vitória Metropolitan Region
6. Guandu-Ribeirão das Lajes in the Rio de Janeiro Metropolitan Region
7. Cantareira, Upper Tietê, Rio Claro, Ribeirão da Estiva, Rio Grande, Guarapiranga, Upper & Lower Cotia in the São Paulo Metropolitan Region
8. Iguaçu, Irai, Passaúna & Miringuava in the Curritiba Metropolitan Region
9. Rio das Velhas & Paraopeba, which link the Manso, Vargem das Flores & Serra Azul systems in the Belo Horizonte Metropolitan Region
10. João Leite & Meia Ponte in the Goiânia Metropolitan Region
11. Descoberto & Santa Maria-Torto in the Distrito Federal

Urban Population – 2013 (million)



Total Municipalities (%)

Rising pressures on wellsprings, constraints on water availability and underground wellspring management problems are the main factors spurring the search for new water sources, seeking out wellsprings that are increasingly more remote and requiring infrastructure that is steadily more complex, in order to respond to demands.

In this context, it is important to underscore the need to tighten up demand management, encouraging more rational water use and controlling losses from water systems that average out at around 36% nationwide.

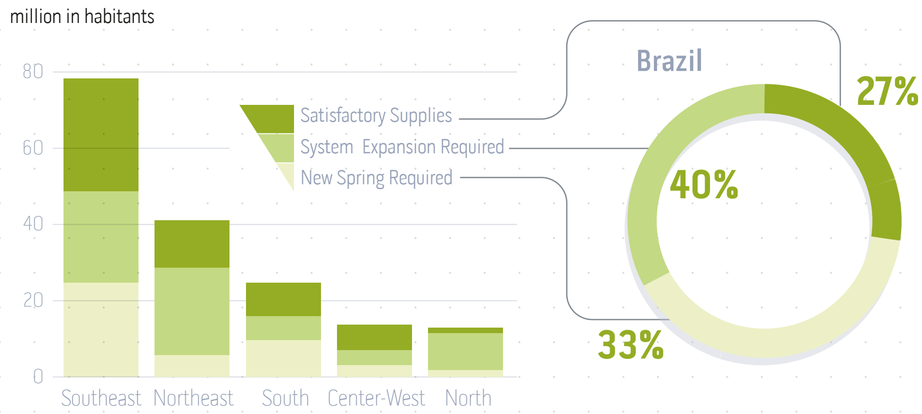
According to 2015 data released by the National Sanitation Information System (SNIS), available at: ***goo.gl/F3SiUi***

Although lost or misused water returns to the hydrological cycle at some point, it is displaced, missing out on opportunities for its use and generating economic and financial costs for society.

From the standpoint of water supplies, Brazil's consolidated diagnosis for 2010 indicated that 46% of Brazilian cities had weak points associated with water production, with 9% requiring new water sources.

There are proportionately more towns in Northeast Brazil requiring new wellsprings, due to low water availability, particularly in the Semi-arid region. In the Southeast, this need is driven by tightly-clustered urban populations.

STATUS OF URBAN WATER SUPPLIES AND INVESTMENT NEEDS FOR THE SERVICED POPULATION



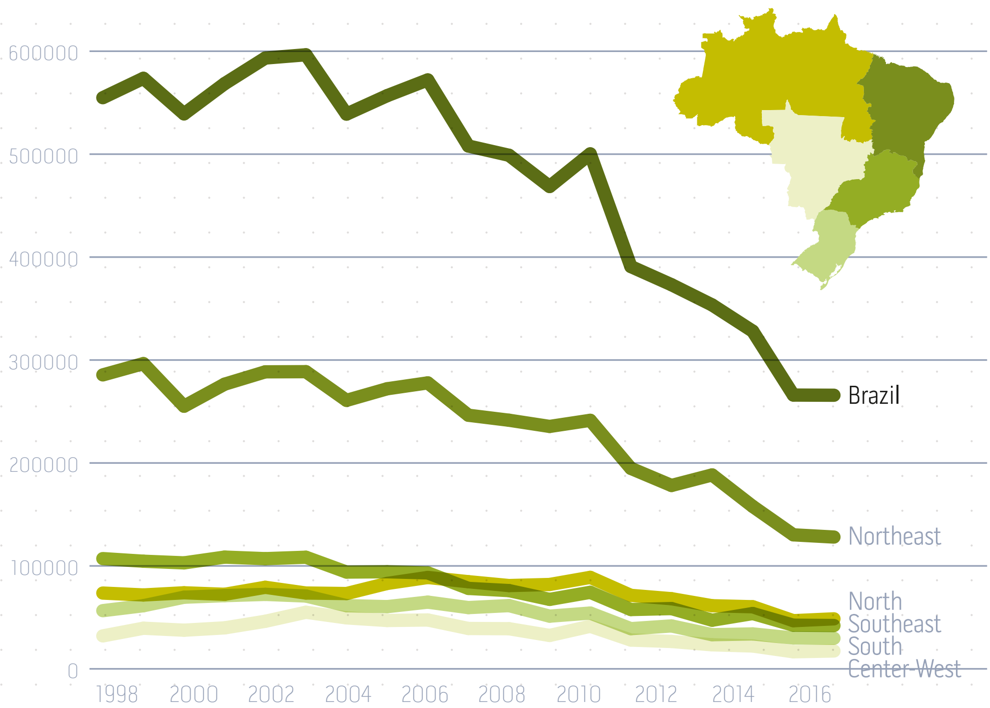
Water used for urban supplies flows back into water resources as sewage. Low sewage collection and treatment rates degrade water quality, particularly around urban areas, with impacts on population health and even undermining the feasibility of responding to downstream uses, particularly human consumption.

Sewage dilution by water-bodies is **part of the self-cleansing process**, dependent on their streamflows and the concentration of the loads discharged, possibly conflicting with other uses. This is why the sanitation and water resource sectors must act in close accord, as sewage treatment significantly upgrades water quality for other purposes. In contrast, it is important to bear in mind that water resource demands are rising all over the world, and wastewaters are becoming increasingly important as alternative and trustworthy sources, shifting their management paradigm from "treatment and elimination" to "**reuse,** recycle and recovery of resources".

Self-cleansing is the natural recovery process of a water-body after receiving discharges of biodegradable matter – such as household sewage – through microorganisms that encourage pollutant decomposition.

Reuse means utilizing a water resource for several applications, such as non-potable and potable urban uses (direct or indirect), irrigation, industry or aquifer recharge. Reuse is a sustainable strategy ensuring water security, particularly in regions or situations where water shortages are frequent. Reusing effluents directly for potable purposes still encounters resistance and requires advanced purification techniques and stringent controls.

HOSPITALIZATION FOR WATER-BORNE DISEASES



Data on hospitalization for water-borne diseases include admissions for cholera, typhoid and paratyphoid fevers, shigellosis, amebiasis, diarrhea and gastroenteritis of presumably infectious origin, together with other infectious diseases of the gut, taken from Brazil's Unified National Health System Database (DATASUS) and available at: ***goo.gl/3T7fd3***

In addition to upgrading water quality, interventions in basic sanitation are directly reflected in improved public health conditions, with fewer water-borne diseases. These rates are tending to drop all over Brazil, particularly from 2003 onwards, mainly in the Northeast.

Introduced in 2007 by Law Nº 11,445, the National Basic Sanitation Plan (PLANSAB) pursues universal access to basic sanitation services in Brazil. Stumbling-blocks hampering the implementation of sanitation actions include: inadequate project designs, lack of technical staff, sluggish civil service procedures and poor teamwork among the entities involved: ***goo.gl/LxpH32***

Issued by the National Environment Council (CONAMA) in 2011, Resolution Nº 430 rules on effluent discharge standards and conditions, requiring removal of at least 60% of BOD for direct discharges of effluents from sewage treatment systems.

According to the Sewage Atlas – River Basin Cleanup (Atlas Esgotos – Despoluição de Bacias Hidrográficas), Brazil has 2,952 sewage treatment stations located in nearly 30% of its towns and cities. Data available at: ***goo.gl/A2oE89***

Only 43% of Brazil's urban population is serviced by sewage collection and treatment facilities, with 12% using stand-alone septic tanks. This indicates that 55% of Brazil's urban population may be considered as adequately serviced, based on the PLANSAB classification: sewage is collected but not treated for 18%, which may be rated as inadequate service; and there is no collection or treatment for 27%, meaning that no sewage services are provided.

The vast majority (4,801) of Brazilian towns have organic load removal levels of less than 60%, for a total of 129.5 million inhabitants. There is a predominance of towns with low organic load removal levels in all regions, particularly the North and the Northeast. the other extreme, only 769 towns (14% of the total) present BOD removal rates of over 60%, most of them in the Southeast Region.

At the State level, only the Federal District removes more than 60% of the generated sewage loads, with São Paulo and Paraná close to this figure and the other States posting low removal rates that portray the national average.

Organic loads derived from urban sewage generate more than 9,100 tons of BOD a day, of which 39% are removed through treatment processes.

This means that 5,500 tons of BOD/day are still flowing into Brazil's water-bodies. An analysis of the effects of these remaining sewage loads on water-bodies indicated the BOD removal efficiency levels required in each principality, sized to water availability in existing and potential receiving water-bodies and based on the limits of **water quality objectives** for each class.

The wide variety of water availability in Brazil's water-bodies requires an equally broad range of solutions for removing pollutive loads. In addition to adopting more advanced treatment processes for municipalities whose receiving water-bodies have less water available for dilution purposes, close attention is needed to areas that are critical for water quality in the Semi-arid region as well as river headwaters and above all in basins that are more densely populated.

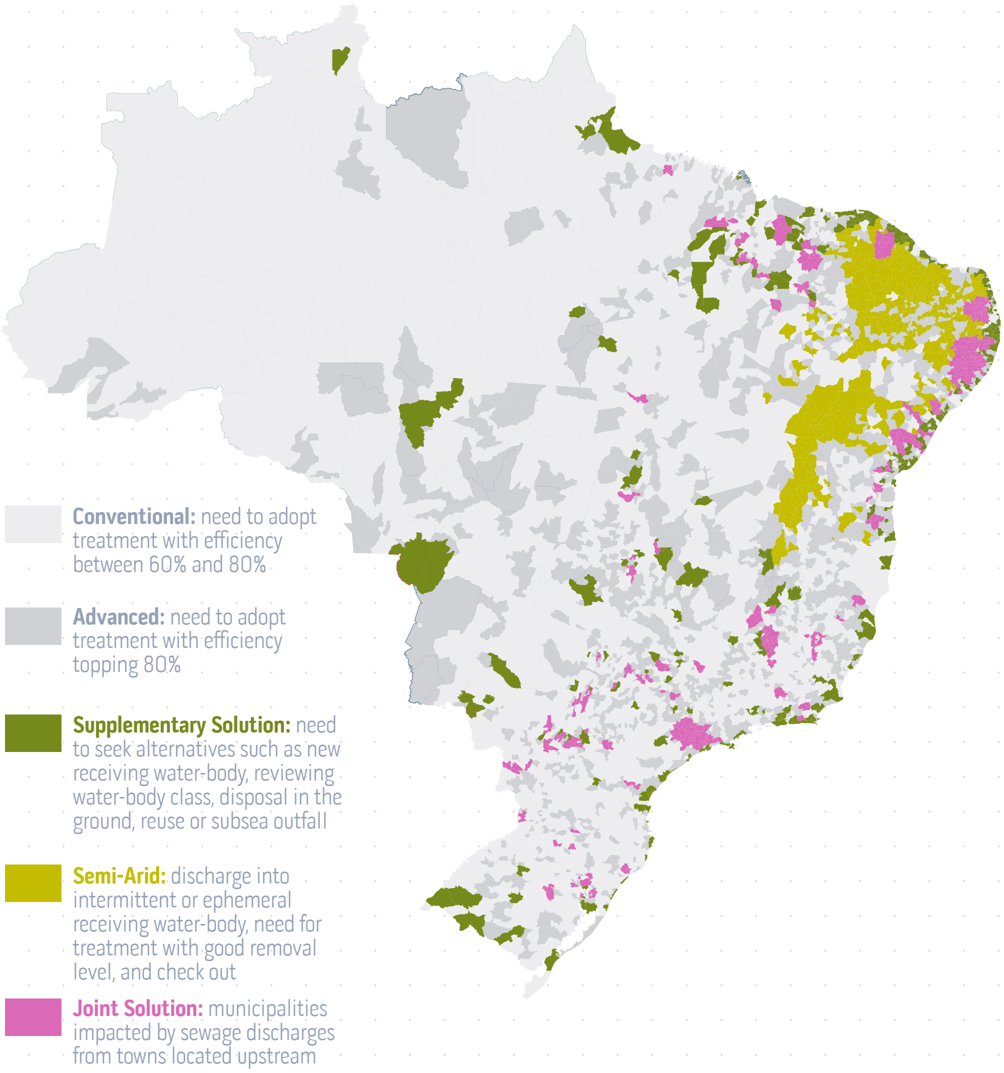
The classification of water bodies by water quality objectives is addressed in detail in Chapter 4. Water classification parameters and limits for preponderant uses (water quality objectives) were established through Resolution Nº 357, issued in 2005 by the National Environment Council (CONAMA), and supplemented by alterations to effluent discharge conditions and standards introduced in 2011 through its Resolution Nº 430.

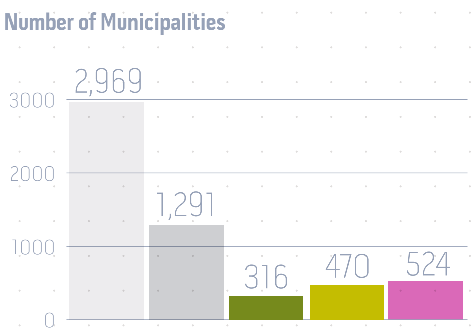
In these more densely populated regions, water resource logic must be taken into consideration when taking decisions and implementing sewage solutions, especially where **River Basin Committees** have already been established, such as the Sinos, Tietê, Velhas, Paraíba do Sul, Doce, Meia Ponte, Piracicaba, Capivari and Jundiaí river basins, among others.

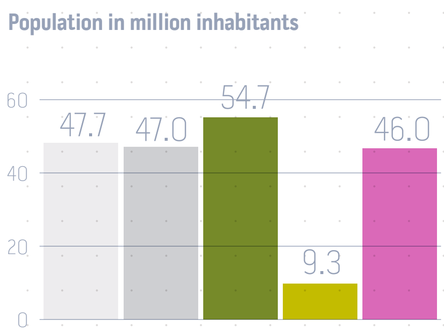
The implementation status of River Basin Committees in Brazil is presented in Chapter 4.

OVERVIEW OF SEWAGE COLLECTION AND TREATMENT IN BRAZIL

SEWAGE TREATMENT COMPLEXITY DUE TO BOD REMOVAL REQUIRED IN 2035



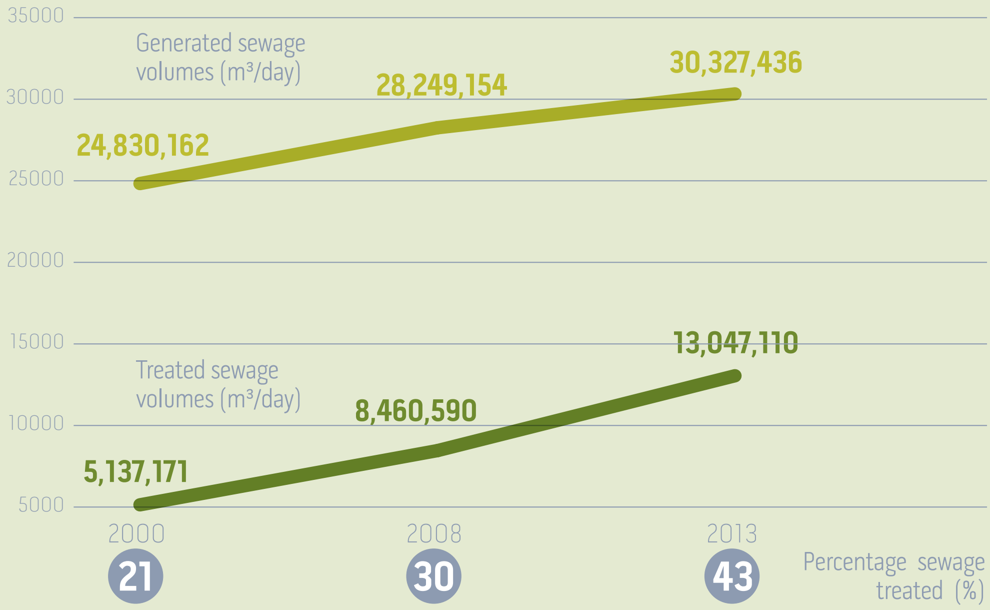




INVESTMENTS IN SEWAGE TREATMENT

Brazil invested some USD 9.5 billion (BRL 30 billion) in sewage treatment between 2007 and 2015. Furthermore, its National Sanitation Plan forecasts investment requirements at around USD 57 billion (BRL 180 billion) through to 2033.

ESTIMATED URBAN SEWAGE VOLUMES GENERATED AND TREATED IN COLLECTIVE SYSTEMS AND RESPECTIVE TREATMENT PERCENTAGES



These estimates were drawn up on the basis of the Brazilian population and a per capita value of 180 liters/inhabitant/day, referenced to data in the Demographic Census and the National Basic Sanitation Survey (PNSB) conducted by the Brazilian Institute for Geography and Statistics (IBGE).

Ever since it was first established, ANA has conducted a program focused on the sanitation field: the River Basin Cleanup Program (PRODES), which has already allocated USD (BRL 403.125 million) to the sector between 2001 and 2016.

Despite its relatively small financial budget, this Program operates in areas where water quality is critical. For example, sewage treatment stations encompassed by this Program in the Piracicaba, Capivari and Jundiaí (PCJ) river basin are generally located in towns where effluent generation is more significant, such as Piracicaba, Campinas, Rio Claro and Bragança Paulista. In this basin, load removal (BOD/year in tons) by sewage treatment stations receiving some type of PRODES support accounted for 19% of total loads removed in this basin during 2013. Consequently, strategically-located investments may be quite efficient.

Also known as the "treated sewage purchase program", PRODES is an innovative initiative that does not finance works or equipment, but rather pays for results, meaning sewage actually treated. Through this Program, the Federal Government offers financial incentives to sanitation service-providers that invest in setting up and operating sewage treatment stations, provided that they comply with the conditions set forth in their contracts.

Another important use for water is **industrial,** with industry meaning any human activity that works to convert raw materials into products for consumption by people or other industries. Industry may be classified as processing or extractive.

Extractive industries remove raw materials from nature, for use in other industries. There are two main types: plant extraction and mineral extraction. The oil industry is an example of extraction, while **mining** is the extractive industry that consumes the largest amounts of water in Brazil, clustered mainly in Minas Gerais and Pará.

Together, these two States account for more than 85% of water demands by the mining industry in Brazil, with total withdrawn flows reaching 32.8 m³/s.

Manufacturing industries turn raw materials into feedstock for other industries (production goods) as well as food, clothing and all the other goods that are consumed in our daily lives (consumer goods).

In the manufacturing industry, water demands vary by service or product type and the associated industrial processes, reaching a total withdrawn flow of 192.4 m³/s in Brazil.

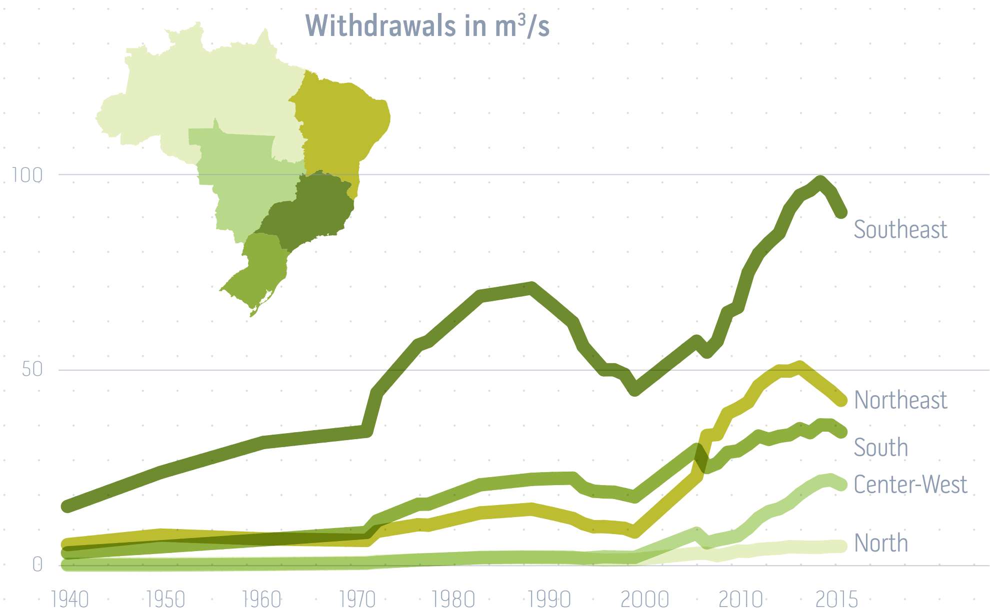
Water use intensity depends on a wide variety of factors, including process and product types, technology, good practices and management maturity. Water use during production processes is affected by many different aspects, such as: raw materials and reagents; solid, liquid and gas substance solvents; rinsing and retention of matter contained in mixtures; suspension excipients; heat transmission operations and others.

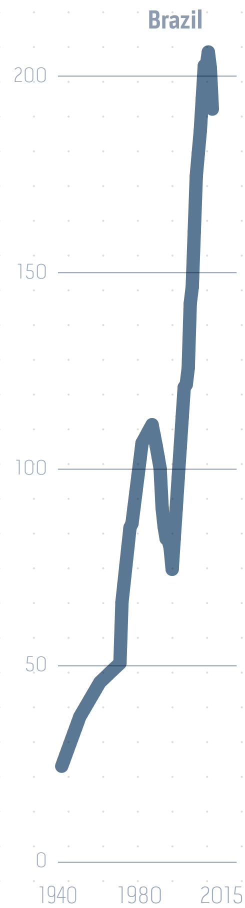
Due to its climate and geographical characteristics, together with its historical, social and economic development over several centuries, Brazil is particularly noteworthy in the primary sector, with activities linked to farming, ranching and extractivism, followed by broad-ranging industrialization that swept through the country during the second half of the XX century.

The configuration of the processing industry presents regional disparities, as industrialization did not take place evenly nationwide, with industries scattered irregularly all over the country.

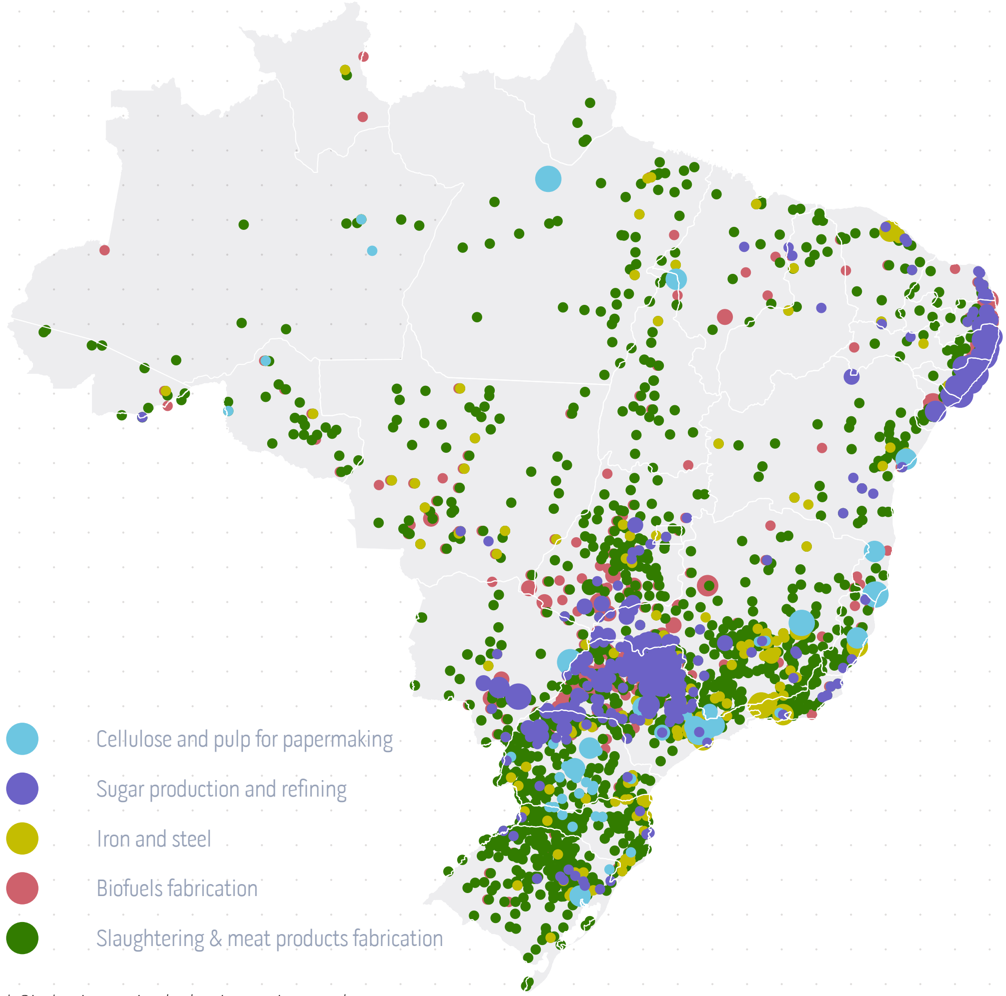
The largest clusters of processing industries are located in the Southeast, mainly in São Paulo, Rio de Janeiro and Minas Gerais States. This Region has diversified industrial parks, particularly for the chemical and auto-assembly sectors. Next in terms of industrial development is Southern Brazil, where agribusinesses are particularly noteworthy, processing and transforming primary goods. The profile of industrial activities in the Northeast is linked mainly to textile production and the sugar and alcohol sector. More lightly industrialized, the North and Center-West are regions where agribusinesses predominate.

INCREASES IN WITHDRAWAL FLOWS FOR INDUSTRIAL USE





WITHDRAWAL FLOWS FOR INDUSTRIAL USE IN 2015



** Circle size varies by business sizes and concentrations at each location*

Published by ANA in 2017, the study of Water in Industry: Use and Technical Coefficients (Água na Indústria: Uso e Coeficientes Técnicos) fine-tuned methods and databases associated with water demands by industrial types, based on the National Economic Activities Classification (CNAE); it is available at: ***goo.gl/LtuwxL***

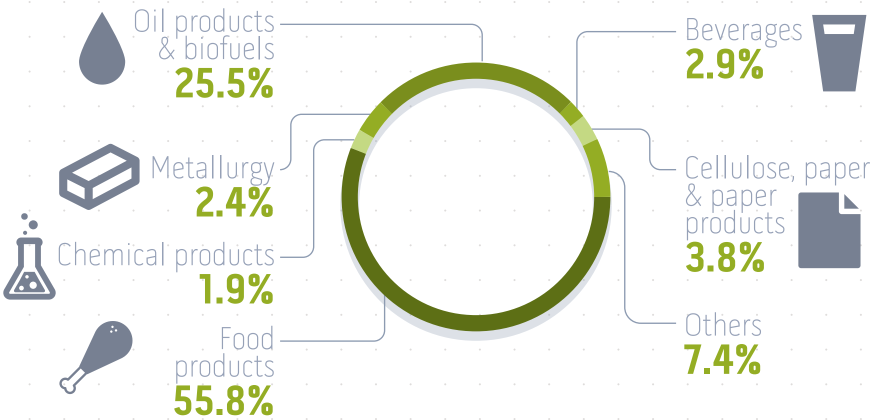
Industries producing foods, beverages, cellulose, paper and paper products, oil products and biofuels, chemical and metallurgical goods, together account for some 85% of water withdrawal demands and around 90% of streamflows consumed by Brazilian industry, considering the most water-intensive sectors. In 2016, total water consumption by industry in Brazil reached 104.9 m³/s.

Consolidated industrialization in some river basins may trigger competition between industrial water supplies and **priority uses** such as water for human consumption.

According to Law Nº 9,433 promulgated in 1997, priority uses during water shortages are human consumption and drinking water for livestock.

For example, in the Tietê river basin, industry accounts for 45% of withdrawn streamflows.

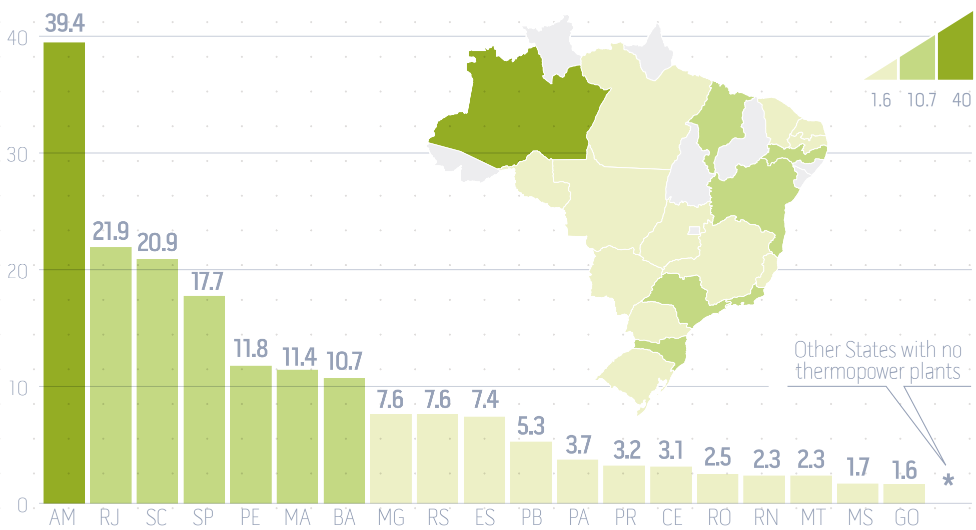
INDUSTRIAL WATER CONSUMPTION IN BRAZIL



Nationwide, water withdrawals by thermopower plants are close to the figures for industry and livestock supplies, although consumption is not significant. At these plants, water is used to drive steam turbines and also runs through cooling systems. Water demand intensities depend on generation technologies, fuel types and cooling systems, as well as the meteorological conditions influencing these processes. Energy sources commonly used in thermopower plants are coal, natural gas, diesel oil or biomass, in addition to nuclear options.

Flows withdrawn to service thermopower plants in 2016 were estimated at around 216 m³/s, particularly in Amazonas, Rio de Janeiro, São Paulo and Santa Catarina States.

STREAMFLOWS WITHDRAWN FOR COOLING PURPOSES IN THERMOPOWER PLANTS (m³/s)

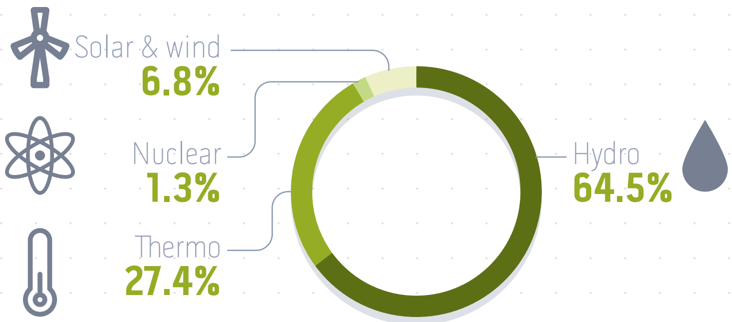


Brazil's energy matrix is grounded predominantly on renewable sources, particularly water resources. Oil and oil products account for much (around 81%) of the world's energy matrix, while renewable sources (hydro, solar, biomass and wind) make up only 14%, according to data released by the International Energy Agency (IEA), available at ***goo.gl/Y1dJeN***

Thermopower plants are often run as supplementary energy sources in Brazil, brought into operation in response to demands not met through hydropower, which is the main source in the nation's **electricity matrix.**

In 2016, Brazil's installed power generation capacity reached 150.14 GW, with hydropower making the greatest contribution as an energy source at 64.5% of installed energy. Next come thermopower plants, with 27% of power generated in Brazil. Although still only minor players in Brazil's power generation sector, wind and solar sources are nevertheless expanding.

BRAZIL'S ELECTRICITY MATRIX



Data on hydropower generation are managed and released by Brazil's Power Sector Regulator (ANEEL) at: ***goo.gl/Fh6zow***

In 2016, there were 1,241 hydropower facilities operating in Brazil: 581 hydropower generation complexes (CGH); 441 small hydropower complexes (PCH) and 219 hydropower plants (UHE). Data on the expansion of installed electricity production capacity in Brazil, encompassing all energy sources, reflects an increase in the total system capacity of 9,864 MW during 2016, of which 5,662 MW was water-based, including UHE, PCH and CGH.

Other renewable energy sources – such as solar and wind power – are options with the lightest environmental impacts. The diversification of its renewable energy matrix over the past few years has endowed Brazil's power supplies with greater security. In the Northeast, for example, the risk of power outages would have been considerably higher in 2016 without wind farms.

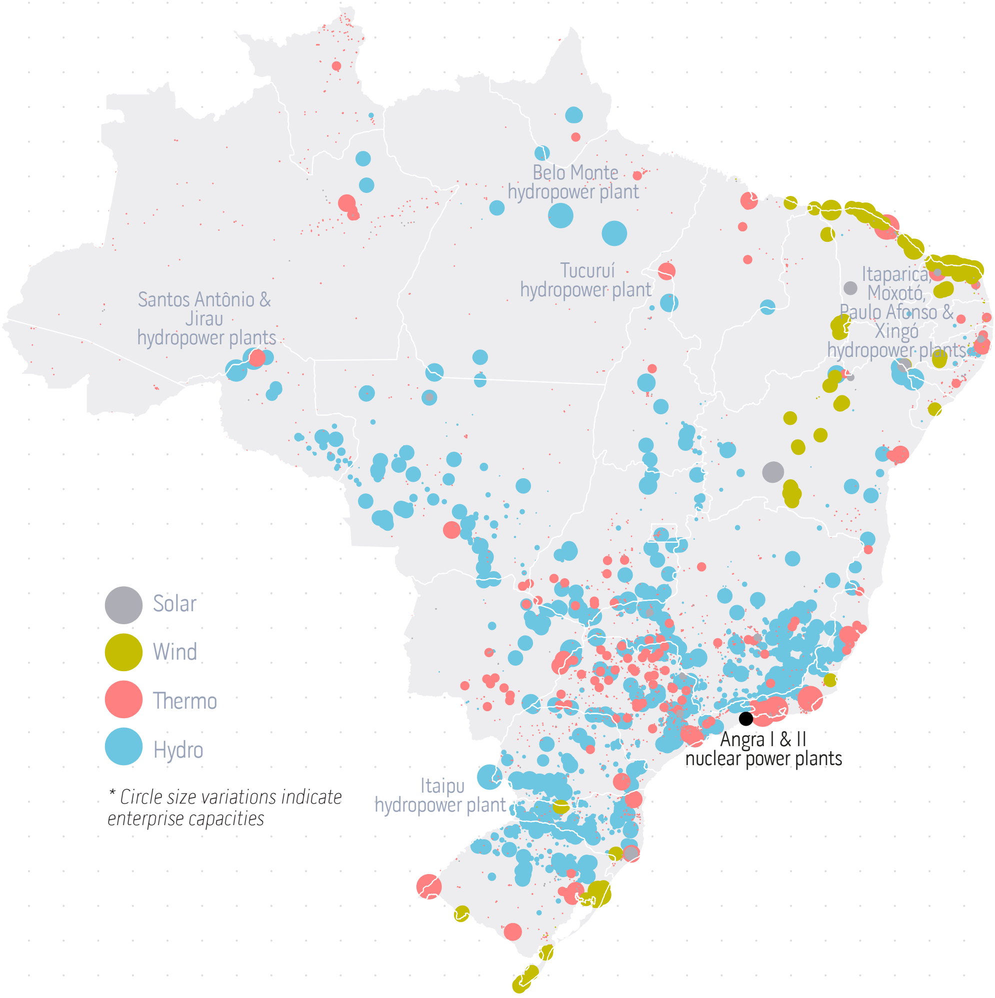
Hydropower is obtained through harnessing the potential generation capacity of a watercourse. In order to make good use of potential generation sites, plants must be built on rivers with ample streamflows and marked height differences along their courses. These plants build reservoirs to store water that will be used to generate electricity.

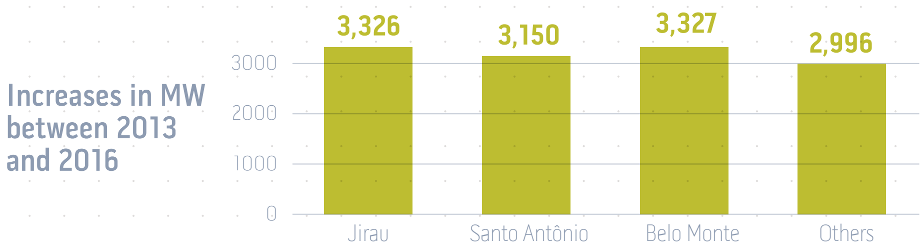
The main difference between hydropower plants (UHEs) and their smaller counterparts (PCHs) is installed capacity. With a capacity of 5 MW to 30 MW, a small powerplant must be authorized by the grantor authority. Hydropower plants have capacities of more than 30 MW and are awarded concessions by the grantor authority. Additional information is available at: ***goo.gl/KWEPmW***

In the Paraguay Hydrographic Region, the expansion of hydropower complexes is rated as a critical issue. This prompted ANA to commission impact assessment and zoning studies for these enterprises in 2016, providing feedback for water resource management entities decisions on water use by hydropower complexes in this region.

POWER GENERATION CAPACITY IN BRAZIL

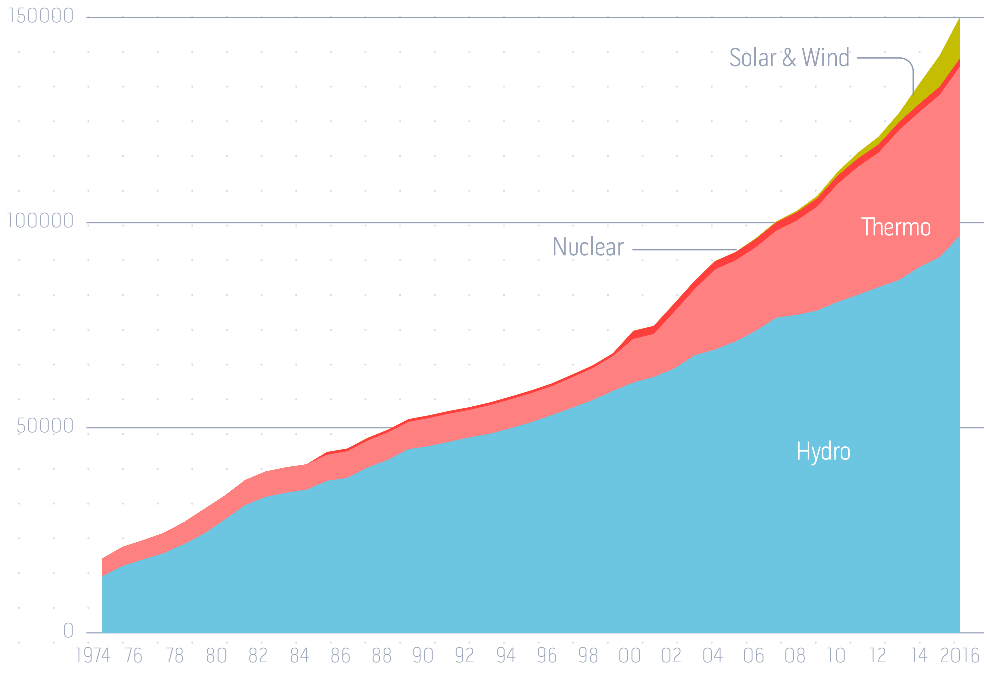
Enterprises in Operation





For the 12.8 GW expansion of installed hydropower capacity between 2013 and 2016, 77% came from three plants in Northern Brazil: Belo Monte on the Xingu River; and Santo Antônio and Jirau, both on the Madeira River.

EXPANSION OF INSTALLED POWER GENERATION CAPACITY IN BRAZIL (MW)



Net evaporation is the difference between actual evaporation from the surface of a water-body (reservoir) and actual evapotranspiration in the surrounding river basin before the reservoir was established. This consequently represents water used for consumption deriving from the establishment of the reservoir.

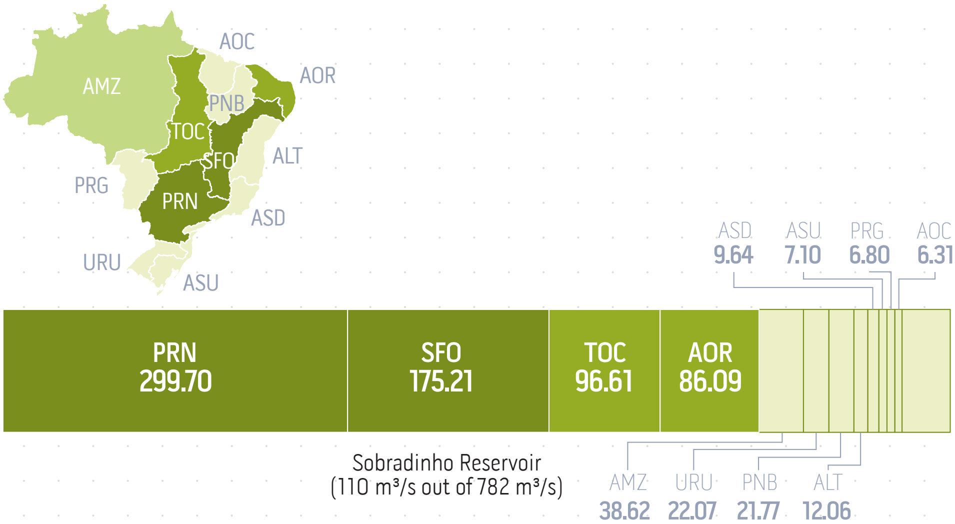
Hydropower is rated as clean energy as it is generated from a renewable source and does not emit pollutants through burning fossil fuels such as oil. On the other hand, the construction of most powerplants requires large-scale flooding and some of the water volume in power dams is lost through evaporation.

Brazil's National Grid Operator (ONS) provides **net evaporation** data on 148 power dams scattered all over Brazil, mainly in the South and Southeast, with a total evaporation surface area of 31,548 km².

The remaining 7,210 artificial reservoirs in Brazil with surface areas of more than twenty hectares have a total evaporation surface area of 10,505 km². They are intended for other purposes such as urban supplies, aquaculture and irrigation.

Total use as a function of net evaporation from Brazilian reservoirs was estimated at 782 m³/s in 2016.

WITHDRAWAL FLOWS IN M³/S BY NET EVAPORATION



Net evaporation constitutes a multiple use, as artificial water-bodies may be used for a wide variety of purposes, such as public supplies, aquaculture and irrigation, with power generation prevailing.

Brazil's hydrographic network offers ample potential for inland navigation. However, transportation along its navigable waterways is still minor, accounting for only 5% of cargoes shipped (split between agricultural and non-agricultural bulk solids, bulk liquids and general cargoes).

Only 22,037 kms of Brazil's 41,635 kms of navigable waterways are economically feasible for navigation, and not all of them are in full conditions for use.

Data on navigable waterways, ports and navigation goods in Brazil are available from the National Waterways Transportation Regulator (ANTAQ) at: ***goo.gl/kdCiUn***

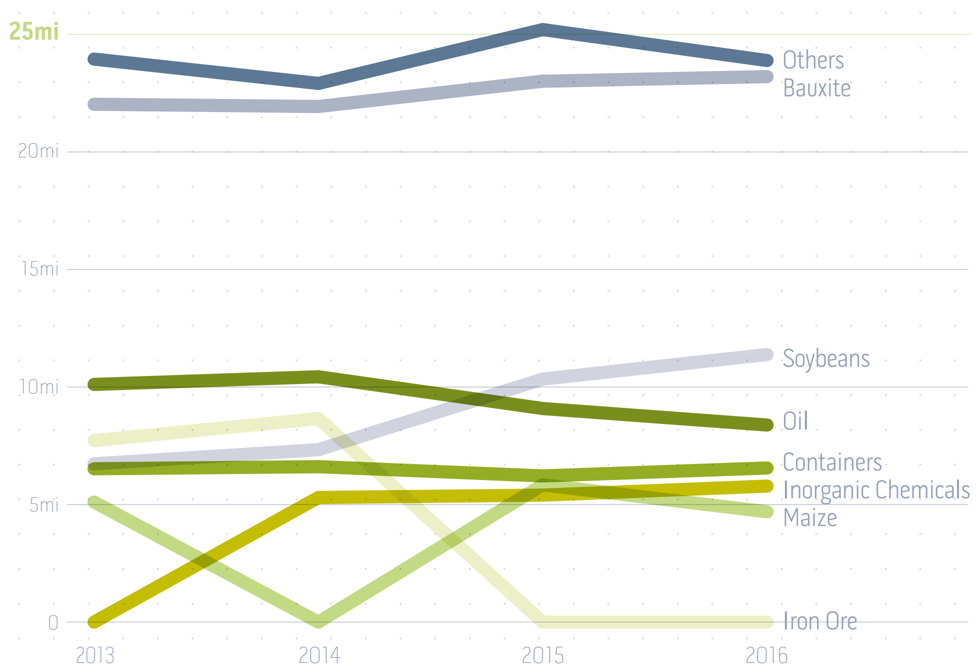
In 2012, ANA regulated the requirements for navigation lock systems in Water Availability Reserve Declarations (DRDH) and water resource usage permits for hydropower generation sites. Further information on these declarations and licenses is presented in Chapter 4.

This is often due to the absence of structural interventions (terminals, locks and sluices, as well as increased draft and regularization works) that allow vessels to navigate water-bodies. For example, **locks** with the world's largest drop (about 85 meters) were inaugurated in 2010 at Tucuruí in the Tocantins-Araguaia Hydrographic Region, in order to allow navigation along the Tocantins river. However, many Brazilian waterways still lack the infrastructure needed to allow navigation. Other factors – such as **shallow stretches along water-courses** – also affect navigation directly, and may even prevent it completely, often resulting from the operations of power dams used to generate electricity

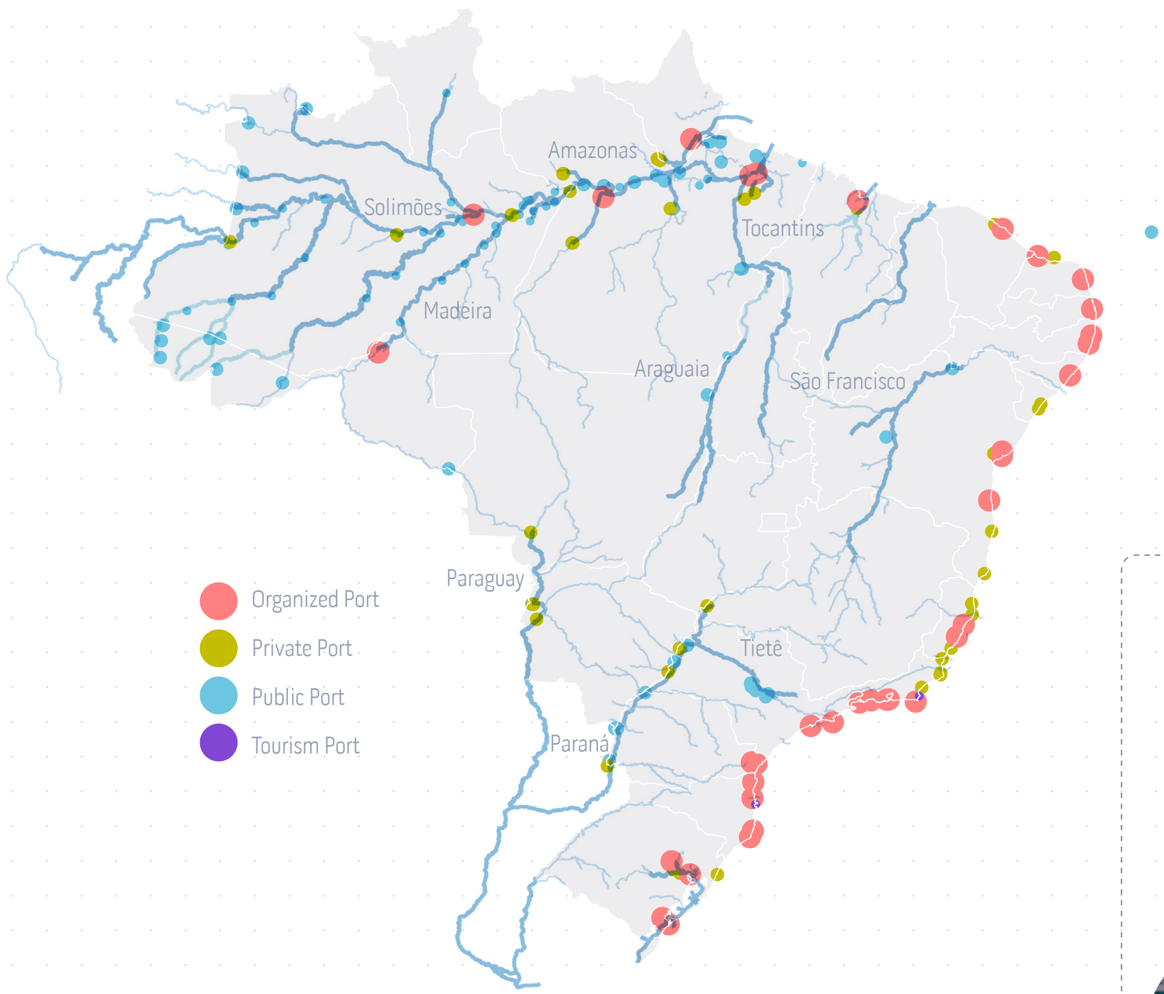
Among Brazil's public ports, 44% are located in the Amazon Hydrographic Region, due to the importance of river navigation for transporting goods and people in this area.

Unfavorable hydro-meteorological conditions in 2014 lowered water stocks in regularization reservoirs operated by the power sector, bringing navigation to a halt along the Tietê-Paraná and São Francisco waterways, but starting up again in early 2016 along the Tietê-Paraná waterway.

GOODS TRANSPORTED BY INLAND NAVIGATION (TONS)



WATERWAYS AND PORT FACILITIES IN BRAZIL



Brazil's massive network of navigable inland waterways, freshwater reservoirs, lakes, lagoons and waterfalls offers extremely attractive settings for a wide variety of tourism activities, including watersports, boating and fishing. Boating includes the use of various types of vessels for transporting tourists, such as river cruises through Amazonia and the Pantanal wetlands.

Widely used for fishing, reservoirs, lakes and lagoons offer ample potential for aquaculture, raising organisms whose natural lifecycles take place fully or partially in water, including fish, shellfish and crustaceans. Methods consist of **netting tanks** and excavated tanks in fresh or salt water environments.

Aquaculture output licensed by ANA in netting tanks in 43 Brazilian reservoirs reached 743,450 tons a year in July 2017, with a maximum annual capacity of 2,643,185 tons.

Excavated tank in the Paraguay river basin

Netting tank in the Grande river basin, São Paulo State

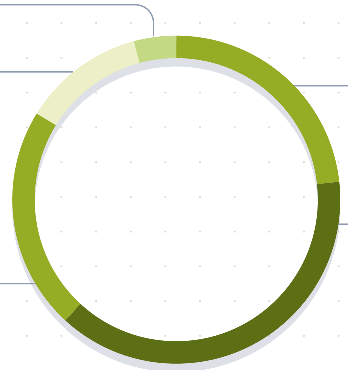
During the past few years, aquaculture has been expanding in Brazil and worldwide, due mainly to rising fish production.

The FAO estimates that 17% of all animal protein consumed by the world's population consists of fish – outstripping pork, chicken, beef, goat and egg consumption individually. Aquaculture accounts for 50% of all fish consumed worldwide.

In 2015, aquaculture output from water-bodies and Brazil's territorial waters reached 1,148,329 tons of fish, shrimp and shellfish (oysters, clams and mussels). Fish accounted for 84% of these figures, particularly tilapia and tambaqui.

From 2013 onwards, production data for fish yielded by aquaculture at the municipal level have been included in the Municipal Livestock Survey (PPM) conducted by the IBGE. This Survey encompasses only raised animals. Hand-caught fish, extractive fishing and amateur or sportfishing, catches at farm hotels and ornamental fish are not analyzed through surveys in Brazil. The data are accessible at: ***bit.ly/2weWn1Z***

AQUACULTURE PRODUCTIVITY IN BRAZIL (2015)



Using inland water-bodies for recreational purposes is also very common in Brazil, particularly when close to towns and cities, varying by region, climate and hydrological system. At many locations, reservoirs are great places for watersports throughout the year, with beaches forming along some water-courses only during the dry season.

Water used for recreational purposes must be suitable for bathing, with **bathing water quality** measuring the sanitary status of waters destined for primary contact recreation, as well as direct contact and prolonged contact during which bathers may ingest significant amounts of water. Consequently, information on quality is important for protecting the health of people using water for recreational purposes.

Bathing water quality is assessed in Brazil through Resolution N° CONAMA N° 274 issued by the National Environment Council (CONAMA) in 2000, rating beaches as Suitable and Unsuitable for bathing. Contamination along beaches is measured through the presence of fecal coliforms at levels higher than permitted by the law, generally due to sewage outfalls and animal feces, as well as pathogenic micro-organisms that may infect bathers with water-borne diseases or cause skin problems.

Brazilian Water Resources Report 2017

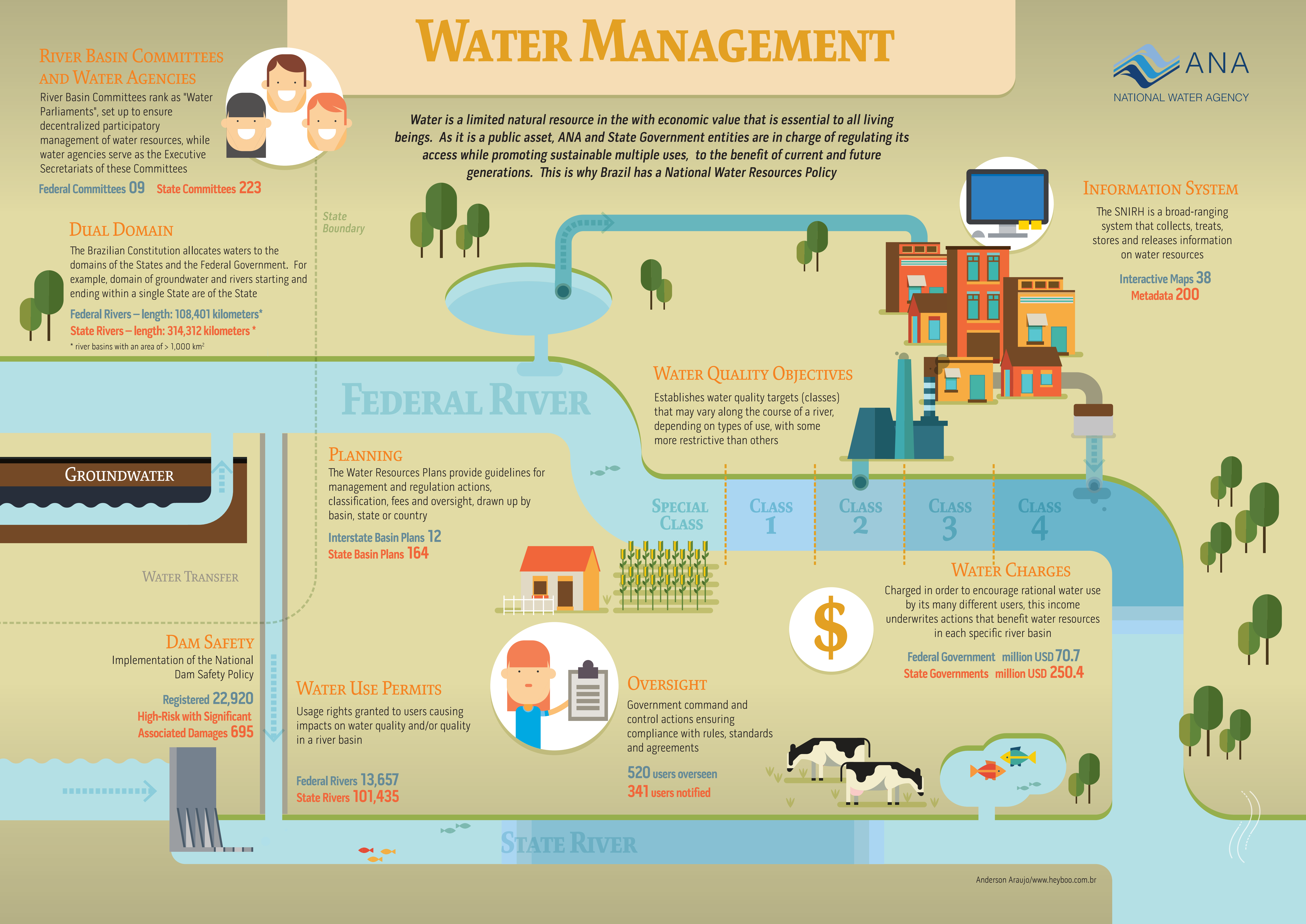
Chapter 4 Water Management

Water management is the process through which activities and social engagement are structured and organized in order to control and regulate water use.

It is intended to ensure water supplies today and in the future. **How?**

Click on this tab to see the infographic we have prepared for you to understand this, quite simply!

Open here


WATER MANAGEMENT
ANA
NATIONAL WATER AGENCY
Water is a limited natural resource in the with economic value that is essential to all living beings. As it is a public asset, ANA and State Government entities are in charge of regulating its access while promoting sustainable multiple uses, to the benefit of current and future generations. This is why Brazil has a National Water Resources Policy
RIVER BASIN COMMITTEES AND WATER AGENCIES
River Basin Committees rank as "Water Parliaments", set up to ensure decentralized participatory management of water resources, while water agencies serve as the Executive Secretariats of these Committees
Federal Committees 09 State Committees 223
DUAL DOMAIN
The Brazilian Constitution allocates waters to the domains of the States and the Federal Government. For example, domain of groundwater and rivers starting and ending within a single State are of the State
Federal Rivers – length: 108,401 kilometers*
State Rivers – length: 314,312 kilometers *
* river basins with an area of > 1,000 km²
State Boundary
FEDERAL RIVER
GROUNDWATER
WATER TRANSFER
PLANNING
The Water Resources Plans provide guidelines for management and regulation actions, classification, fees and oversight, drawn up by basin, state or country
Interstate Basin Plans 12
State Basin Plans 164
INFORMATION SYSTEM
The SNIRH is a broad-ranging system that collects, treats, stores and releases information on water resources
Interactive Maps 38
Metadata 200
WATER QUALITY OBJECTIVES
Establishes water quality targets (classes) that may vary along the course of a river, depending on types of use, with some more restrictive than others
SPECIAL CLASS
CLASS 1
CLASS 2
CLASS 3
CLASS 4
WATER CHARGES
Charged in order to encourage rational water use by its many different users, this income underwrites actions that benefit water resources in each specific river basin
Federal Government million USD 70.7
State Governments million USD 250.4
DAM SAFETY
Implementation of the National Dam Safety Policy
Registered 22,920
High-Risk with Significant Associated Damages 695
WATER USE PERMITS
Usage rights granted to users causing impacts on water quality and/or quality in a river basin
Federal Rivers 13,657
State Rivers 101,435
OVERSIGHT
Government command and control actions ensuring compliance with rules, standards and agreements
520 users overseen
341 users notified
STATE RIVER
Anderson Araujo/www.heyboo.com.br

Water Management

The first law addressing water use and allocations in Brazil was its Waters Code, promulgated in 1934 through Federal Decree Nº 24,643 in a context of nationwide modernization and economic development where water was viewed as an abundant asset.

With rising industrialization and population growth after the 1970s, water supplies began to run short in some regions, triggering more heated disputes among water users and underscoring the **need for water use planning and coordination mechanisms** that would fine-tune allocations.

In Brazil today, **water resource management** is based on its **National Water Resources Policy (PNRH)**, defined in the Waters Act promulgated in 1997 (Law Nº 9,433). This Policy structured, steered and modernized water resource management in Brazil, with this Act underpinning significant progress in its water resource management. Previously, Ceará and São Paulo had already promulgated their own State Water Resource Policies in 1991.

In Brazil, water resource management may be understood as a set of planning, monitoring, resource allocation and implementation actions, together with oversight and inspection of legal tools intended to ensure efficient coordination and sustainable use of water nationwide.

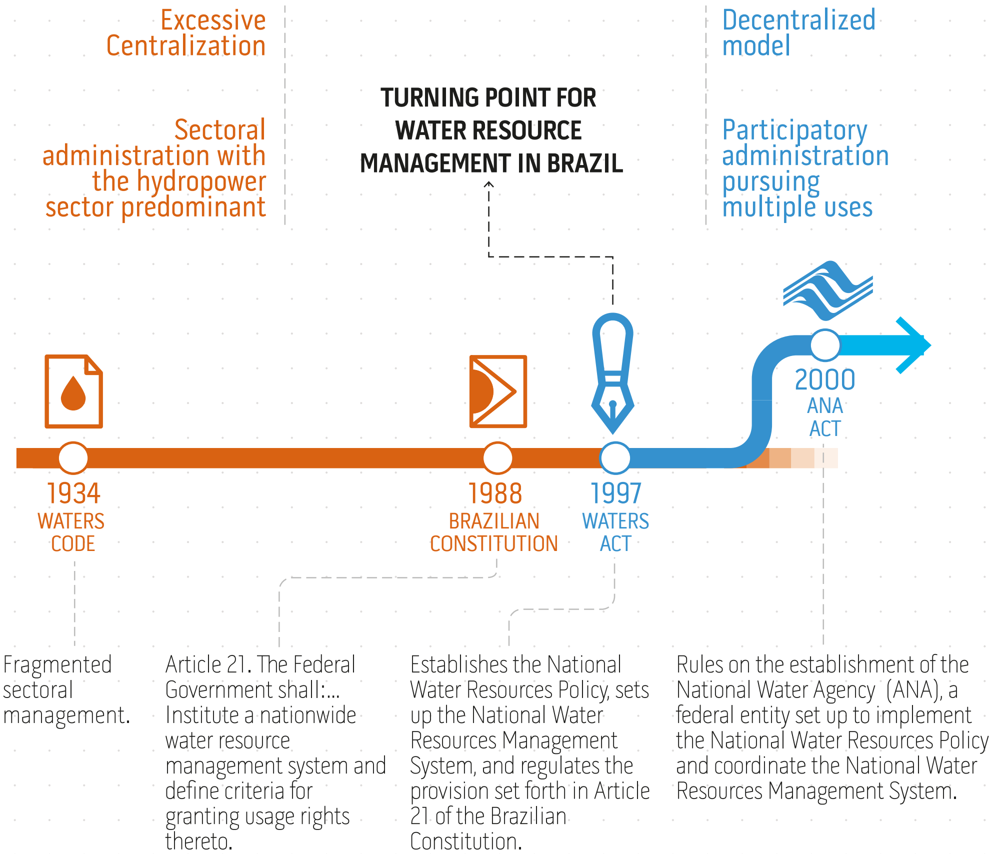
Its National Water Resources Policy is underpinned by six core concepts: (1) water is a public asset; (2) it is a limited natural resource with economic value; (3) multiple water uses must be guaranteed; (4) when in short supply, top-priority uses are public water supplies and drinking water for livestock; (5) the water resource management unit is the hydrographic basin; and (6) water resource management must be handled in a decentralized manner.

The PNRH establishes that water resource management may not separate aspects related to quantity and quality, necessarily considering the geographical, social and economic diversity of Brazil, with planning by region and user sector at the state and national levels, in parallel to integration with environmental management systems, including land use, estuary complexes and coastal zones.

In addition to this Water Resources Policy, Law Nº 12334 (2010) established Brazil's **National Dam Safety Policy (PNSB)**, with 29 dam safety oversight entities – three Federal and 26 State – declaring dams to be monitored.

One of the tools deployed through the National Dam Safety Policy Is the Dam Safety Report (RSB). Drawn up each year by ANA, it offers society an overview of progress in Brazilian dam safety, together with the implementation of the National Dam Safety Policy, in addition to guidelines steering the activities of dam entrepreneurs and oversight entities. These Reports are available at: ***www.snisb.gov.br***

HISTORICAL MILESTONES FOR WATER RESOURCE MANAGEMENT IN BRAZIL



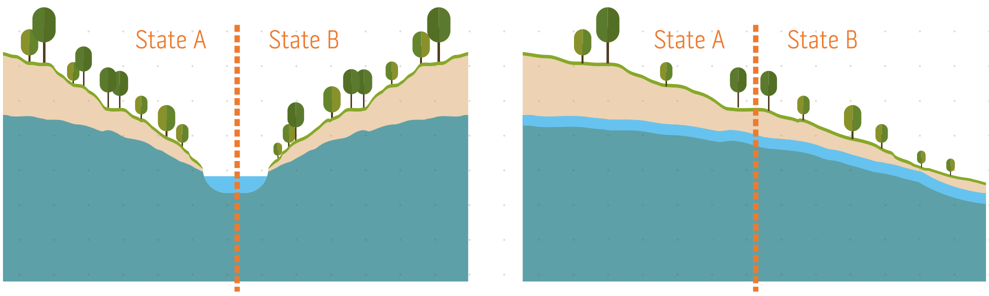
Under Brazil's 1988 constitution, a surface water-body falls under the domain of the State within which it lies completely, and is in the Federal domain if located in more than one State or country. The Federal domain also encompasses water-bodies located on areas protected by law, under the public domain and possession, as indigenous lands and some types of conservation units, while groundwaters always fall under State domain.

In Brazil, **water-body domain** is an attribute that defines which government entity, either Federal or State, is in charge of water management. Based on domain definitions, management is handled by 28 different institutions – ANA at the Federal level and 27 State water management entities). They must work seamlessly together to define rules and procedures, in addition to establishing minimum streamflows delivering water from one State to a bordering State, as well as settling any disputes over water use that may arise among States.

WATER-BODIES UNDER FEDERAL DOMAIN IN BRAZIL

In Brazil, a river is Federal when

it defines a boundary between States, and when it rises in one State and runs through the territory of another or others.

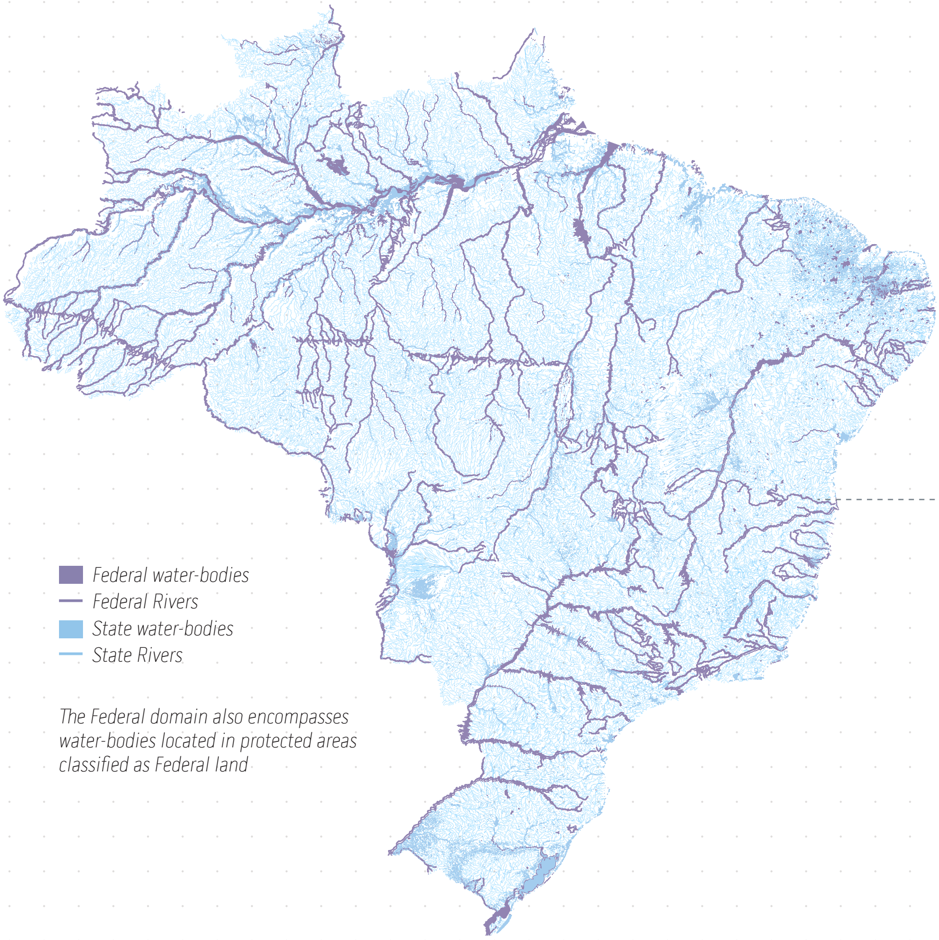


Surface and groundwater management must be handled in an integrated manner, as there are natural intrinsic links between them in the hydrological cycle, despite being located in different domains. Assessing **baseline flows** and their contributions to surface streamflows is vital for integrated management, taking into consideration **surface and groundwater** in the hydrological cycle.

The baseline flow (or baseline outflow) may be understood as the outflow of groundwater resulting from rainwater infiltrating into the soil, which is then released by aquifers.

Recent studies of groundwater diagnosis stages for the Paranapanema, Grande and Paraguay river basin plans drawn up in 2014 and 2015 used assorted methodologies to estimate baseline outflows to mean river streamflows, in order to draft an integrated water balance, separating input to surface flows from surface and underground sources.

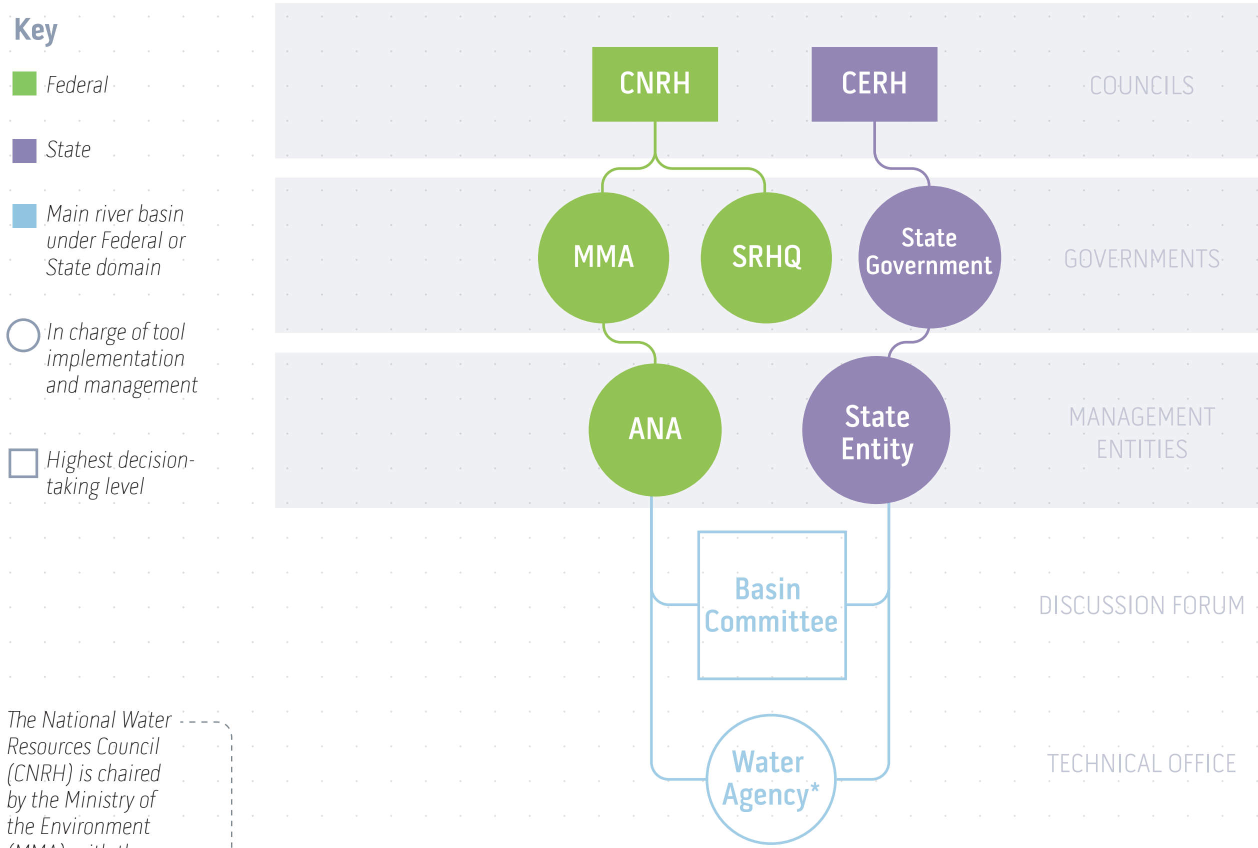
DOMAIN OVER SURFACE WATER-BODIES IN BRAZIL



Information on domain over surface water-bodies is available at: ***goo.gl/MfCHK6****. Theme-specific maps for each Brazilian State may be downloaded from:* ***goo.gl/8Q3hgs***

Brazil's Water Resources Policy is implemented through the **National Water Resources Management System (SINGREH)**, whose institutions are endowed with different legal status and specific functions, which may be deliberative (Water Resource Councils and River Basin Committees) or operational (Management Entities and Water Agencies).

INSTITUTIONAL MATRIX – SINGREH MEMBERS



* Basin agency or collegiate body with similar legal functions, or State water resource management entity

The National Water Resources Council (CNRH) is chaired by the Ministry of the Environment (MMA), with the Water Resources and Environmental Quality Bureau (SRHQ) serving as its Executive Secretariat. The CNRH Plenary consists of 57 board members with three-year terms of office, representing the Federal Government, the States, water users and civil organizations .

The **National Water Resources Council (CNRH)** is an advisory, regulatory and deliberative collegiate body holding the highest position in the SINGREH hierarchy.

This Council has already issued 190 Resolutions and 67 Motions, with ten Technical Chambers addressing specific topics.

There is no CERH in Acre State, instead working through the Water Resources Technical Chamber, which is a discussion forum on this issue established under the aegis of the Environment, Science and Technology Council (CEMACT).

Similar to the CNRH, the State and Federal District Water Resource Councils (CERHs) are advisory and deliberative bodies set up to draft water resource policies for areas under their jurisdiction and hand down final decisions on a variety of matters related to water resources. **In 2016, there were 26 CERHs in operation.**

The Federal entity implementing Brazil's National Water Resources Policy is ANA, with entities in some States and the Federal District holding specific jurisdiction over water resource management, similar to ANA. In others, responsibilities for implementing State water resource policies is assigned to the environment entity.

The necessary integration between actions undertaken by the Federal and State Governments established through domain over water-bodies means that advancing with water management in Brazil depends on an efficient management system at the State level. In order to enhance institutional cooperation and Federal State Main river basin under Federal or State domain In charge of tool implementation and management Highest decision-taking level joint efforts under the aegis of SINGREH, while buttressing State management systems, the **National Water Management Covenant Consolidation Program (PROGESTÃO)** was set up in 2013.

The Progestão Program is subject to Resolutions Nº 379, 512 and 1,485 issued by ANA, all in 2013. Further information is available at: ***goo.gl/uoD2CT***.

This **Program** included the disbursement of up to five annual instalments of almost **USD 230,000*** (BRL 750,000) to each State, in return for meeting pre-set institutional goals. These goals were divided into federative cooperation goals that were common to all States and specific State goals selected by the States themselves and approved by the respective State Water Resource Councils (CERHs), based on the level of complexity of the management system selected by each State. **Four management complexity levels** were identified, ranging from basic to more sophisticated structures, tailored to the specific characteristics of each region and the demands imposed by situations of greater or lesser complexity resulting from the criticality of water resource availability.

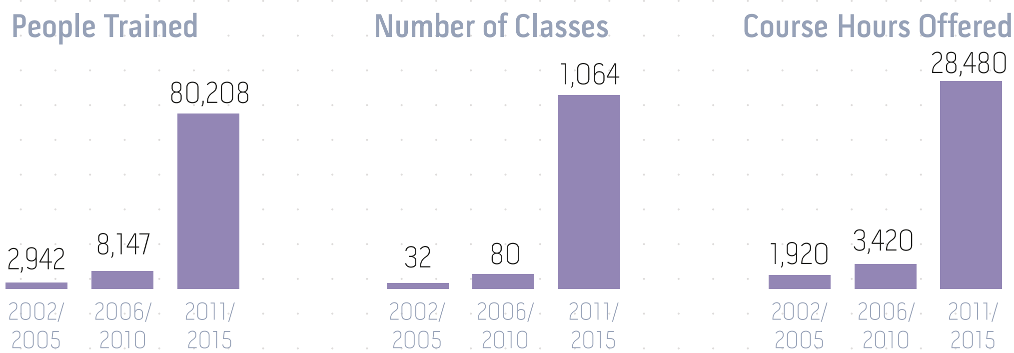
Exchange rate on March 1, 2018

Every State in Brazil signed up voluntarily with the Progestão Program between 2013 and 2016, starting with Paraíba which, together with Alagoas, Goiás, Mato Grosso, Paraná, Piauí, Rio de Janeiro, Rondônia and Sergipe constituted the set of nine States whose cycle ended in 2016. They have already signed up for a new cycle starting in 2017. The remaining ten States – Acre, Amazonas, Bahia, Espírito Santo, Maranhão, Mato Grosso do Sul, Pernambuco, Rio Grande do Norte, Rio Grande do Sul and Tocantins – decided to conclude the implementation of goals in 2017. The rest signed up in 2014, with the Program horizon extending through to 2019.

The Progestão Program is audited by ANA and the CERHs in order to certify that targets are being met. At the end of its five-year term, ANA conducted an assessment seeking improvements and feasible alternatives for dealing with bottlenecks and stumbling-blocks, paving the way for this Program to continue for a further five years.

Moving ahead with water resource management requires proper qualifications for people involved with the SINGREH, through **training at many different levels, ranging from entry-level courses through to graduate degrees in subjects linked to water resources.** The target public for these capacity-building actions consists of civil servants, SINGREH representatives at various levels, opinion shapers, water users and society in general, especially young people. Furthermore, the capacity-building actions of SINGREH also encompass administrators in foreign countries signing cooperation agreements with Brazil, particularly in Latin America and the Portuguese-speaking countries. These courses are held in classrooms and through distance learning, as well as a blend of these two techniques, addressing a wide variety of topics.

All capacity-building actions are described in detail at: ***goo.gl/CdVZn2.*** *Educational materials are available from the permanent collection of water resource education items: ConheceRH.*

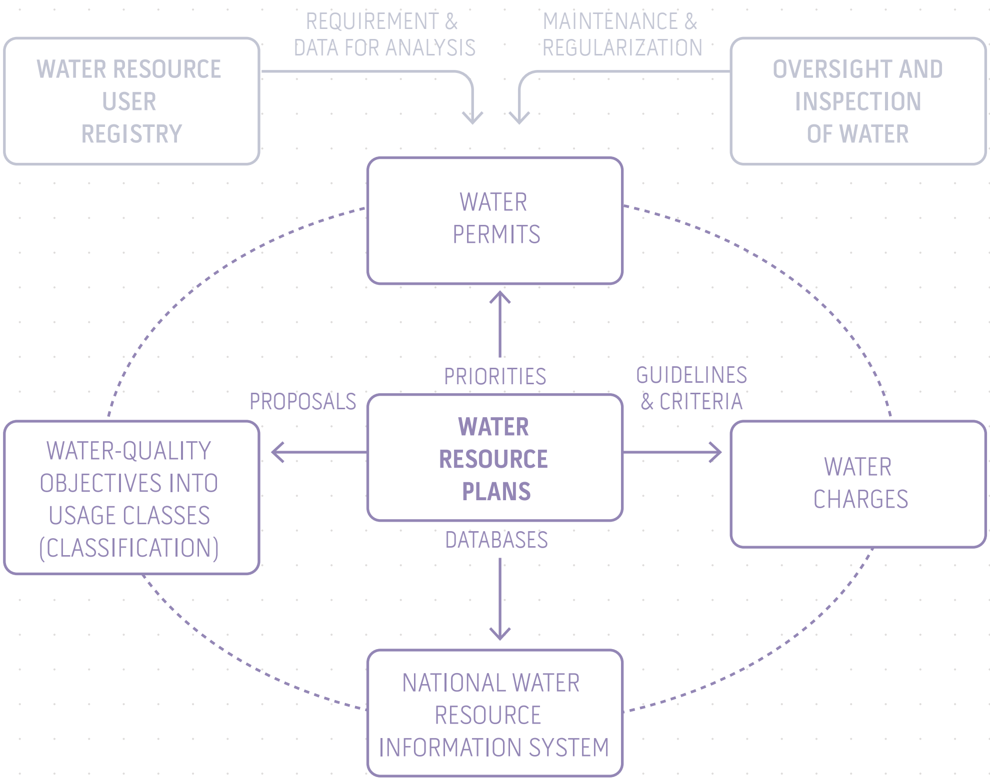


There was a significant increase in the number of people trained, the number of classes and the length of the courses given between 2012 and 2016, prompted mainly by the successful implementation of the distance learning system during this period.

In 2016, 14,210 people were trained, and between 2001 and 2016, people were trained from 2,987 municipalities (54% of the national total) in all States. The international capacity-building schedule included courses attended by more than 1,200 people in more than twenty countries between 2003 and 2016.

Strengthening integrated water resource management at the Federal and State levels is a vital step for the full implementation of the PNRH, whose **management tools** intended to structure it through planning, regulation and oversight/inspection activities, as well as disclosing information.

NATIONAL WATER RESOURCES POLICY TOOLS



The five management tools provided by Brazil's National Water Resources Policy are interrelated. For example, when granting a permit along a specific reach of water, compliance is required with the usage class under which it is classified, preferably defined in the Water Resource Plan. This plan is a planning tool that largely guides the deployment of tools, due to its powerful influence on all of them. User registration and water resource usage supervision are in turn management actions that underpin the efficient deployment of management tools, especially granting water permits and water use charging.

Information is a vital tool for taking decisions and managing water resources, ensuring that they are available in adequate quantities and qualities for current and future generations. Water resource management in Brazil is handled with the participation of society. Consequently, a source of updated and trustworthy information is crucial for steering decisions taken by civil organizations, water users and governments. **The National Water Resources Information System (SNIRH)** is a massive database holding information on water in Brazil, consisting of a set of processes for collecting, organizing and transmitting data and information.

*This System is accessed through a themed menu that systematizes its vast range of data and information on water resources in Brazil, available at: **goo.gl/NSBdYF.** There are also several systems linked into the SNIRH that also provide data and information in different formats.*

The National Water Resources Information System (SNIRH) consolidates water status data from all over Brazil, including reservoir levels, river streamflows and water quality, as well as information on the users of these waters, including urban supply systems, irrigation networks, industries and others. This means that the **quantity** of available water is known, together with its **quality** and what water **uses** are under way. This information is vital for efficient water **management**.

THEMATIC ACCESS TO SNIRH CONTENT

Hydrographic Division
Divisions based on river basins, surface water-bodies and domain definitions

Water Quantity
Rainfall, water availability, quantity monitoring and reservoirs

Water Quality
Quality indicators and quality monitoring

Water Uses
Total consumption demands, urban water supplies, irrigation and hydropower

Balance
Critical segments and basins, quantity balance, quality balance and quality-quantity balance

Critical Hydrological Events
Critical events and situation rooms

Institutional
Basin committees and agencies

Planning
Water resource plans and water quality objectives

Regulation, Inspection Oversight
Regulation, permits and water use charges

Program
Water Producer, *Prodes* and *Progestão*

The SNIRH provides input for a set of actions and studies in Brazil, including the preparation of the Environmental -Economic Accounting for Water and the Sustainable Development Goals, especially SDG-6.

Data and information on water resources, determining factors for taking decisions, such as the action proposed in the plans, classifying water-bodies according to water quality objectives and granting water permits, thus buttressing the **action coordination and priority rankings.**

*At the moment, data and information in the SNIRH are available through three tools: the SNIRH Portal (www.snirh.gov.br; the Metadata Portal (http://www.ana.gov.br/metadados); and the Geo-Services Portal (**goo.gl/qdVtWA**).*

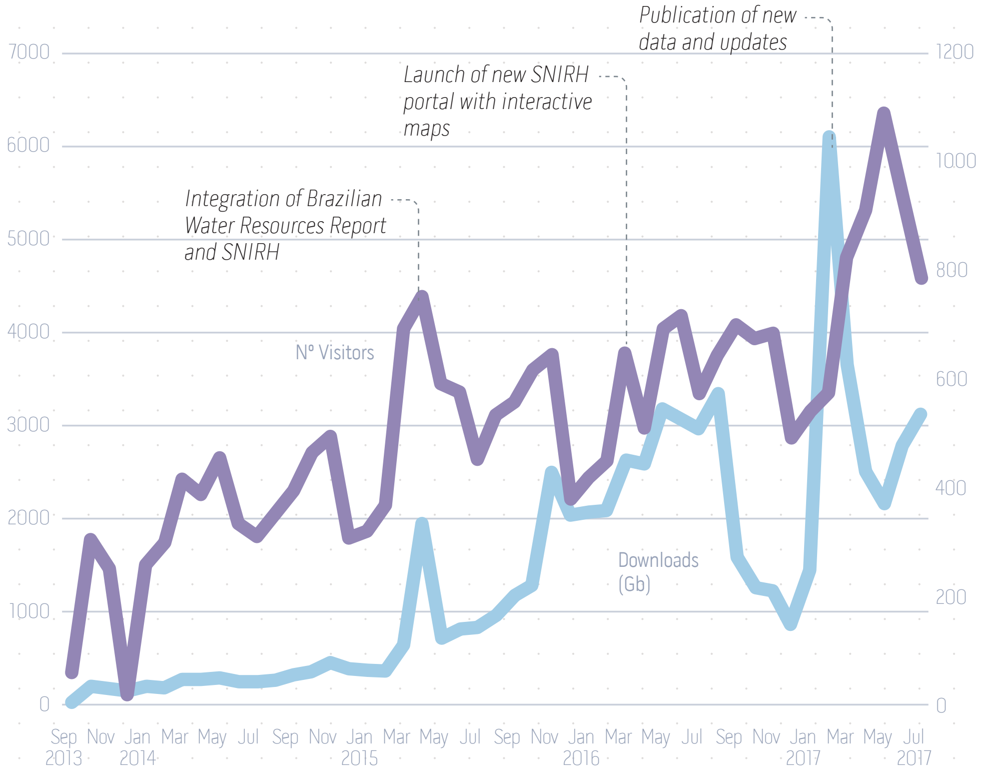
*Data and information in the SNIRH may also be accessed through the National Spatial Data Infrastructure (INDE) portals at: **goo.gl/v3tx5J** and the Brazilian Open Data Portal: **goo.gl/jppDPc**.*

The coordination of the SNIRH is handled by ANA, compliant with the principles of decentralized data and information uptake and production; unified system coordination; guaranteed and access the society as a whole. All SINGREH entities and other institutional partners feed data into the system, ensuring it is updated systematically and regularly.

All this **information is stored** in a database and disclosed in the form of interactive maps. All data in the SNIRH are public and may be accessed free of charge by anyone wishing to do so. There is a Metadata Portal linked to the SNIRH that was set up in order to organize and systematize geospatial information produced and used by ANA, in order to ensure its dissemination and accessibility through the Internet. In turn, the Geo-services Portal offers SNIRH content as webservices, in open data formats that can be accessed and used by other systems and portals.

In 2016 there were 38 interactive maps available in the SNIRH, produced from 144 geo-service layers and associated with 200 different meta data. This Portal chalked up 174,631 visits between 2013 and 2016, with 77,722 of them in 2016. The total download volumes for this year reached 4.64 terabytes.

METADATA PORTAL STATISTICS

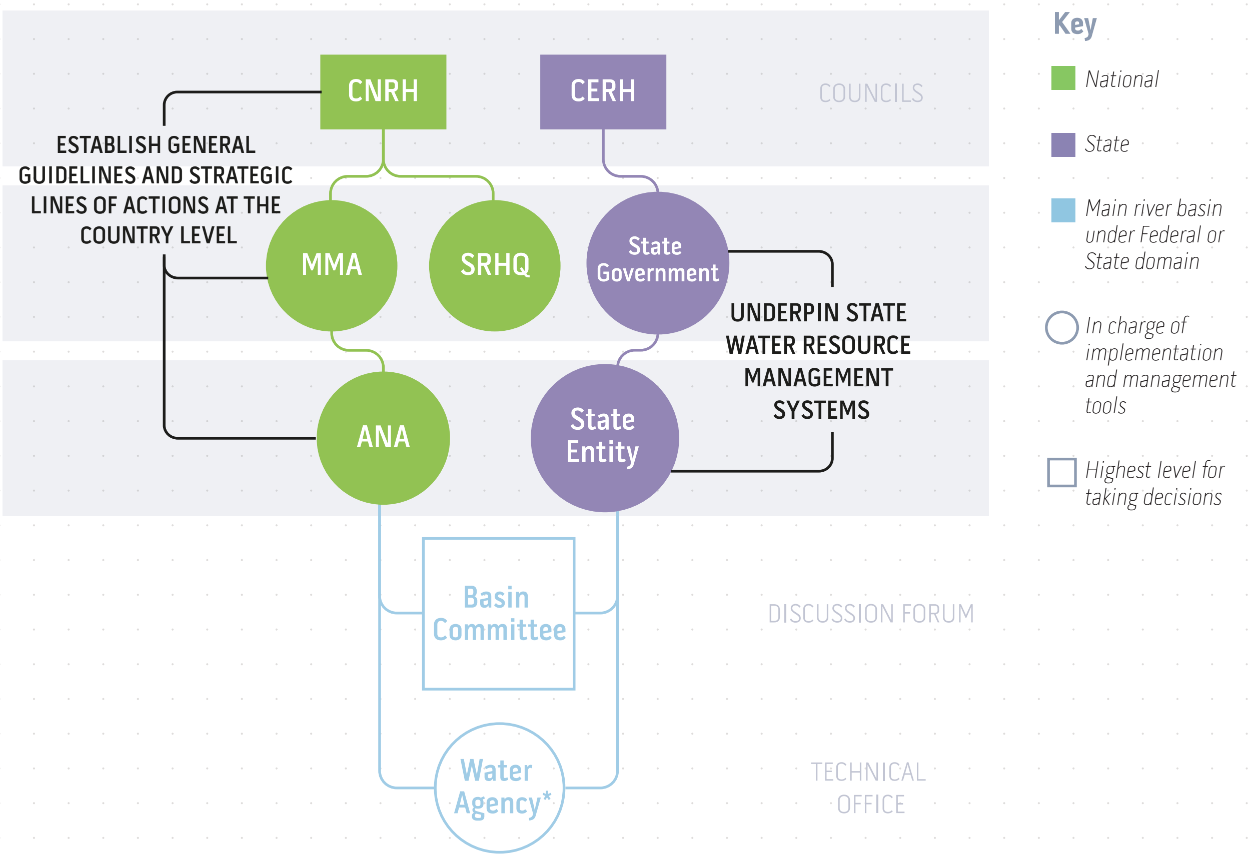


Water Resource Plans (PRH) are management tools that include detailed diagnoses of water within specific territories, in addition to water resource status forecasts based on usage simulation scenarios portraying different social, economic and whether conditions, as well as other aspects. During the prognosis stage, actions, programs and projects are defined for implementation within specific periods, in addition to identifying-priority works and investments through an integrated overview of the many different water uses.

Resolution Nº 145 issued in 2012 by the CNRH establishes preparation guidelines Water Resource Plans.

Plans are drawn up on participatory bases, involving government entities, civil society, water users and a variety of institutions, in order to reach agreement over water usage. It's spatial area may vary from **national to state and river basin**, consequently effecting their content and the entities/boards in charge of preparing, approving and overseeing the implementation of the proposed actions.

WATER RESOURCE PLANS IN BRAZIL



* River basin agency or entity with similar legal functions or State Water Resource Management entity

NATIONAL AND STATE WATER RESOURCE PLANS

This acronym – PNRH – is also used for Brazil's National Water Resources Policy. The National Plan was drawn up in 2005, followed in 2006 by a nationwide participatory process that included all wide variety of players from society. It was approved for 2006 – 2020 by the National Water Resources Council (CNRH) in 2006 through Resolution Nº 58, underpinned by a set of technical studies. The volumes setting forth this Plan may be accessed at: ***goo.gl/8ua5Ua***.

The National Water Resource Plan is a guide document with macro-guidelines steering the implementation of the National Water Resources Policy at the Federal, State and levels, as well as in the Federal District, together with SINGREH actions. Its scope also defines actions and programs to be implemented through to 2020.

This National Plan must be reviewed every four years in order to provide guidance for drawing up the Federal and State Pluri-Annual Plans (PPAs), as well as for the Federal District, together with their respective annual budgets, while also assessing the implementation of actions and defining priorities for the subsequent cycle. The review stages shall include participatory processes that involve society as a whole.

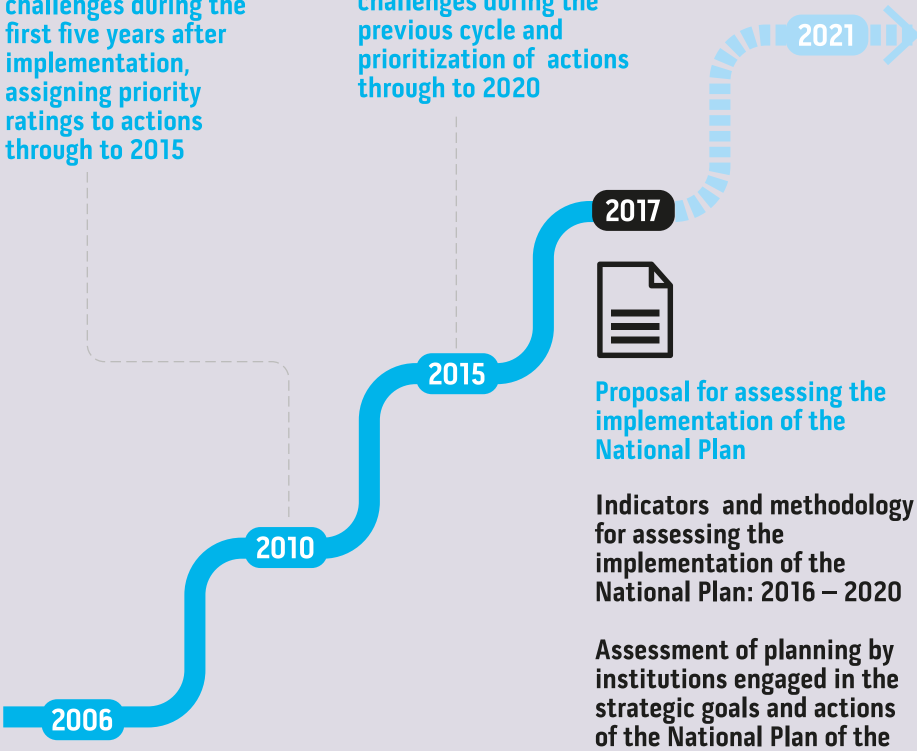
First National Plan Review

Assessment of progress and challenges during the first five years after implementation, assigning priority ratings to actions through to 2015

Second National Plan Review

Assessment of progress and challenges during the previous cycle and prioritization of actions through to 2020

Start of new action implementation cycle for the period subsequent to 2021



Proposal for assessing the implementation of the National Plan

Indicators and methodology for assessing the implementation of the National Plan: 2016 – 2020

Assessment of planning by institutions engaged in the strategic goals and actions of the National Plan of the 2016 – 2020 cycle

Recommendations and guidelines for the new National Plan implementation period, subsequent to 2021

Launch of the National Water Resources Plan
Nº 58/2008 by the National Water Resources Council (CNRH)

Definition of programs and actions for 2006 – 2020

Between 2011 and 2015, 22 priorities were selected and approved by the CNRH, for the implementation of the National Plan (Resolution Nº 181 issued by the CNRH in 2016). For 2016 – 2020, 16 priorities have been approved, as part of the actions replicated from the previous period, with 71 goals to be reached through the implementation of 45 scheduled actions.

During the implementation period for the 2006-2015 National Plan, an execution analysis was conducted for the programs and actions proposed through to 2010, assessing compliance with the priorities listed by the CNRH from 2011 onwards.

It was noted that progress lagged behind expectations for most of the programs and priority actions being implemented. This was due largely to poor planning for the implementation of each action and its target performance during this initial stage, reflected in the lack of pre-defined goals and deadlines, as well and failures to appoint people in charge and allocate resources, in addition to establishing methodologies for overseeing and implementing the proposed actions.

The outcomes prompted the preparation of a planning and oversight strategy in 2016, designed to upgrade management processes and highlight progress in reaching goals for approved themes through to 2020. Recommendations and guidelines also indicated for 2021 onwards.

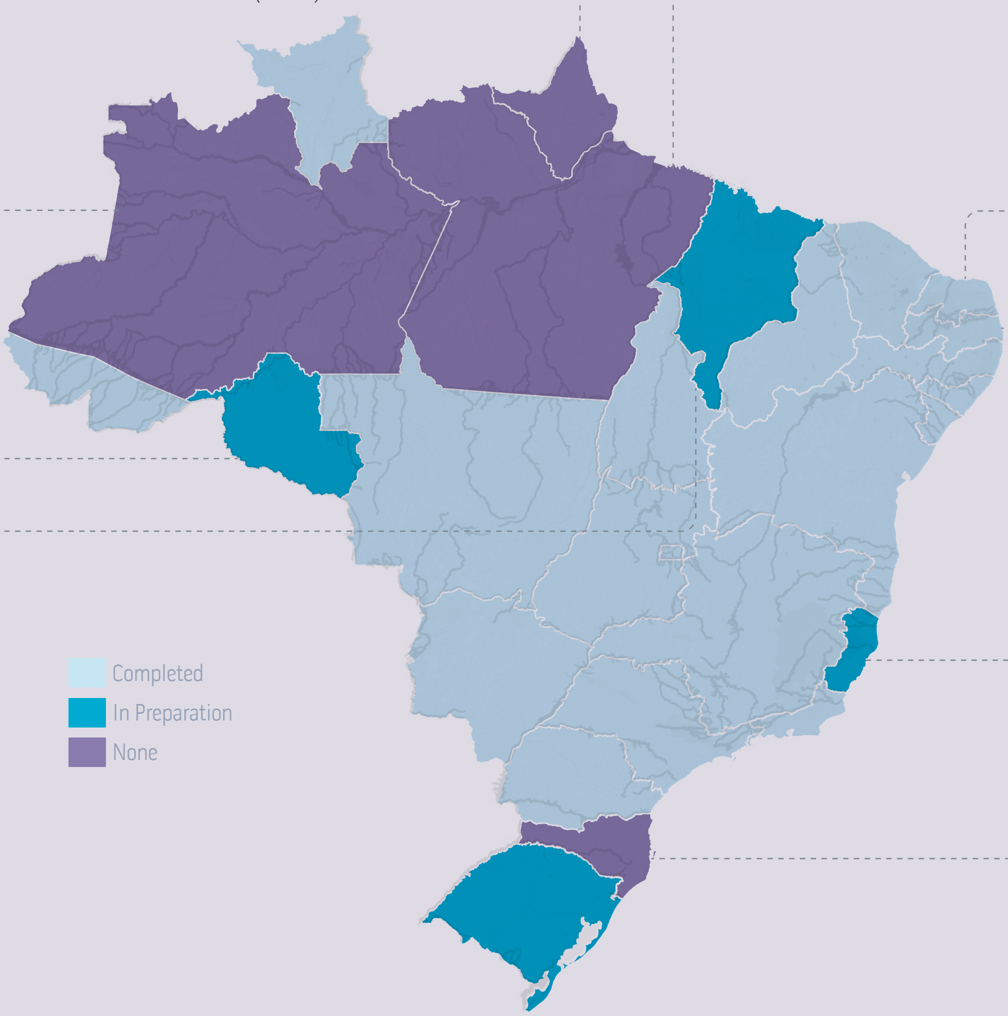
The **proposed methodology** is based on using performance indicators to assess compliance with each of the priorities and their respective goals, in addition to perception indicators evaluating how such progress is viewed by society. Based on this information, additional analytical assessments may be drawn up, examining aspects such as the importance of each of the priority themes in a context of progressing implementation of the National Plan, while also conducting an overall assessment of progress in the implementation of priority actions and their associated targets.

An analysis of the results achieved since the launch of Brazil's National Water Resource Plan during 2016, together with recommendations drawing up a new plan coming into effect in 2021, underpinned by the lessons learned so far.

STATE WATER RESOURCE PLANS IN 2016

Plans are being drawn up for Amazonas, Maranhão and Rondônia States, with technical and financial backing from the SRHQ/MMA, financed by the National Environment Fund (FNMA)

Meanwhile, Amapá and Pará States are engaged in discussions on setting up partnerships with The SRHQ/MMA in order to start preparing their Plans



Rio Grande do Norte and Paraíba signed agreements with the MMA in 2016 on revising their State Water Resource Plans (PERHs)

Espírito Santo is drawing up its State Water Resource Plan with its own resources, and Santa Catarina intends to commission self-funded technical studies for the preparation of its plan

The classification framework is structured into quality classes (or framework classes) as set forth in Resolution N° 357 and N° 396 issued by the by National Environment Council (CONAMA) in 2005 and 2008 respectively, referenced to the river basin as a management unit and uses that are preponderantly more restrictive, as listed in Resolution N° 91 issued by the National Water Resources Council (CNRH) in 2008.

The **classification framework** for water bodies according to water quality objectives is divided into quality classes by preponderant uses, in order to ensure water quality that is compatible with the most demanding uses for which it is intended, while also lowering water pollution mitigation costs through permanent preventive actions.

CLASSIFICATION OF WATER QUALITY OBJECTIVES FOR FRESHWATER-BODIES

FRESHWATER USES	CLASSIFICATION OF WATER QUALITY OBJECTIVES				
	Special	1	2	3	4
PRESERVATION OF NATURAL BALANCE IN AQUATIC COMMUNITIES	Mandatory in Full Protection Conservation Unit				
PROTECTION FOR AQUATIC COMMUNITIES		Mandatory for Indigenous Lands			
PRIMARY CONTACT RECREATION					
AQUACULTURE					
SUPPLY FOR HUMAN CONSUMPTION	After disinfection	After simplified treatment	After conventional treatment	After conventional or advanced treatment	
SECONDARY CONTACT RECREATION					
FISHING					
IRRIGATION		Vegetables raw or fruits with skin	Vegetables and fruit growing, parks, gardens and fields	Trees, cereals or fodder crops	
DRINKING WATER FOR LIVESTOCK					
NAVIGATION					
LANDSCAPE HARMONY					

Resolution N° 357/2005 issued by CONAMA establishes the permitted limits for the physical, chemical and biological parameters in each class. Chapter 2 presents some water quality parameters noted in the classification framework.

Less restrictive **uses in terms of water quality standards** consist of navigation and harmonious landscaping, while the most exigent are intended to preserve the natural balance of aquatic communities human supplies, after disinfection. The special class does not allow any liquid waste discharges, even if treated.

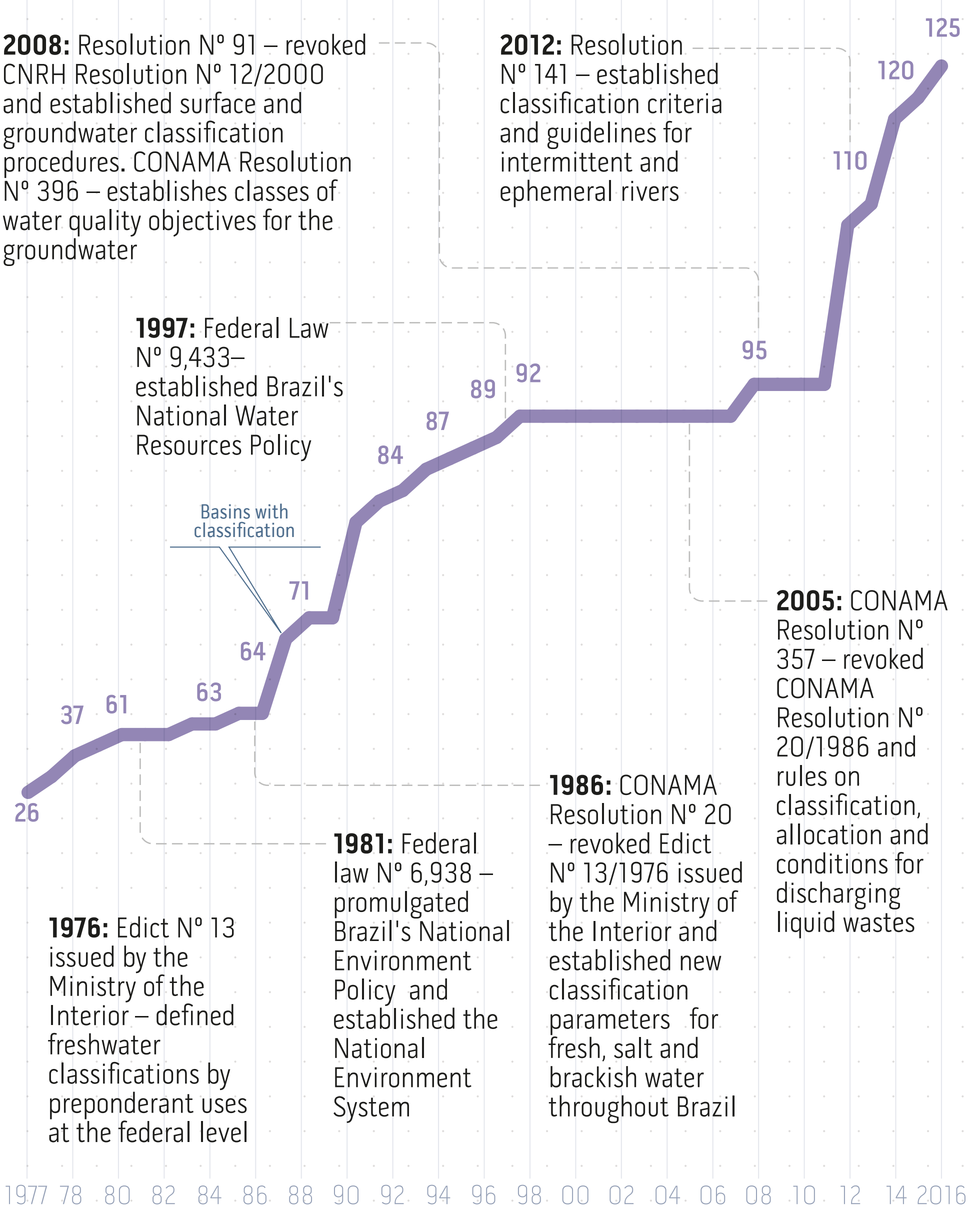
Classifying water-bodies by water quality predates Brazil's National Water Resources Policy (PNRH), drawn up in 1997. The classification framework for water-bodies according to water quality objectives was established by **State and Federal** government entities at their own discretion, with little or no input from society.

São Paulo was the first State to establish a water-body classification system, through Decree Nº 24,806 (1955). However, this classification framework was established through Decree Nº 10,755 only in 1977, based on the classification system set forth in Decree Nº 8,468, promulgated in 1976.

By 2016, 12 States had promulgated normative acts classifying all or some of their water-bodies according to water quality objectives.

Today, water quality standards and criteria for the classification framework classes according to water quality objectives are defined by the National Environment Council (CONAMA) or State Environment Councils, drawing up and approving classification framework proposals are defined by the National Water Resources Council (CNRH) or its State counterparts (CERHs). Normative acts related to the classification framework/water quality objectives may be accessed at: ***goo.gl/UkUtLE***

ADVANCES IN FEDERAL LEGISLATION ADDRESSING THE CLASSIFICATION FRAMEWORK



1976: Edict Nº 13 issued by the Ministry of the Interior – defined freshwater classifications by preponderant uses at the federal level

1981: Federal law Nº 6,938 – promulgated Brazil's National Environment Policy and established the National Environment System

1986: CONAMA Resolution Nº 20 – revoked Edict Nº 13/1976 issued by the Ministry of the Interior and established new classification parameters for fresh, salt and brackish water throughout Brazil

1997: Federal Law Nº 9,433– established Brazil's National Water Resources Policy

2005: CONAMA Resolution Nº 357 – revoked CONAMA Resolution Nº 20/1986 and rules on classification, allocation and conditions for discharging liquid wastes

2008: Resolution Nº 91 – revoked CNRH Resolution Nº 12/2000 and established surface and groundwater classification procedures. CONAMA Resolution Nº 396 – establishes classes of water quality objectives for the groundwater

2012: Resolution Nº 141 – established classification criteria and guidelines for intermittent and ephemeral rivers

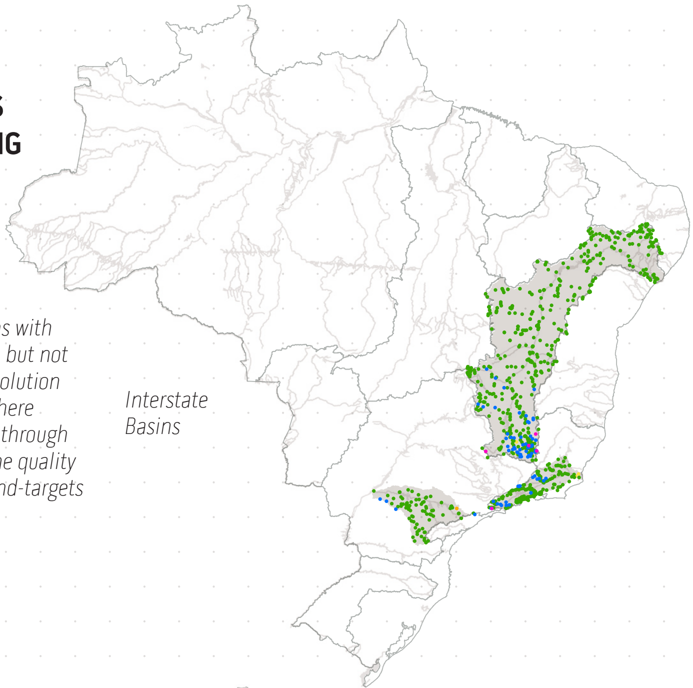
At the Federal level, the first water-body classification system was established through Edict Nº 13 promulgated in 1976 by the Ministry of the Interior. Subsequently, other States drew up classification frameworks for their water-bodies: Alagoas (1978), Santa Catarina (1979) and Rio Grande do Norte (1984).

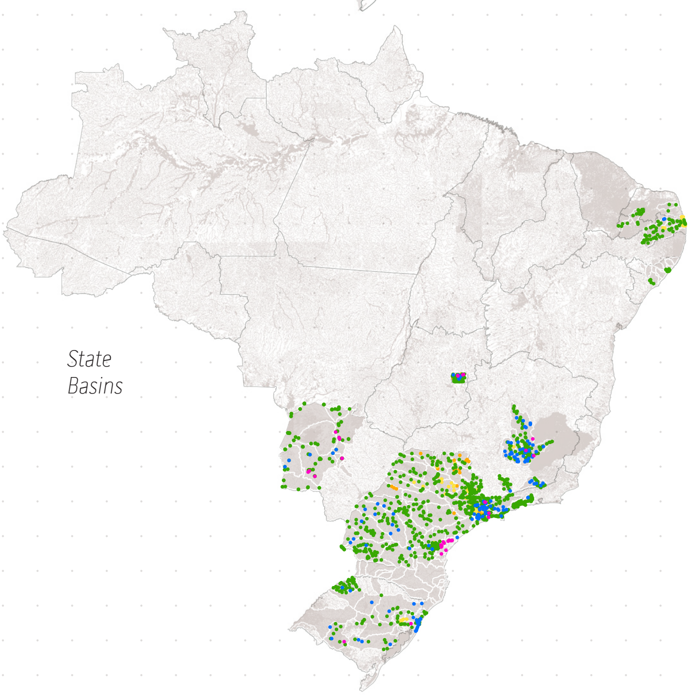
As these regulations progressed, Resolution N° 357/2005 issued by the National Environment Council (CONAMA) included environmental guidelines **classification framework** according to water quality objectives and stipulated that it must be based on the quality levels that a water-body should present in order to respond to community needs, rather than being based on its current status, expressed in end-goals to be pursued, with progressively higher intermediate targets being necessarily set its effective implementation. Issued by the National Water Resources Council (CNRH), Resolution N° 91/2008 laid down the general procedures for the classification framework/water quality objectives and also acknowledged it as a water resource management tool for planning purposes.

Water quality in several Brazilian water-bodies is not compatible with the classes into which they were classified. The Water Quality Objectives Conformity Index (ICE) allows simultaneous assessments of assorted physical, chemical and biological processes in water, referenced to specific values. As a result, this Index can help show how well or how poorly water quality is approaching the targets established in the classification framework/water quality objectives in addition to monitoring the steps established for controlling and mitigating pollution, in order to adjust these actions accordingly.

WATER QUALITY CLASS INDEX FOR MONITORING POINTS IN BASINS WITH CLASSIFICATION FRAMEWORKS

The maps alongside present basins with classification frameworks in place, but not necessarily updated CONAMA Resolution N° 357/2005. In the few cases where progressive targets have been set through these classification frameworks, the quality classes established through the end-targets have been used as references.

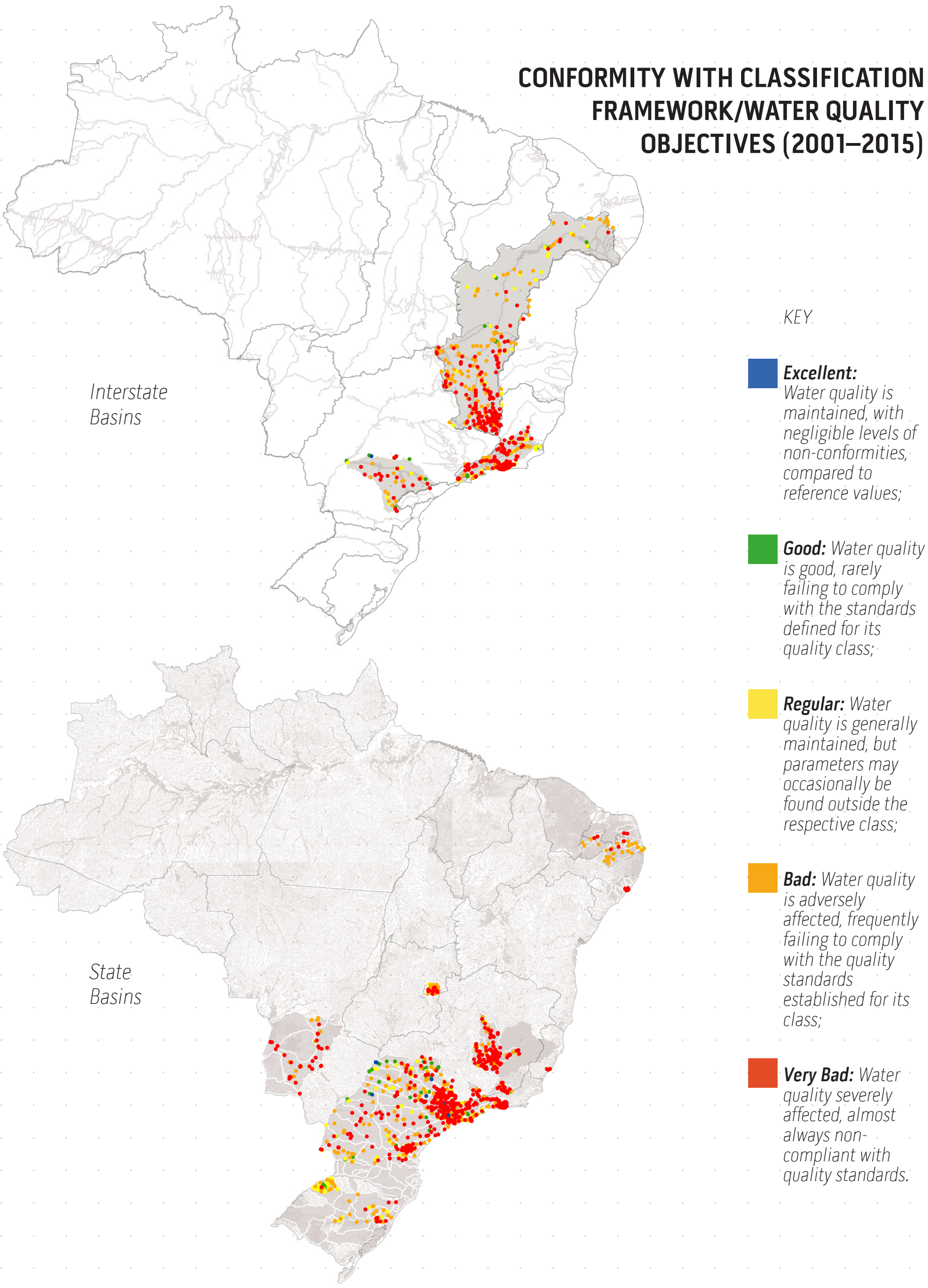




KEY
- Special Class
- Class 1
- Class 2
- Class 3
- Class 4

Places scoring extremely low on the Water Quality Objectives Conformity Index (ICE) predominate in Brazil: out of 2,340 locations analyzed, 1,143 were rated as extremely poor and 831 as poor. With 2,038 locations ranked as Class 2, non-conformities have become the rule for impacted waters, with 86% of the locations in this class rated as extremely poor or poor for Class 2 under this Index. However, the results show a gap between the reality of the water-body classification objectives for preponderant classes of use based on water quality standards in Brazil, and the standards established by law.

CONFORMITY WITH CLASSIFICATION FRAMEWORK/WATER QUALITY OBJECTIVES (2001–2015)



Although some water-body classification for Federal and State river basins were established on the basis of water quality parameters defined in revoked normative acts, these water quality objectives remain in effect under Resolution Nº 91, issued in 2008 by the National Water Resources Council (CNRH).

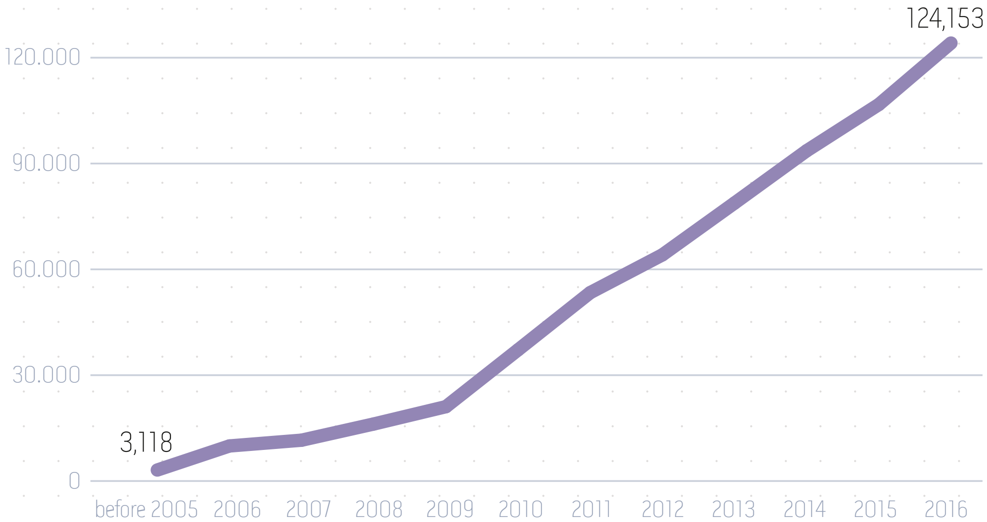
Resolution Nº 126, issued in 2011 by ANA, lays down user registration guidelines and also the integration of surface and water usage databases nationwide. Several State management entities also have their own user registration systems.

There are plans for the National Water Resource Users Registry (CNARH) database to list some 90% of users regularized by the States by 2019.

In Brazil, **Class 2 is used as a reference** for locations where no classification framework has been approved. This applies to most of Brazil's water-bodies, as few classification framework proposals have been approved by the National Water Resources Council (CNRH) and its State counterparts (CERHs). As there are no acceptable reference parameter limits for waters rated as Special Class, and the natural conditions of the water-body must be maintained, the analysis of locations in this class is aligned with Class 1 standards.

In order to ensure greater familiarity with water demands and uses, well buttressing the implementation of water resource management tools and actions – such as licensing water permits and overseeing water uses, the **National Water User Registry (CNARH)** was set up in 2003. From November 2017 onwards, direct registration of water users was no longer mandatory with this system, which now keeps data only on permitted or regularized users provided by water resource management entities. Access to stored in the CNARH is being phased in **gradually**.

USERS REGISTERED WITH THE CNARH THROUGH TO 2016 (ACCUMULATED BY YEAR)



By 2015, 23 States had released data on water interventions and their respective regularization acts on water resource use in the CNARH. A start was made releasing data by the Federal District, as well as Amapá, São Paulo and Rio Grande do Sul States in late 2016.

During the past five years, the CNARH has grown by around 15,000 new records a year, reaching some 124,000 users in 2016, regardless of their use regularization status, meaning whether or not they hold water permits.

Users with **insignificant** water uptake volumes do not need permits, but must register with the respective water resource management entity. Other users must apply **for permits from the respective water resource management entity**. From November 2017 onwards, users must request permits directly through the new Federal Water Regulation System (REGLA) from ANA and also in Maranhão, Pará, Piauí, Rio de Janeiro, Rio Grande do Norte and Tocantins States. Once the permit has been issued, the management entity must register regularized user data in the, CNARH. Granting water resource permits is the management to through which the government authorizes users to make use of a specific amount of surface or groundwater for a pre-set length of time under the terms and conditions set forth in a specific administrative act. The purpose of these permits is to ensure qualitative and quantitative control over water uses and the effective exercise of the right of access to water. There are two special types of water use authorizations: the **Water Reserve Availability Declaration (DRDH)** and the **Waterworks Sustainability Certificate (CERTOH)**.

Varying by water-body, insignificant uses consist of withdrawals or discharges up to specific limits, when not affecting the availability of water for other users. Water-bodies falling within the Federal domain are subject to Resolution 1,175, issued by ANA in 2013. Insignificant uses in State water-bodies vary, depending on the criteria established by the respective management entities.

From 2013 to 2016, 14 DRDHs were issued, 3 of them in 2016. A total of 19 enterprises were issued with CERTOHs, or were altered during the period, 3 of them in 2016.

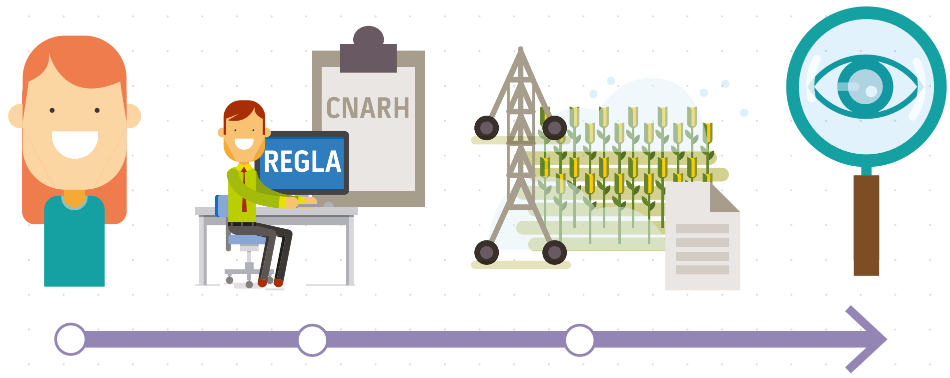
For hydropower complexes, Brazil's Power Sector Regulator (ANEEL) must obtain the DRDH from ANA or the respective water resource management entity, which is automatically transformed into a permit after authorization or concession of hydropower complex site.

Permits are requested by water users and issued by state management entities, if the water is drawn from a water-body under State domain, or ANA for Federal water-bodies. Discharges of liquid wastes into water-bodies must also be permitted by the competent entity, as this constitutes a form of use that disqualifies water for other uses under quality standard requirements. Water users may also apply for pre-emptive permits, in order to reserve streamflows that could be licensed, in order to underpin enterprise planning. However, pre-emptive permits do not confer water usage rights on their holders, but must instead be converted into permits through applying to the competent entity.

Waterworks financed by the several government worth more than just over USD 3 million (BRL) 10 million also require a CERTOH, which attests to the hydrological and operational sustainability of the enterprise, in terms of the capabilities of the institution in charge in the existence of funds for its operation and maintenance.

The power to issue water permits may be delegated from the Federal domain to a particular State through a specific normative act issued by ANA. For example, the Federal District, Ceará, and São Paulo States hold this prerogative.

WATER PERMITS ISSUING AND MAINTENANCE PROCEDURES



USER
Submits a water use permit application to the competent entity

MANAGEMENT ENTITY
Assesses the possibility of issuing the requested permit

PERMITTED & REGISTERED USE
Water use as specified in the act granting the permit

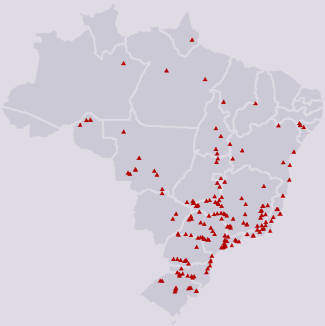
INSPECTION AND OVERSIGHT
Management entity ascertains use is compliant with the permit

WATER CHARGES IN THE HYDROPOWER SECTOR

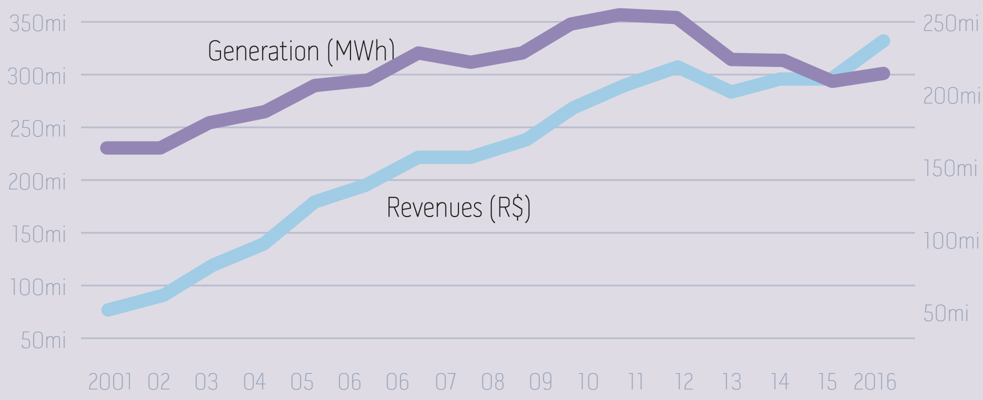
Users subject to permits may be required to pay **water use charges**, charged in order to acknowledge water as an economic asset, providing users with an indication of its real value and encouraging rational use, while bringing in funds to underwrite programs and interventions addressed in the Water Resource Plans.

Hydropower complexes generating less 30 MW are exempt from paying any type of compensatory fees, under two Laws: Nº 7,990 and Nº 9,427, promulgated respectively in 1989 and 1996. In general, small hydropower plants (PCHs) and hydropower generation centers (CGHs) pay no fees for using water resources.

A specific charge is applied on water resources used by hydropower complexes in Brazil. Concessionaires or permit-holders authorized to engage in the **exploitation of water power** pay 0.75% of the value of the electricity produced through the Water Resource Usage Fee (CFURH). The amounts brought in are earmarked for implementing the National Water Resources Policy and the National Water Resources Management System (SINGREH).



INCREASES IN WATER CHARGES



In 2016, the Water Resource Usage Fee (CFURH) rose by 9.5% over the 2015 rates, compliant with power sector regulations.

Electricity generated by Brazil's hydropower plants in 2016 was around 3.3% higher than in 2015.Revenues brought in through water charges paid by the hydropower sector in 2016 topped USD 63 million (BRL 208.80 million), some **13% higher than the previous year**. The replenishment of water volumes stored in hydropower dams contributed to the final figures.

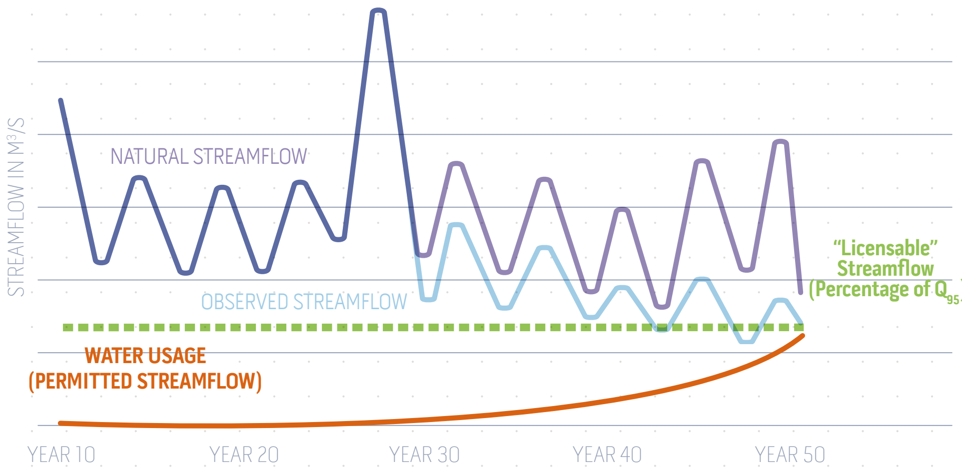
Each State and the Federal Government is endowed with autonomy for defining the criteria for granting usage rights for water falling within their domains. A **reference streamflow** (minimum flow that must always be guaranteed in the water-course) is generally adopted, through which an assignable streamflow is established (flow that may be permitted). For example, a reference streamflow of Q_{95} is adopted for rivers within the Federal domain, meaning that this flow must be guaranteed for 95% of the assessed time. Consequently, only streamflows of less than Q_{95} may be granted, in order to ensure control over water use demands at appropriate risk limits.

Further information on permits issued by ANA is available at: ***goo.gl/NmgsWA***.

The reference streamflow is associated with minimum flows from the water-body, constituting a condition with the strongest possible guarantee of water for users of these resources. Authorizations to withdraw water (permits) may be issued only up to the limit of this amount, as water availability may be adversely affected for other users, as well as for maintaining an ecological balance.

LICENSABLE STREAMFLOW

The natural flow is when no water is withdrawn and with no regularization through reservoirs. The observed streamflow is measured in the water-body after volumes are withdrawn off for a wide variety of uses.



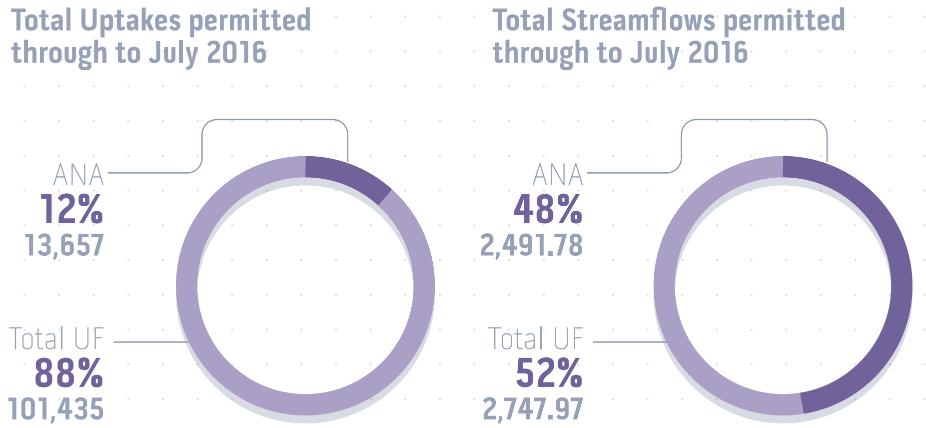
During water shortages, it may be necessary to establish **regulatory frameworks** that consist of a set of general rules on water use for a specific water-body, defined by the grantor authorities with input from water resource users, which legally prevail over permits granted previously.

All water consumption permits issued in Brazil through to July 2016, including those that have expired over the years, constitute a total of 115,092 water uptake points, with 88% permitted by the States (State permits). Although ANA accounts only 12% of the total number of licensed uptake points (Federal permits), the total streamflow licensed by ANA is close to the sum of the streamflows permitted by the States. Overall (ANA and the States), irrigation accounts for 63% of all licensed streamflows.

There are also users that are not regularized, meaning that they withdraw water but do not apply for permits, although legally required to do so. It is presumed, therefore, that the total volume licensed does not represent the total water use in Brazil.

User categories addressed in analyses of streamflows covered by Federal and State permits (except in Amazonas and Amapá States that have not yet issued permits through to July 2016) consist of irrigation, industry (mining included), urban/rural water supplies (public water supplies, landscaping, rural water supplies, urban services such as hotels and gas stations, among others) and others (aquaculture, drinking water for livestock, cooling thermopower plants and other less significant uses).

PERMITTED UPTAKES AND STREAMFLOWS IN BRAZIL THROUGH TO JULY 2016 *m³/s*

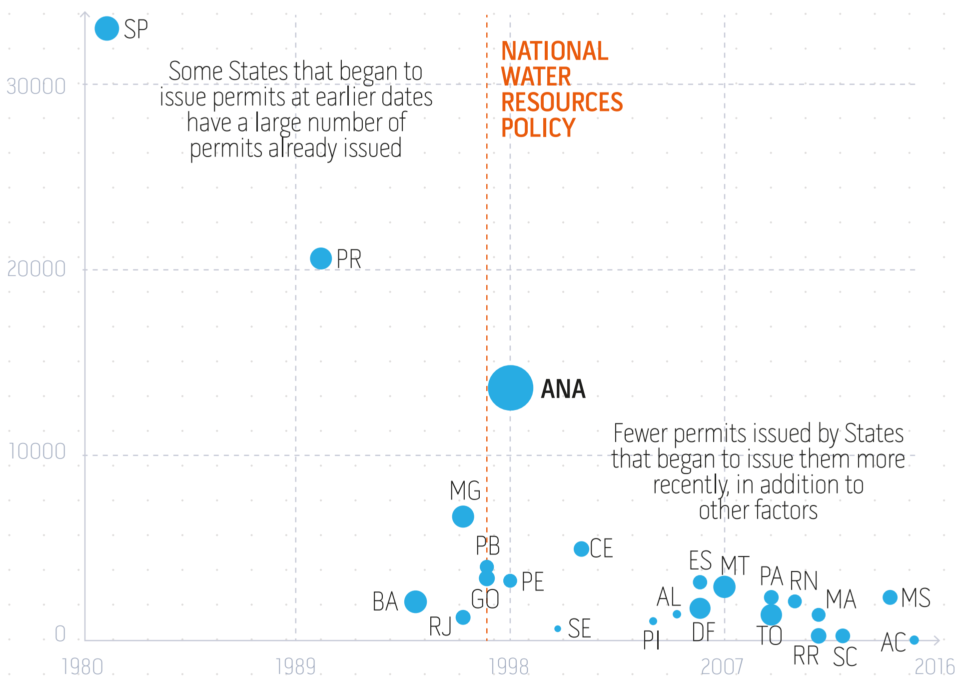


The spatial distribution of permitted uptake and discharge points along federal rivers is shown at: ***goo.gl/YrRdtz.***

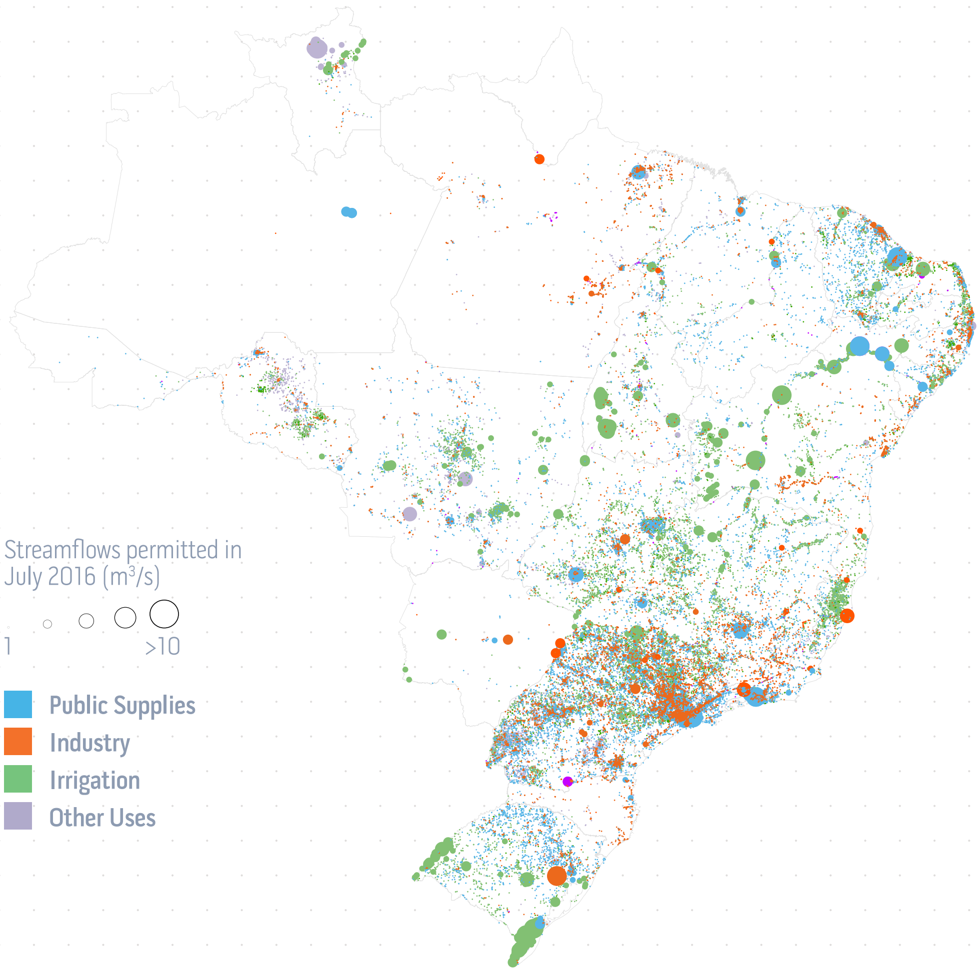
Irrigation, urban/rural water supplies (solely for public use under water permits issued by ANA) and for industrial purposes (mining included) account for 94% of permitted streamflows in Federal rivers, based on accumulated total volumes since licensing began in June 1998, through to July 2016.

Groundwater uptakes are permitted by State water resource management entities. In general, the streamflows are smaller than their surface counterparts, intended mainly for public consumption and urban/rural water. **Groundwater uptakes account for 63% of total uptake volumes permitted by Brazilian States, and 12% of the streamflows.**

HISTORICAL OVERVIEW OF WATER PERMITS ISSUED



WATER PERMITS ISSUED BY ANA AND THE STATES, VALID IN JULY 2016



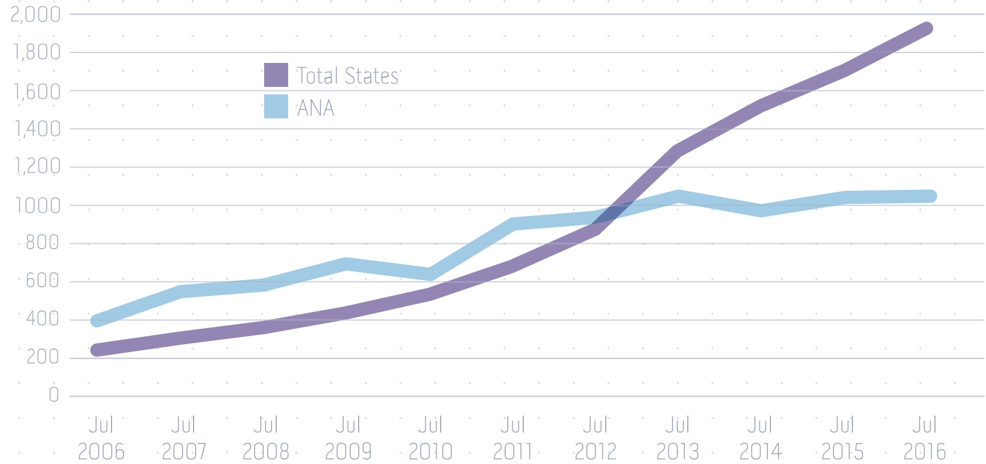
Historical datasets for licensed streamflows show significant annual increases in streamflows licensed by the States, compared to Federal permits issued by ANA, indicating an increase in user regularization by the States.

Historical datasets for permits issued by ANA and the States were analyzed by annual increases from July 2006 through to July 2016, including data from permits issued previously, accumulated through to July 2006, or as from the first year in which data was available, when issued after 2006.

The length of time for which permits remain valid varies, generally from 1 to 10 years, depending on the State. Permits issued by ANA are valid for 10 years.

A better comparative overview of permit expansion can be obtained through analyzing the permits in place at the end of each period, throughout the decade. **Permits in place** reflect only permits valid on the specific date and water use reality, as permitted users are theoretically drawing off water at rates equal to or lower than the maximum amounts defined in the administrative acts issuing the permits.

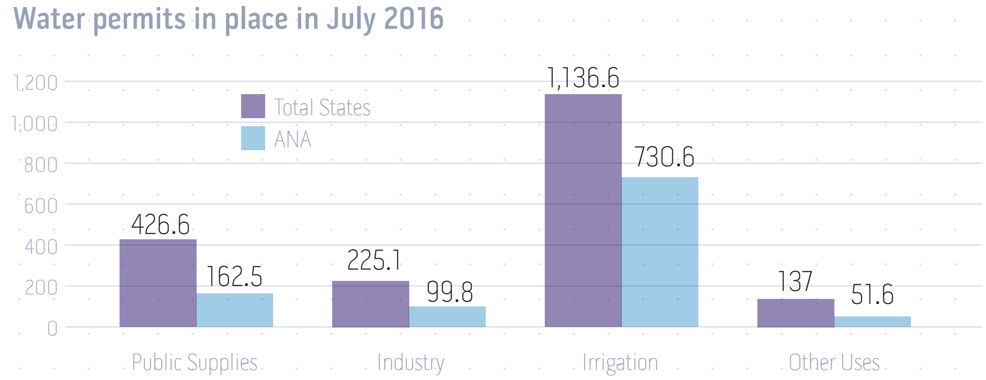
PERMITTED STREAMFLOWS IN PLACE EACH YEAR, AUTHORIZED BY ANA AND THE STATES (m^3/s)



Among the 25 States currently issuing water use permits, 12 accounted for 91% of total licensed streamflows in July 2016. By decreasing order of licensed streamflows, the following are particularly noteworthy: São Paulo, Mato Grosso, Bahia, Rio Grande do Sul, Tocantins, Goiás, Minas Gerais, Rio de Janeiro, Roraima, Paraná, Ceará and Rondônia. Irrigation accounts for most of the streamflows currently licensed in these 12 States.

With larger streamflows permitted for urban/rural water supplies and industry, São Paulo, Rio de Janeiro and Paraná States, are exceptions, together with Roraima and Rondônia States that have larger streamflows allocated to aquaculture (in excavated tanks), which predominated in the Others Class.

STREAMFLOWS LICENSED BY ANA AND THE STATES, IN JULY 2016 (m^3/s)



Inspection and oversight activities conducted by ANA are regulated by Resolution Nº 662 (2010) and Edict Nº 30 (2011).

Grants of water resource usage permits are underpinned by regularization actions that include user registration and water resource usage **oversight** and inspection actions that constitute command and control activities undertaken by government authorities that deploy their administrative policing powers in order to ensure compliance with normative acts.

Inspection and oversight activities are intended to identify and rectify irregular water uses, while ensuring compliance with permit terms and conditions and/or water resource usage regulations. Water use inspection and oversight activities consist of systemic monitoring and control of water uses, checking irregularities, investigating offences, ordering corrective steps and imposing penalties for offences breaching the Law, particularly in **areas of special interest** for water resource management.

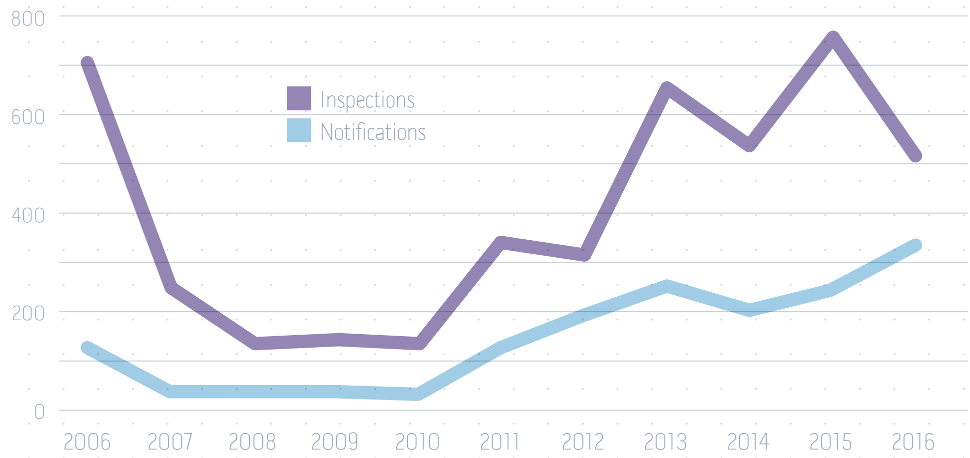
Areas of special interest for water resource management due to their critical status in terms of water quality and/or quantity are presented in Chapter 5.

From 2013 onwards, prompted by severe water shortages in Brazil, oversight and inspection activities were stepped up by ANA in the Semi-arid region and the Southeast Region. Satellite images and helicopter overflights have been used constantly by ANA to monitor water resource users and provide input or planning oversight and inspection campaigns in several river basins.

Inspection and oversight actions along the Piracicaba, Caligari, Jundiaí (PCJ) and Paraíba do Sul rivers in Southeast Brazil and the Piancó-Piranhas-Açu rivers in the Semi-arid region, which have been severely affected by water shortages during the past few years, are presented in detail in Chapter 5.

Control over larger-scale users is also handled through metering systems that monitor water uptake volumes. Users forward information on streamflows and uptake volumes to ANA over the Internet, through the Annual Water Resource Usage Declaration (DAURH). Specific rules on the submission of this Declaration have been established for the Doce, Quaraí, São Marcos, São Francisco, river basins, as well as the Preto, Bezerra and Verde Grande tributaries flowing into the São Francisco river.

INSPECTIONS CONDUCTED AND NOTIFICATIONS ISSUED BY ANA



In the Paraíba do Sul basin, 14 **Deeds of Commitment** have been signed since 2012, three of which were completed in 2016, in order to decrease the organic load consisting of residential sewage and industrial wastewaters. There are municipalities where liquid wastes discharged by households and mostly affect the water quality objectives established for receiving water-bodies. The protocols have been drawn up, but regularization of discharges is a complex matter requiring long-term actions that include the design and implementation of collection, treatment and disposal facilities.

The protocols are agreed between water users and ANA as the watchdog entity. In addition to monitoring the agreed deadlines and goals, ANA reaches out to other institutions in order to ensure the feasibility of commissioning and implementing municipal sewage treatment projects and/or works.

The Annual Water Resource Usage Declaration (DAURH) was introduced by ANA in 2009 through Resolution Nº 782, and was subsequently revised through Resolutions Nº 603 and Nº 632, both issued by ANA in 2015. It is intended to build up information on real water resource usage in specific river basins or hydrographic regions.

Some river basins are subject to annual withdrawn streamflow constraints that depend on water use purposes. Streamflows must be monitored by metering systems and notified to ANA through the **Annual Water Resource Usage Declaration** (DAURH).

In 2016, In 2016, streamflow constraints were in place for the Doce, Quaraí, São Marcos and São Francisco Rivers, as well as the Preto, Bezerra and Verde Grande tributaries.

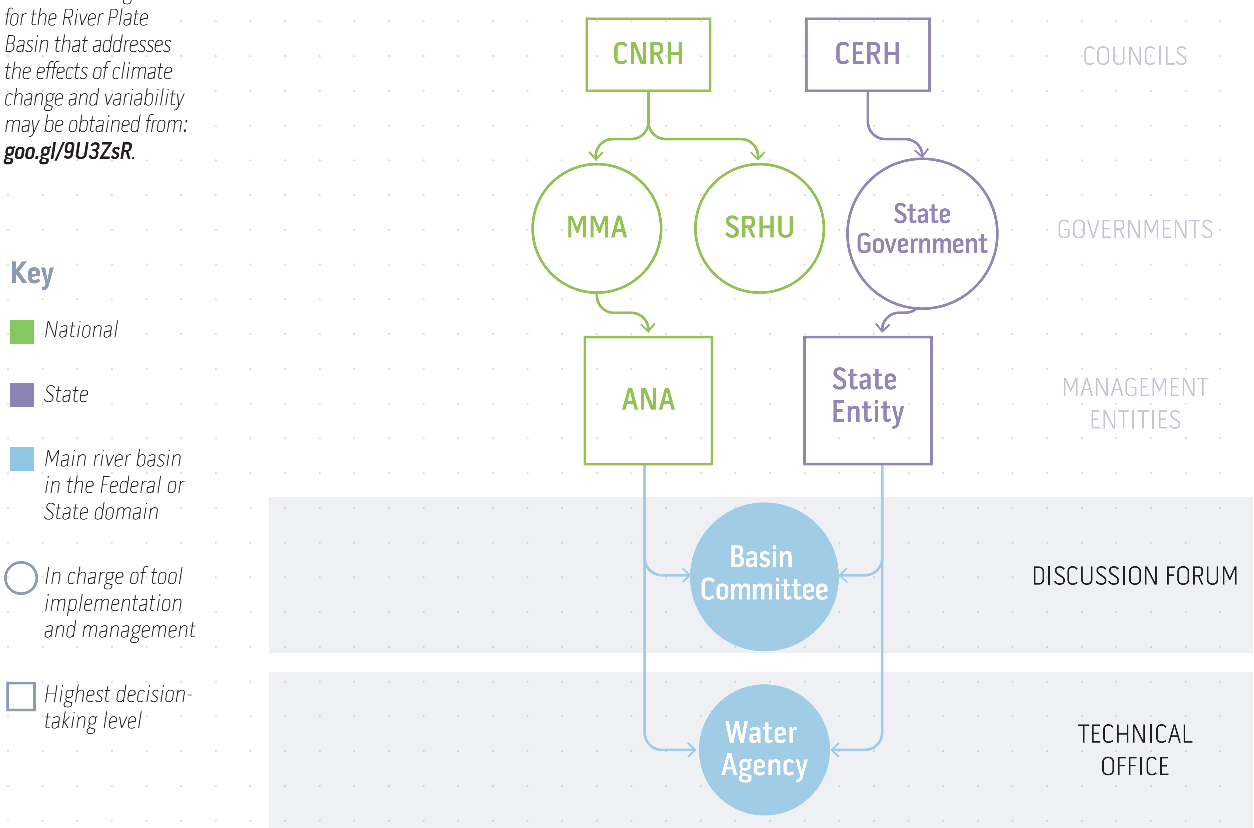
The river basin is the water resource management unit defined by Brazil's National Water Resources Policy (PNRH), which is why these territorial divisions (that overstep State and Federal political boundaries) must be considered for the deployment of management tools and the actions undertaken by **river basin committees and water agencies**. Different territorial segments may be defined for management activities, based on basin demarcation that may encompass hydrological, environmental, social, economic, political and institutional criteria.

*Information on the Regional Action in the Water Resources Area by the Amazon Cooperation Treaty Organization is available at: **goo.gl/xPy99U**.*

*Information on the Sustainable Water Resource Management Framework Program for the River Plate Basin that addresses the effects of climate change and variability may be obtained from: **goo.gl/9U3ZsR**.*

Brazil is engaged in international cooperation activities focused on water management with neighboring countries in South America, with which it shares the **Amazon** and **Plate** (Paraná, Paraguay and Uruguay rivers) river basins, in addition to bilateral cooperation in the Lagoa Mirim basin, with cooperation discussions underway with France (French Guiana) for the Oiapoque river basin.

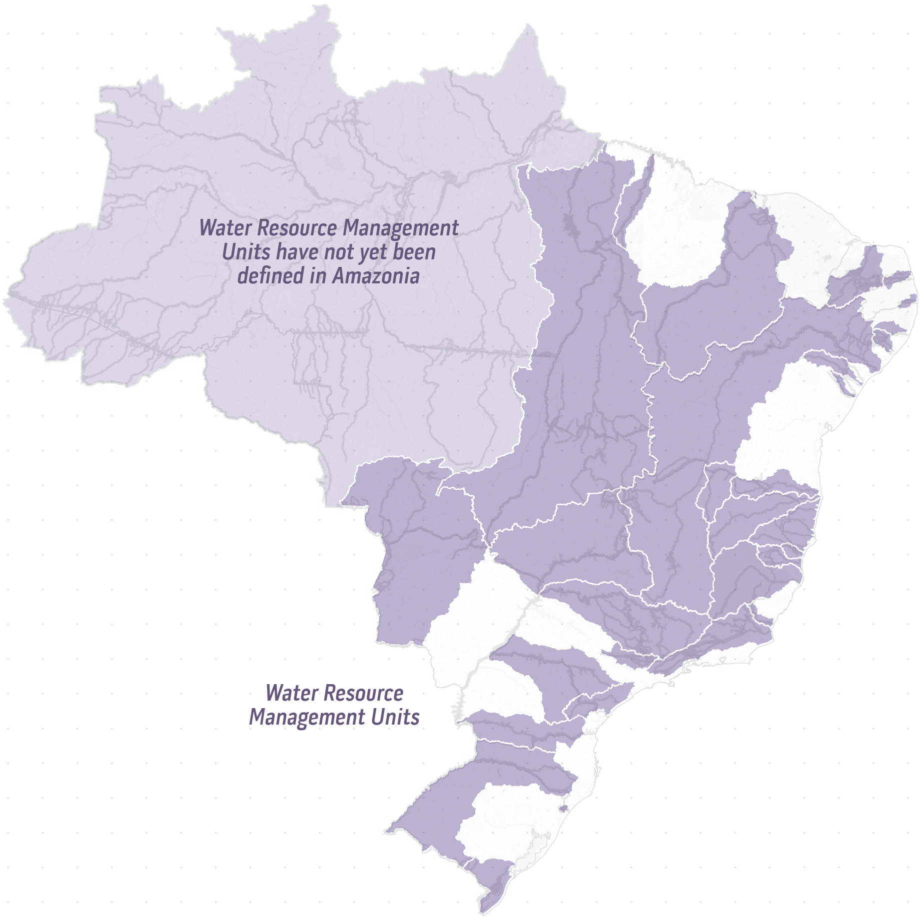
INSTITUTIONAL FRAMEWORK OF THE SINGREH



Brazil has 29 **Water Resource Management Units (UGRH) for river basins under Federal domain**. These Units are planning, management and intervention territories that are designed to underpin high priority approaches for setting up river basin committees and implementing tools established through the National Water Resources Policy (PNRH), always encompassing more than one State.

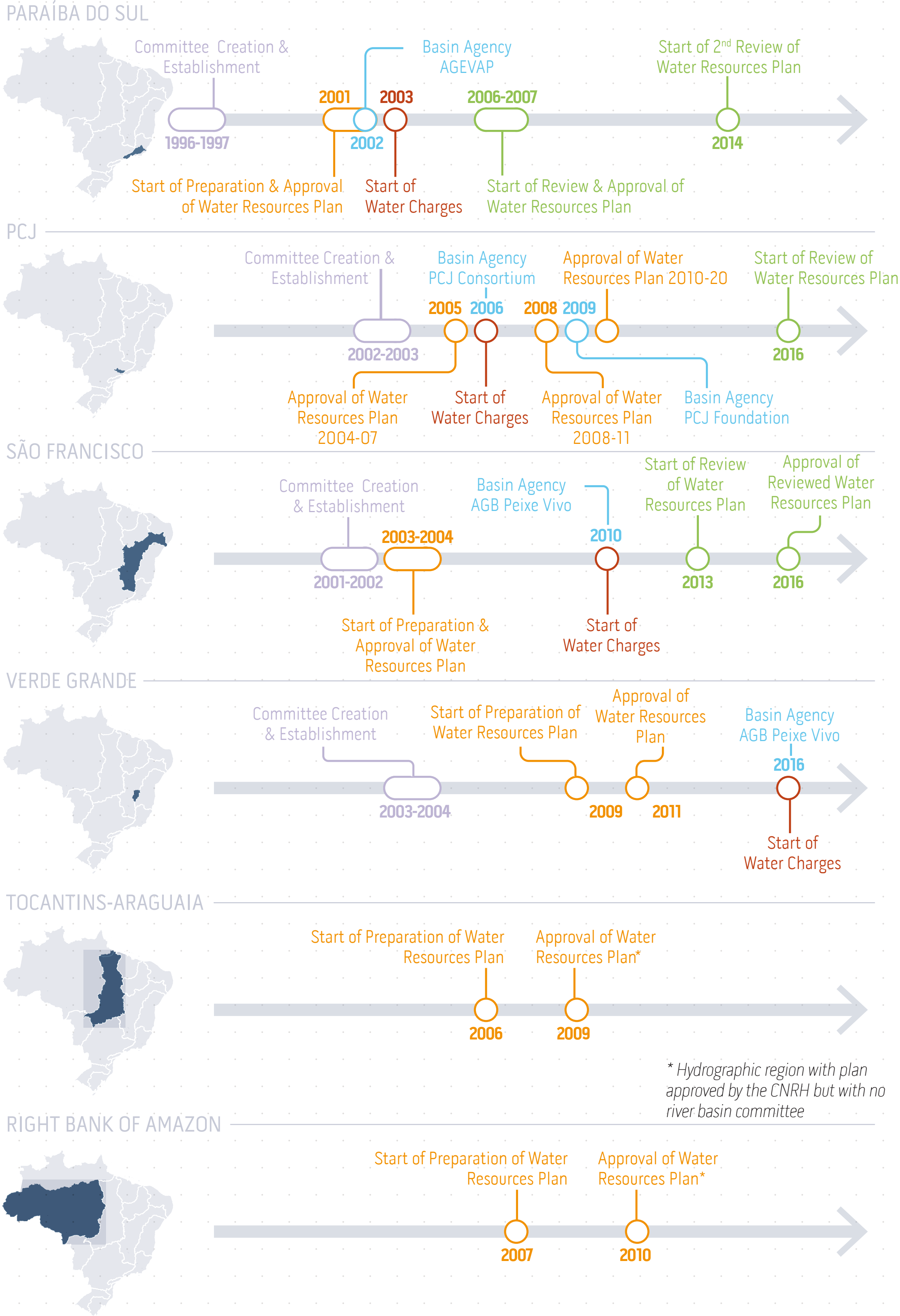
These Units were introduced in 2010 by the National Water Resources Council (CNRH) through Resolution Nº 109.

WATER RESOURCE MANAGEMENT UNITS UNDER FEDERAL DOMAIN

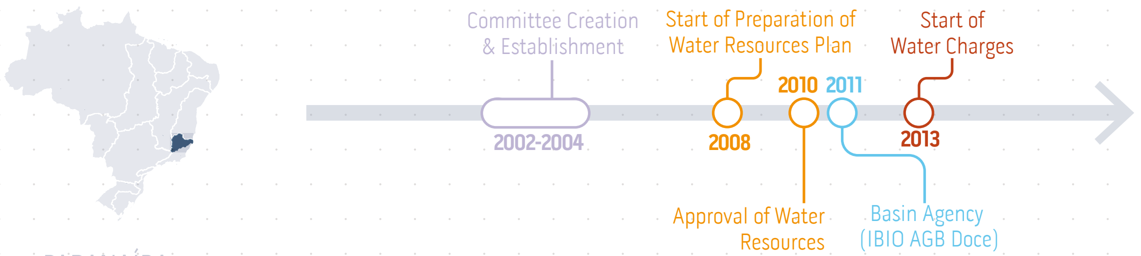


The implementation of water resource management tools and their integration at the Federal and State level over time reflect progress in water resource management in each basin. Due to the different characteristics of Brazilian basins, in terms of social, economic, hydrological and environmental aspects, as well as existing and potential disputes over water use, needs vary widely, together with the implementation stage of management tools. Political, institutional and legal factors also influence management performance, either fostering or hampering its progress in specific basins.

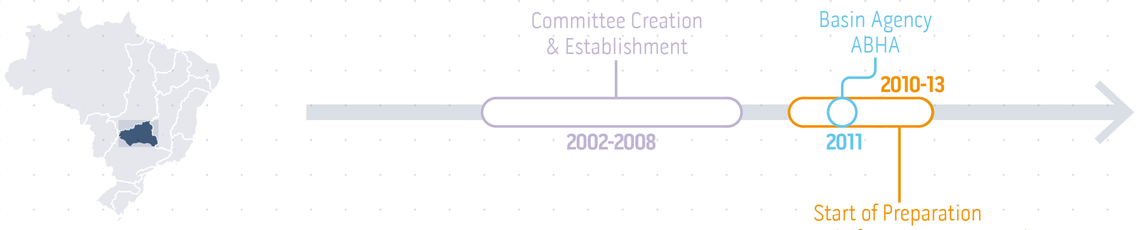
WATER MANAGEMENT IMPLEMENTATION STAGES IN UGRHS



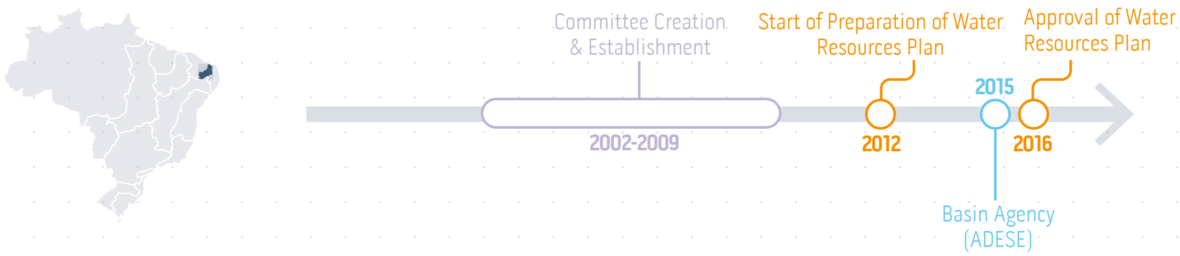
DOCE



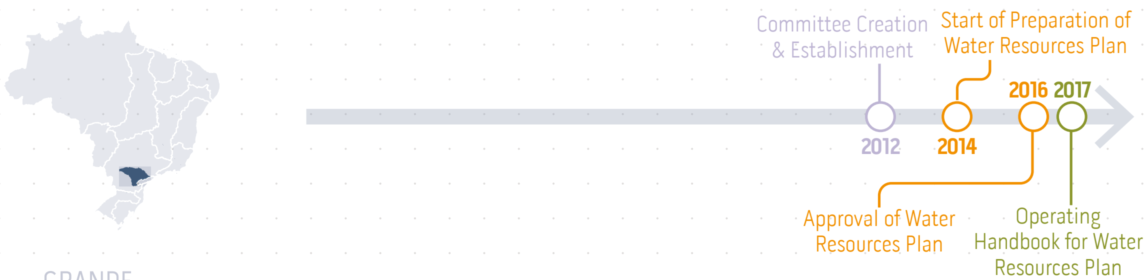
PARANAÍBA



PIRANHAS-AÇU

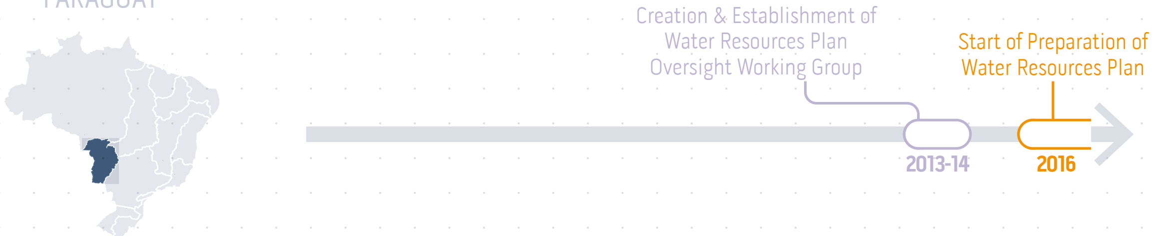


PARANAPANEMA



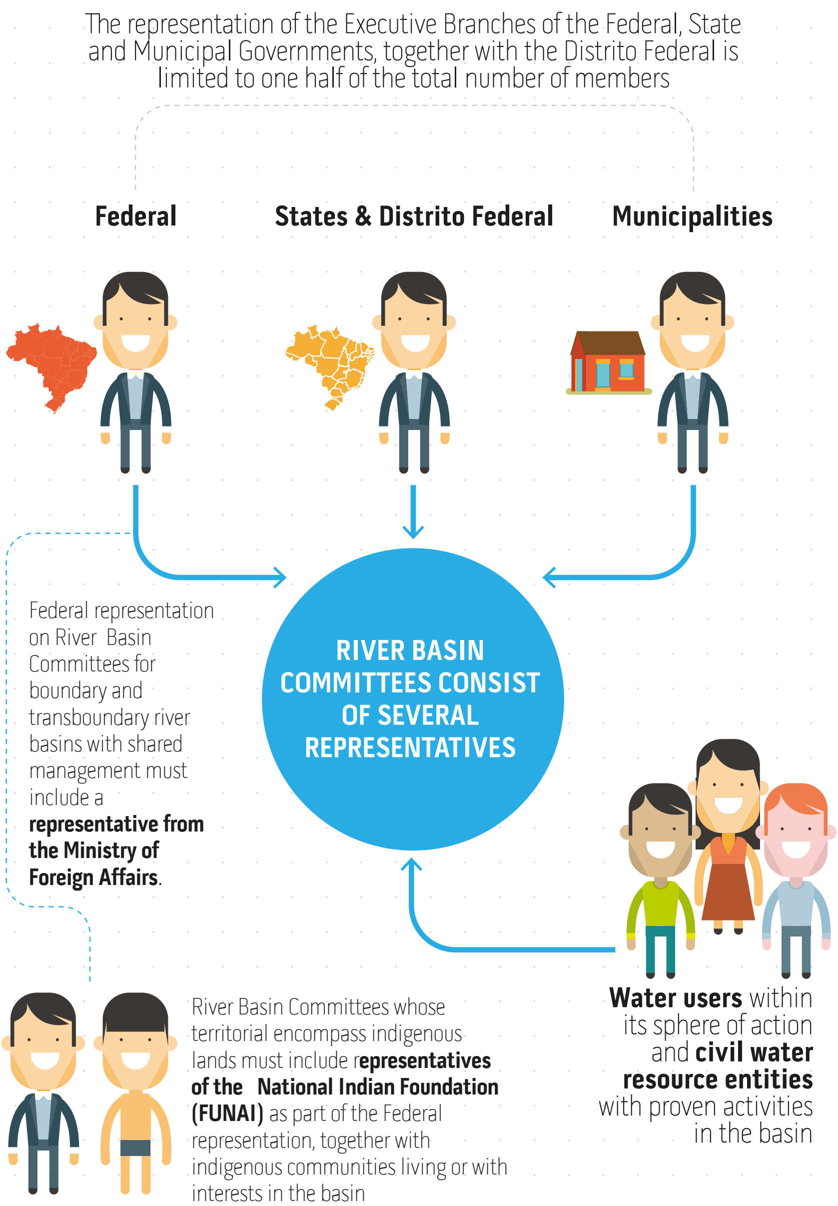
GRANDE

PARAGUAY



The National River Basin Committee Strengthening Program (ProComitês) is intended to channel funds for upgrading River Basin Committee (CBH) activities, consolidating them as effective spheres for drawing up public policies on water. This implementation was conceptualized in a five-year cycle, with indicators and targets clustered into different components that focus on the main weak points identified previously in CBH performances. By year-end 2016, agreements had been signed with Espírito Santo, Rio Grande do Norte and Santa Catarina States.

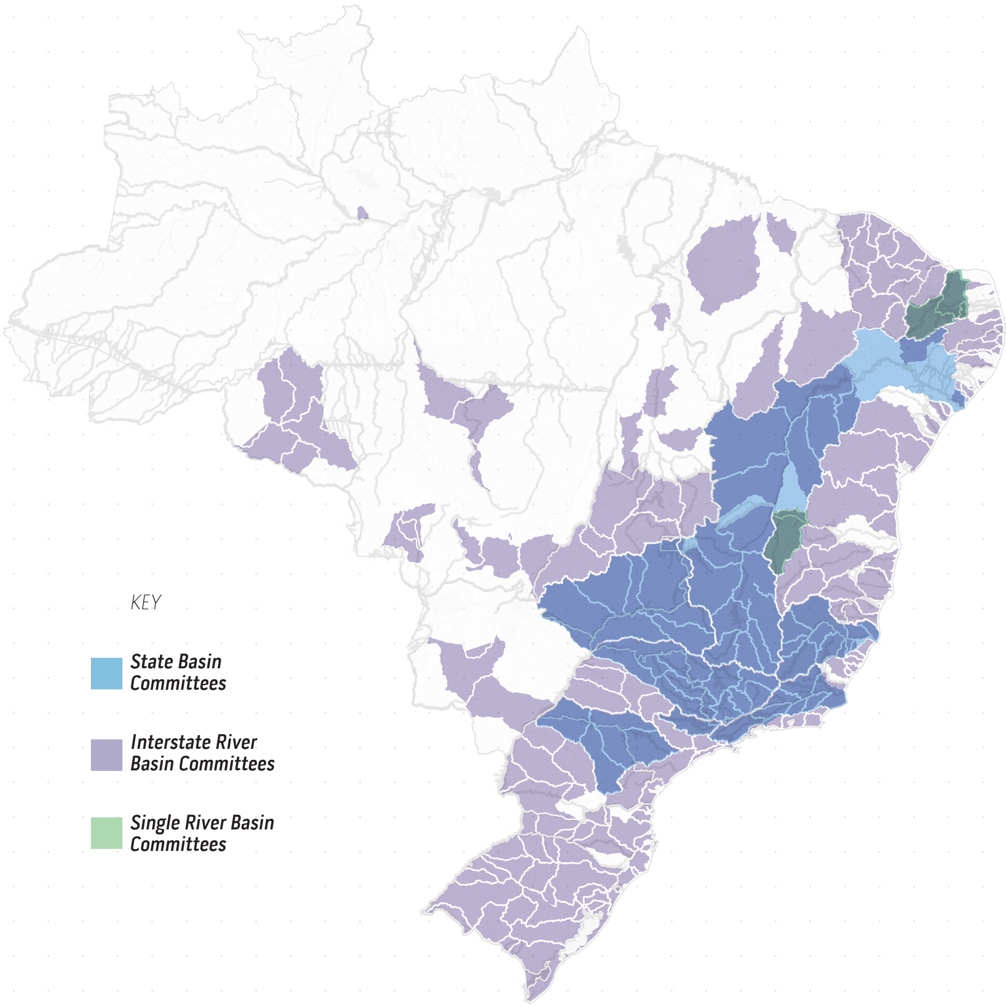
The River Basin Committee (CBH) is a forum for discussions and decisions taken on water resource management issues in a specific river basin. These Committees are **structured** in ways that encourage participatory and decentralized water resource management, buttressing the implementation of management tools, underpinning negotiated solutions to disputes over water users, and promoting different uses for water in each basin. This is why they are known as "water parliaments", with their composition including representatives of governments and civil society.



Depending on their geographical boundaries that directly affect their **spheres of action**, these Committees may be Federal or Interstate (encompassing river basins located in more than one State); there are also State Committees that manage one or more river basins within a single State; and finally there are Single Committees with only one decision-taking level for Interstate and State basins, meaning that a single committee functions at both the Federal and State levels.

River basin committees are set up by the National Water Resources Council (CNRH) or its State counterparts, depending on their spheres of action.

RIVER BASIN COMMITTEES IN BRAZIL



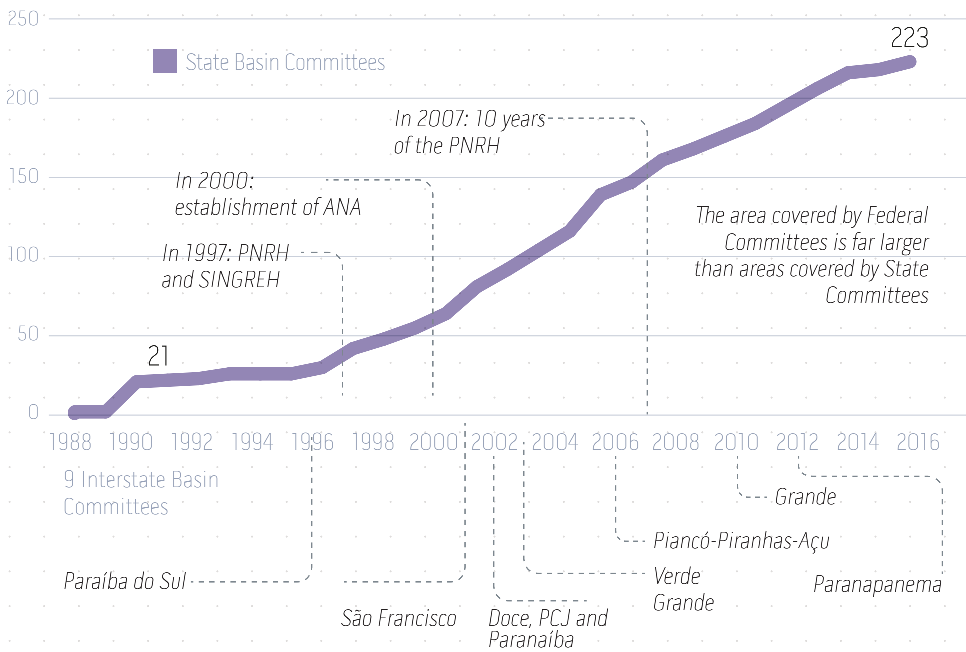
*A list of River Basin Committees and their spatial distribution in Brazil may be accessed at: **goo.gl/eVQP5o**.*

By 1997, 30 River Basin Committees had been set up in basins under State domain in Brazil, rising to 223 by 2016. Furthermore, nine Interstate River Basin Committees had been set up and were functioning by 2016, with two of them being Single Committees: Verde Grande (Minas Gerais/Bahia States) and Piancó-Piranhas-Açu (Paraíba/Rio Grande do Norte). By 2016, five State River Basin Committees had been created in Brazil.

Creating a river basin committee does not mean that it is properly established, coming into operation immediately. There may be a time gap between the creation and establishment stages.

In terms of the population covered by River Basin Committee area, some 25.5% of the population lives in the areas of Federal Committees, while 75.5% are subject to State Committees. Due to overlapping jurisdiction between them, 49% of the Brazilian population lives in areas subject to the actions of a River Basin Committee.

CREATING RIVER BASIN COMMITTEES IN BRAZIL



I Information on Water Resource Plans may be obtained from ***goo.gl/MFZrBU***.

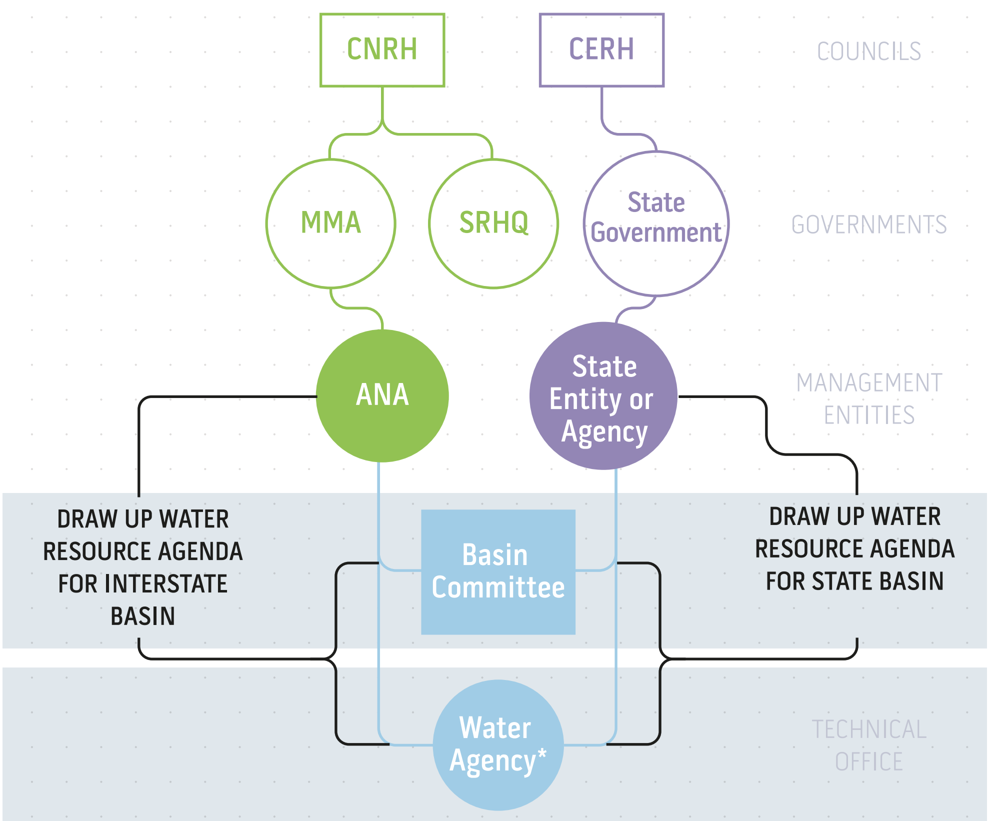
According to the report prepared by the Organization for Economic Cooperation and Development (OECD) available at ***goo.gl/mdTQZ4****, there are many Water Resource Plans (PRHs), but they are generally poorly coordinated and ineffective in practice, due to a lack of financing and implementation capabilities. As a result, they are no more than "paper tigers" or promises to be fulfilled by others.*

Water resource plans (PRH) for a river basin are approved by River Basin Committees (if any) in the areas covered by each plan. They define water usage rules, including priorities for water permits and reservoir operating conditions, as well as guidelines and criteria for water charges, among other aspects. Technical studies outlining the classification framework may also be handled within the context of a river basin water resource plan.

The 12 Interstate Water Resource Plans up through to 2016 cover an area corresponding to 54% of Brazil.

However, there has been little **effective implementation of the actions proposed** in these Plans. For example: even after water charges were approved for some basins covered by these Plans, few of the scheduled interventions have been effectively undertaken. Moreover, these Plans receive little attention in the programs and budgets drawn up by State water resource management entities.

WATER RESOURCE PLANS IN BRAZIL



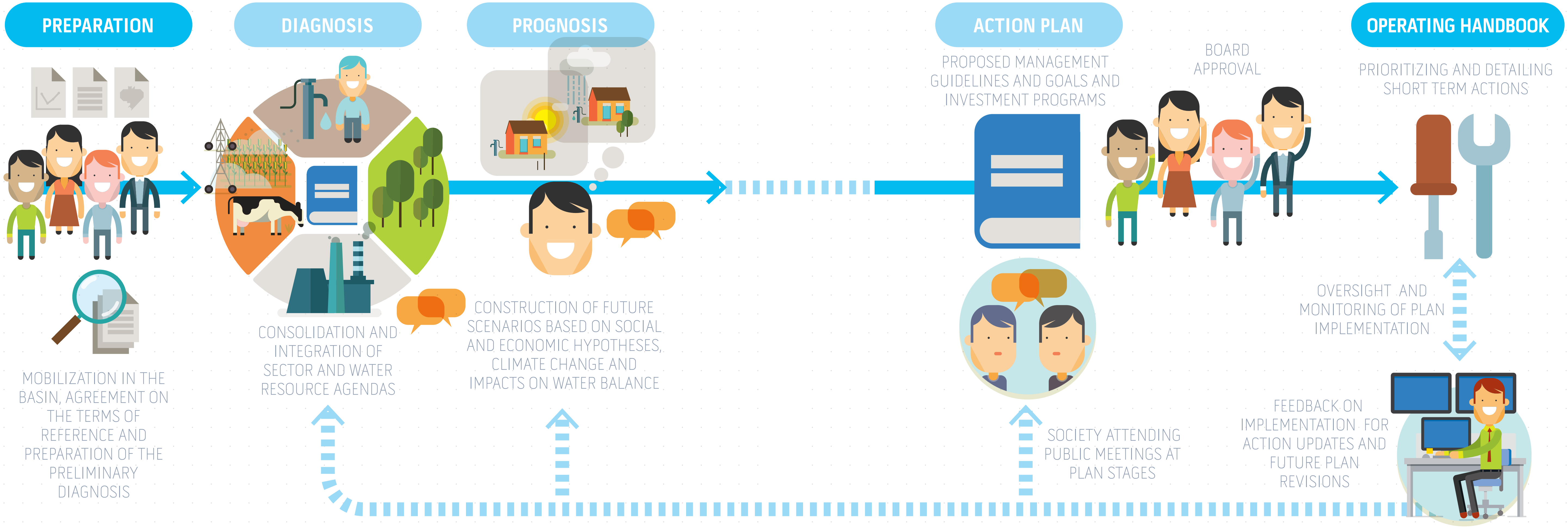
As there is still no River Basin Committee, the CNRH established the Paraguay Water Resources Plan Oversight Working Group (GAP) in 2013, in order to oversee the preparation of this Plan.

Water resource plans for Interstate river basins that were drawn up and approved more recently – for the Piancó-Piranhas-Açu river basin in June 2016, the Paranapanema river basin in October 2016, and the **Grande River basin** in November 2017, as well as a plan currently being drawn up for the **Paraguay river basin** – have adopted a new approach that shortens plan preparation lead-time and ensures plan conceptualization with more realistic action budgets. Focused on the governability of water resource management systems, it provides step-by-step instructions on implementing strategic actions through an **Operating Handbook**.

Coordinated by the Grande River Basin Committee since 2015, this Plan is currently preparing actions that will define its goals and the estimated investments required for its implementation.

The Operations Handbook provides input for implementing the actions listed as high priority in the Plans. This step-by-step tool allows committees and management entities to ensure the feasibility of the proposed and agreed actions endowing them with greater effectiveness. The first Operations Handbook was drawn up for the Paranapanema basin and is available at ***goo.gl/Zrdr4t***.

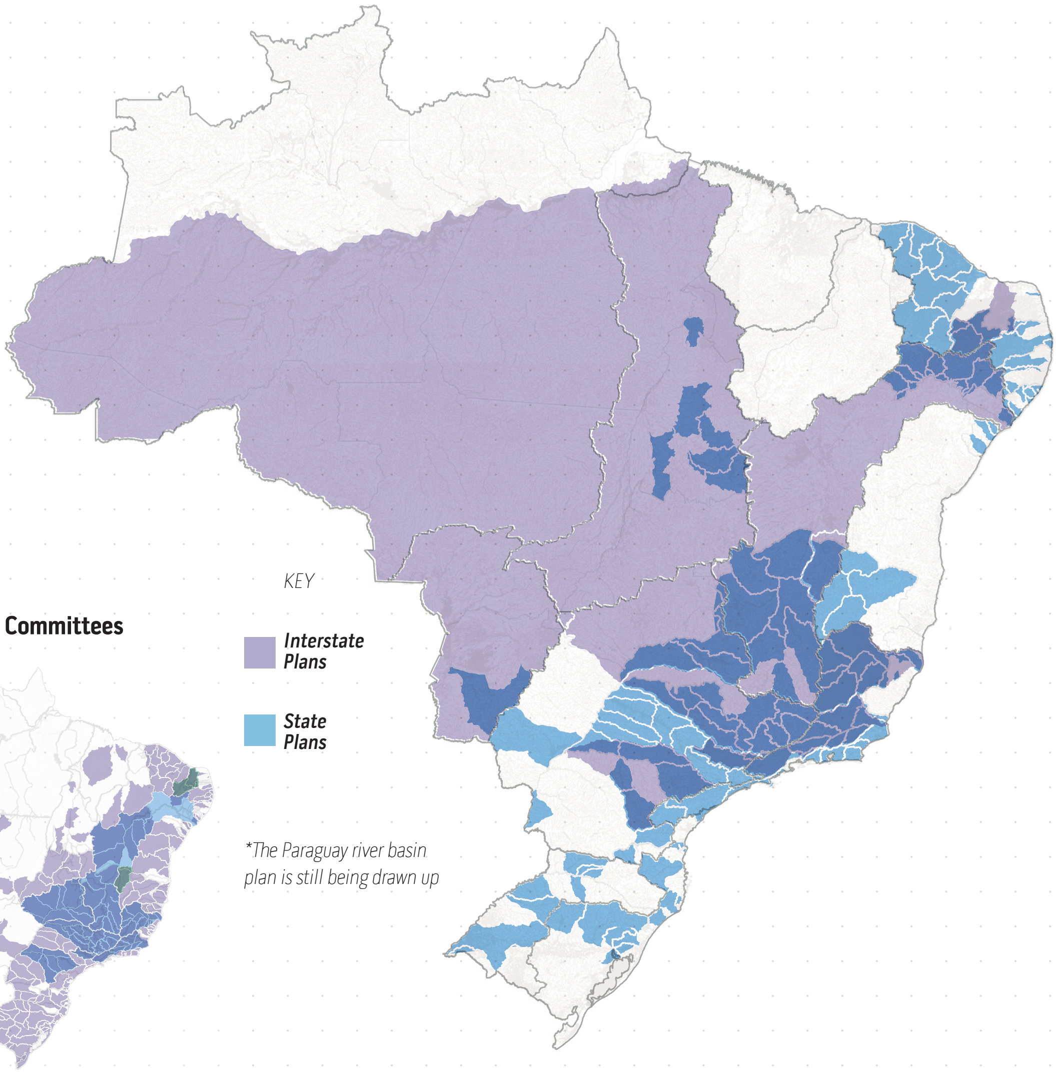
PARTICIPATORY PROCESS FOR DRAWING UP AND IMPLEMENTING RIVER BASIN WATER RESOURCES PLANS



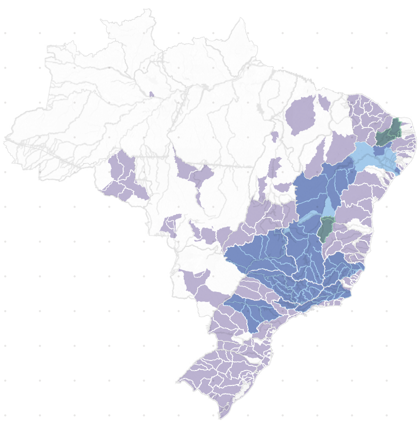
For example, the action program for the Piancó-Piranhas-Açu river basin Water Resources Plan was modified to fit a more realistic budget of around USD 45 million (BRL 150 million). Since its approval, several scheduled actions have already been implemented, such as setting up a technical office in this basin, as well as others related to monitoring, regularization, oversight, inspections and negotiated allocations. Planned structuring actions – such as dams, pipeline systems and water piping – totaling some USD 1.2 billion (BRL 3.9 billion) were included as a budget associated with the Water Resources Plan, as they are not encompassed by the sphere of water resource management sector governability.

The investment budget for the Paranapanema Plan was also more realistic, estimated at around USD 33 million (BRL 110 million) through to 2035. Potential fee revenues hover around USD 6.3 million (BRL 21 million) a year in this basin, confirming the feasibility of implementing the management actions proposed in the Operating Handbook, focused mainly on upgrading water quality and the quantitative water balance. Along similar lines, the Grande river basin plan (approved in November 2017) makes provision for investments of over USD 86 million (BRL 285 million) in water resource conservation, management and governance.

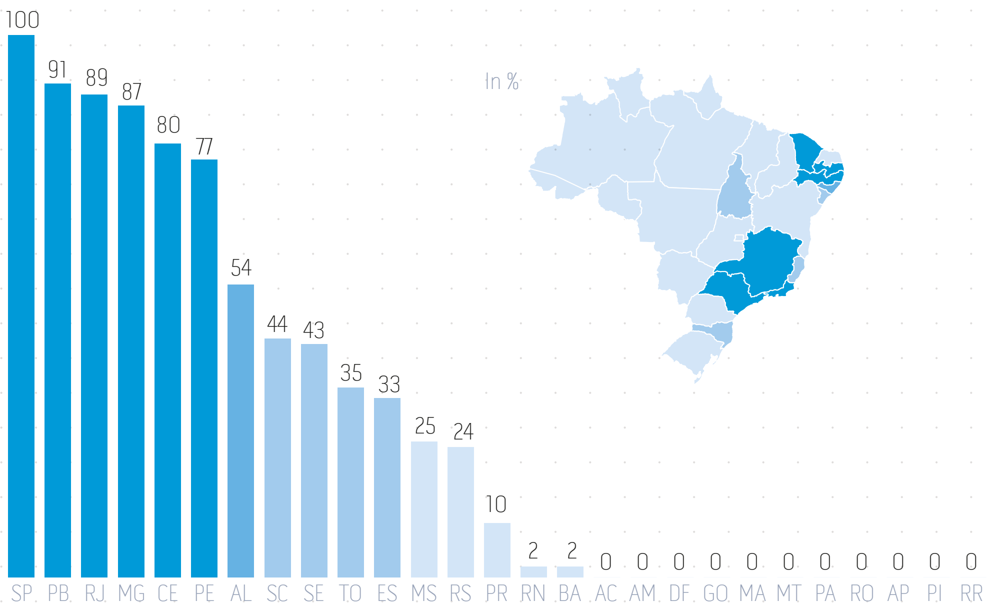
WATER RESOURCE PLANS FOR STATE AND INTERSTATE RIVER BASINS IN 2016



Interstate and State Committees



STATES WITH WATER RESOURCE PLANS FOR STATE RIVER BASINS



Water resource plans for State river basins usually focus on more specific problems that are clearly defined, due to their smaller territorial scope.

*The list and spatial distribution of water resource plans for State river basins is available through the National Water Resources Information System (SNIRH) at: **goo.gl/1eKByM**.*

By year-end 2016, 164 State River Basin Plans had been drawn up in 17 States, with 19 Plans under preparation in four States: Espírito Santo, Bahia, Pernambuco and Paraná. These Plans are coordinated and supervised by the respective River Basin Committees.

Basin or water agencies are technical and executive entities whose actions support the Committees, providing input for water use planning and management. They help draw up water resource plans and assist with the financial administration of revenues brought in through water charges. Their activities are overseen by the respective River Basin Committees to which they are linked.

Water agencies have not yet been regulated by the Federal Government. However, Law Nº 10,881 (2004) allows their functions to be performed by **delegatory entities.**

*Delegatory entities must be non-profit civil society organizations appointed by the Committees, and may be qualified by the National Water Resources Council (CNRH) to perform the legal duties and responsibilities of a basin agency. Delegatory entities are listed at: **goo.gl/RpNuKh**.*

In 2016, there were five delegatory entities functioning in interstate river basins.

They function under management agreements signed with ANA stipulating targets and indicators for specific work programs, with the assent of the respective Interstate Basin Committees.

The operating sphere of water agencies is the same as that as one or more River Basin Committees. Through specific decisions and recommendations issued by State Basin Committees, delegatory entities have also signed management agreements with State entities, such as the Rio de Janeiro State Environment Institute (INEA) and the Minas Gerais State Water Management Institute (IGAM). At the State level, there were five other entities performing **water agency functions** in 2016.

Additionally, the Seridó Sustainable Development Agency (ADESE) handles the functions of the Executive Secretariat of the Piancó-Piranhas-Açu River Basin Committee, with three state management entities performing the functions of Water Agencies: the Ceará State Water Resources Management Company (COGERH); the São Paulo Electricity and Water Department (DAEE); and the Paraná Water Institute (Águas Paraná).

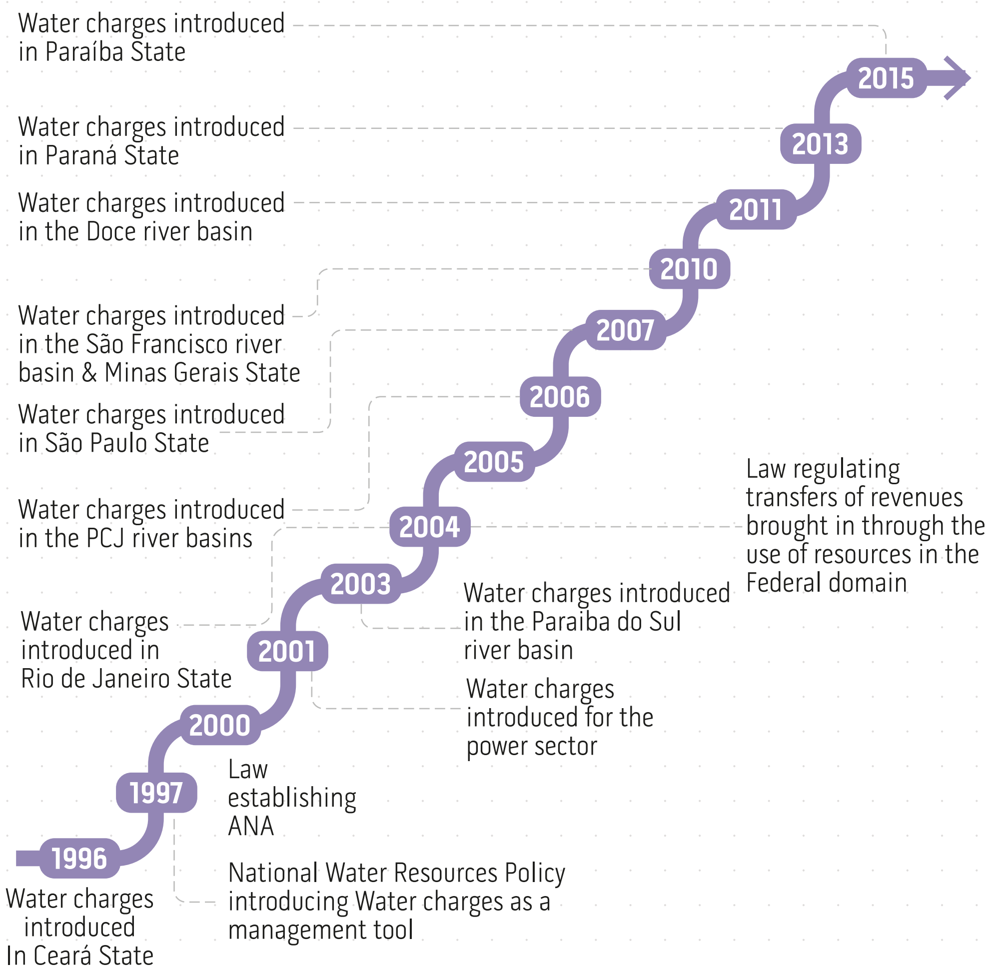
The introduction of water charges for using water in a specific river basin is linked to the existence of its respective agency. Under the National Water Resources Policy, fees are charged for the use of water resources subject to water permits licensing. The **amounts involved** are channeled back mainly to the river basins where they are generated, through financing the actions proposed in the water resource plans, in addition to covering expenditures incurred for the implementation and back-office expenditures of organs and entities belonging to the National Water Resources Management System (SINGREH), limited to 7.5% of total fee revenues.

Revenues brought in through water charges for using water resources in the Federal domain are transferred in full to delegatory entities by ANA.

At the Federal level, in addition to water charges for water used to generate hydropower, there are also four basins with water charging systems already in place: the Paraíba do Sul river; the Piracicaba, Capivari and Jundiaí (PCJ) rivers; the São Francisco River (except the Verde Grande River sub-basin) and the Doce river. There are also six States charging water usage in some basins or management units, except in Ceará and Rio de Janeiro, where waters are charged throughout these States.

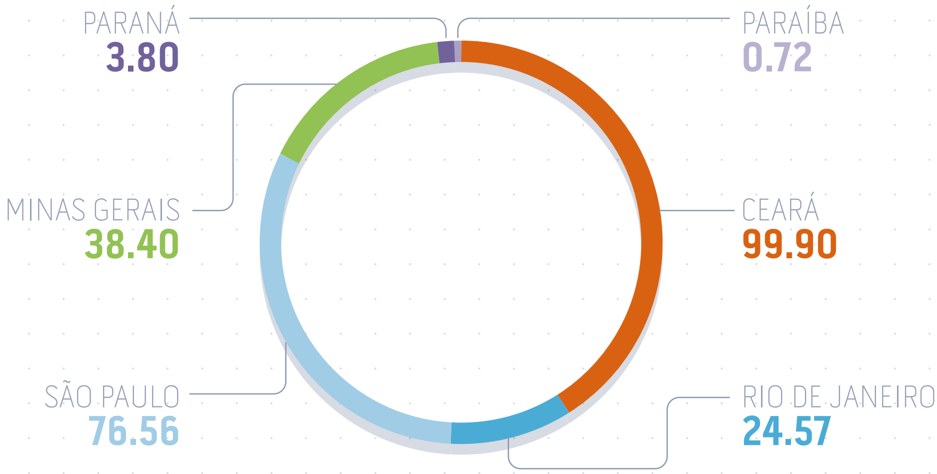
Together with the Federal District, Paraná and Pará States are charging water resource usage oversight fees, endowing their administrations with policing powers and introduced for purposes other than the water charged under the aegis of water resource policies.

ADVANCES IN WATER CHARGES IN BRAZIL

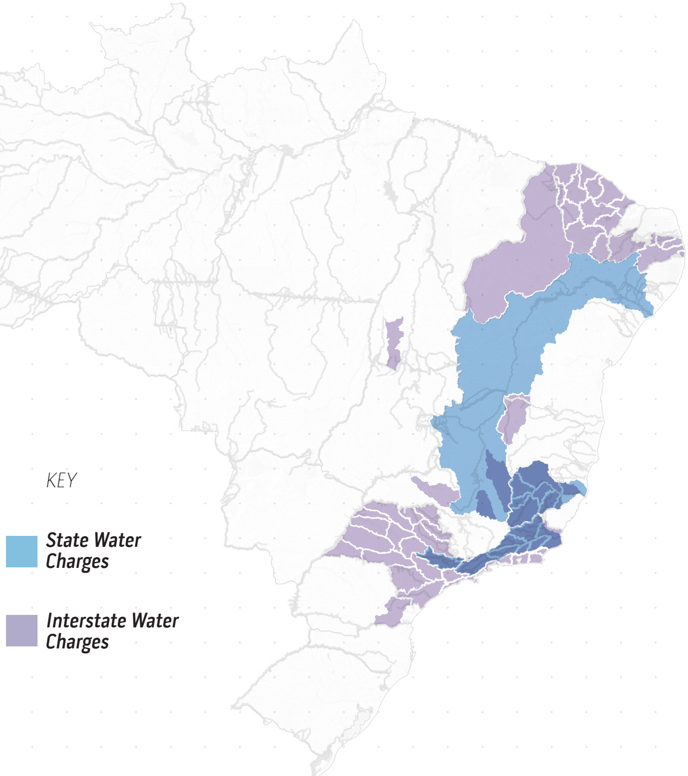


REVENUES BROUGHT IN WATER CHARGES IN BASINS UNDER STATE DOMAIN IN 2016

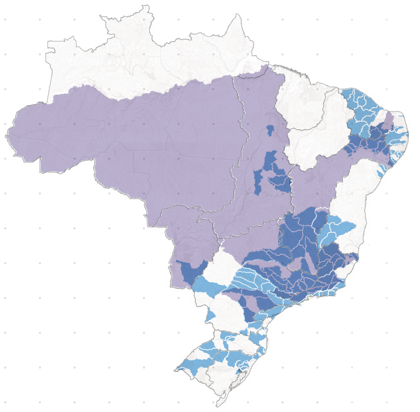
BRL million
Exchange Rate on March 1, 2018: USD 1 / BRL 3.3



NATIONWIDE OVERVIEW OF WATER CHARGES

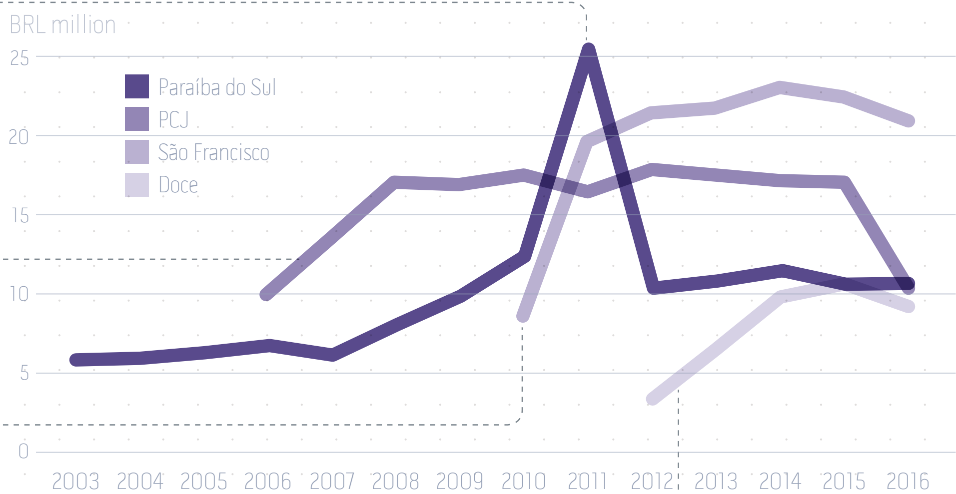


Interstate and State Water Resource Plans



In 2016, water charges reached USD 100 million (BRL 328.60 million), bringing in around 90% of the amounts charged. For river basins in the Federal domain, water charged to 2,876 water users in all reached almost USD 20 million (BRL 66 million) – around 20% of the total amount charged in Brazil during 2016 – with 76% actually paid.

PAYMENT OF WATER CHARGES ALONG RIVERS IN THE FEDERAL DOMAIN



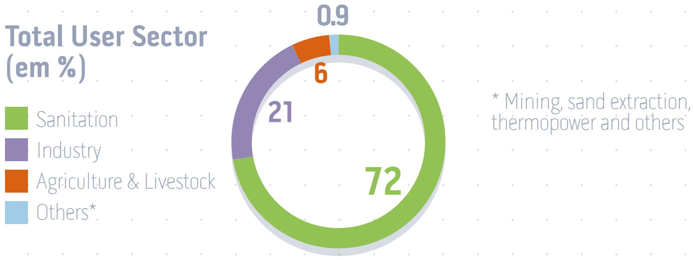
Paraíba do Sul basin: increase in water charged after 2007 revenues from the National Steel Company (CSN) in 2011.

Piracicaba, Capivari and Jundiaí (PCJ) basin: water charged phased in between 2006 and 2008, with monetary restatement from 2014 onwards.

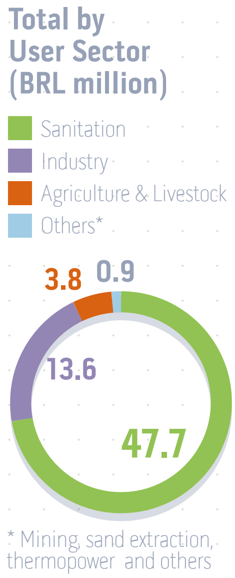
São Francisco basin: water charged for 2010 onwards, with new user registration in 2011.

Doce: progressively higher water charged in the basin between 2012 and 2015.

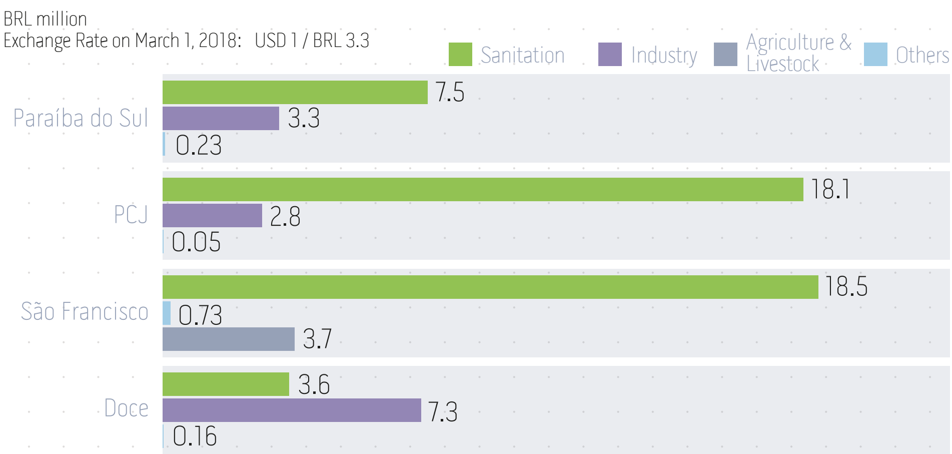
AMOUNTS CHARGED IN FEDERAL BASINS BY USER SECTOR IN 2016



Fees charged to the industrial sector were higher than those for sanitation purposes in only the Doce river basin, due to contributions from wood pulp industries in this region. Although irrigation is the predominant usage category in terms of water demands in Brazil, lower fees charged to the agriculture and livestock sector are explained by the reduction coefficient for these fees (proposed by Basin Committees and approved by the National Water Resources Council), in order to adapt water consumption volumes to user payment capacities.



WATER CHARGES IN THE FEDERAL DOMAIN BY USER CATEGORY IN 2016



Actions **implemented with funding brought in through water charges** include management activities such as environmental education projects, mobilization, capacity-building and rational water use incentive campaigns; planning actions such as drawing up master plans, municipal sanitation plans and sewage projects; and structuring actions such as sewage treatment systems, together with water sources recovery and erosion control activities.

Further information on actions underwritten by water charges in the Federal domain is available from delegatory entities:

AGEVAP: ***www.agevap.org.br***

PCJ River Basins Agency: ***www.agenciapcj.org.br***

Peixe Vivo Agency: ***www.agenciapeixevivo.org.br***

IBio AGB Doce: ***www.ibioagbdoce.org.br***

For example, emergency actions in the Paraíba do Sul basin prompted by the 2014 – 2015 water crisis were funded by revenues brought in through water charges, including works adjusting untreated water withdrawal points for urban supplies.

Chapter 5

Water Crisis

Although many water resources management actions are underway, alterations to the water cycle raise massive management challenges during times when water run short. These alterations may derive from climate change or steadily-increasing water demands.

Crises require analyses and plan reviews. **How?**

Click on this tab to see the infographic we have prepared for you to understand this, quite simply!

Open here

WATER CRISIS
ANA
NATIONAL WATER AGENCY
Disputes over water use are triggered by an imbalance between uses and aspects related to water quantity and quality. These critical situations may be aggravated by other factors, such as extreme events or a sharp upsurge in deforestation, for example, and absence of investments in water infrastructure
WATER RATIONING
In crisis situations, steps are taken that cut back or even halt urban water supplies, in order to prevent sources from running dry
DEFORESTATION
ELECTRICITY
As river streamflows drop, powerplant operating conditions are altered in order to respond more effectively to multiple water uses, and may curtail hydro-power generation
EUTROPHICATION
EMERGENCY SUPPLIES
Tanker trucks and quick-coupling mains-pipes are emergency solutions for supplying water to urban and rural areas
OPERATING RULES
Power dams are subject to operating rules that are intended to ensure specific water quantities for downstream uses
HEALTH
Water rationing or shortages and steadily worsening water quality in supply wells boosts the occurrence of waterborne diseases such as diarrheas
WATER USE SUSPENSION
Low reservoir levels and weak river streamflows made trigger disputes over water use and lead to usage constraints and suspensions
UNDERGROUND WATER SOURCES
As water runs short, the use of this type of source may be stepped up
WELL
GROUNDWATER
ECONOMIC IMPACTS
Water shortages adversely affect farming and ranching activities, industrial output, trade, and people's daily lives
Anderson Araujo/www.heyboo.com.br

Water Crisis

Although rainfall distribution patterns vary naturally, **extreme events** have been noted over the past few years that have resulted in too much or too little water, which may offer circumstantial evidence of **climate change** and alterations to rainfall patterns in Brazil. Droughts, severe dry seasons and floods account for around 84% of **natural disasters** in Brazil between 1991 and 2012. During this period, almost 39,000 natural disasters were registered, affecting close on 127 million people. In economic terms, total losses of around USD 55 billion (BRL 182.7 billion) were registered between 1995 and 2014, equivalent to annual losses of some USD 2.7 billion (BRL 9 billion), or around USD 242 million (BRL 800 million) a month **caused by natural disasters**.

A disaster is the outcome of adverse events in a vulnerable ecosystem, either natural or caused by human beings, causing human, material and/or environmental damages with subsequent economic and social losses. Natural disasters may be geological, geophysical, meteorological, hydrological or climatological.

According to information from the Engineering and Civil Defense Research and Studies Center (CEPED) at the Santa Catarina Federal University, available at: **goo.gl/btZiUt** *and* **goo.gl/ckjGWn**.

A total of 2,641 (47.5%) Brazilian municipalities declared Emergency Situations or Public Calamities due to flooding at least once between 2003 and 2016. Some 1,435 (55%) of these municipalities are located in the South and Southeast Regions. Emergency Situations or Public Calamities caused by drought or severe dry seasons were declared by 2,783 (some 50%) of Brazilian municipalities during this same period.

Emergency Situations or Public Calamities require legal acknowledgement by the government, consisting of anomalous situations resulting from one or more disasters causing bearable and reparable damages to the community in question (Emergency Situation) or severe damage to health, well-being and even life (Public Calamity).

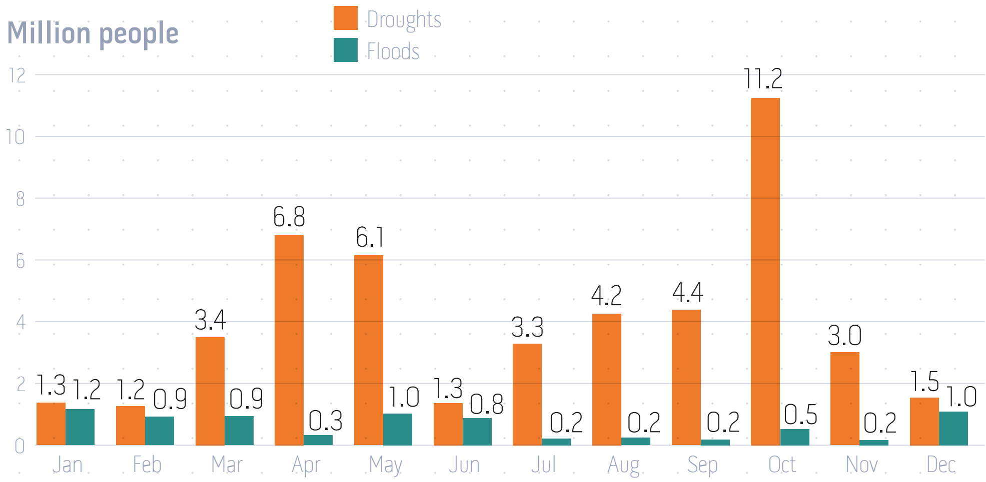
Between 2013 and 2016, around 7.7 million people were affected by flooding in Brazil, with the main harm to human beings consisting of the loss of their homes. More severe effects (death, disappearance, disease and injury) affected less than 1% of these people.

Human damages are measured by deaths and injuries, disappearances, diseases, homelessness and other after-effects. They do not necessarily coincide with legally-acknowledged disasters as they are based on all data declared by municipalities through records, proceedings underway, proceedings already acknowledged or proceedings denied Federal acknowledgement in the Integrated Disaster Information System (S2ID) run by the Ministry of Integration and available at: **goo.gl/kJtDTk**.

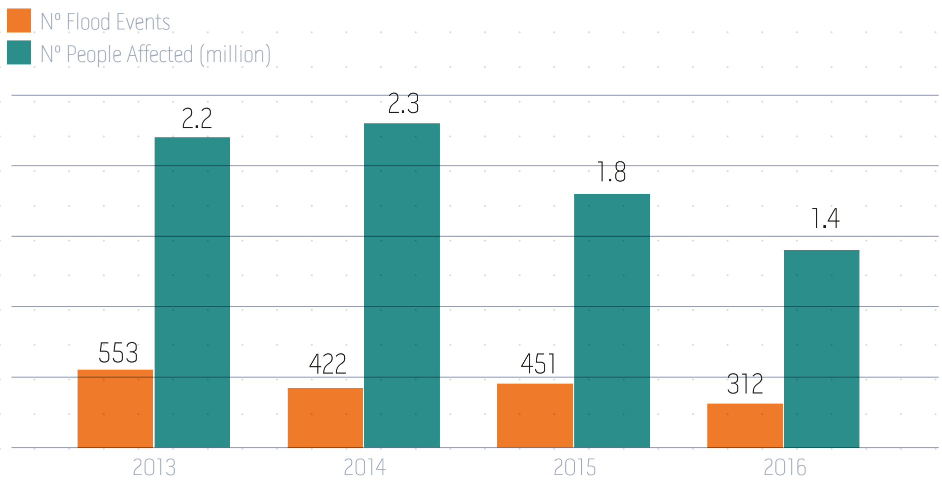
Due to the **characteristics of its climate**, January is the month with the largest number of flood events in Brazil, followed by June and December. In contrast, the months with the fewest flood records are August and September. The largest number of flood events associated with harm to human beings were recorded in Santa Catarina and Rio Grande do Sul States between 2013 and 2016, accounting for 44% of these records in Brazil. In terms of intensity, Pernambuco State posted an average of 26,000 people affected per event.

These characteristics are presented in detail in Chapter 2 on pages 24 and 25.

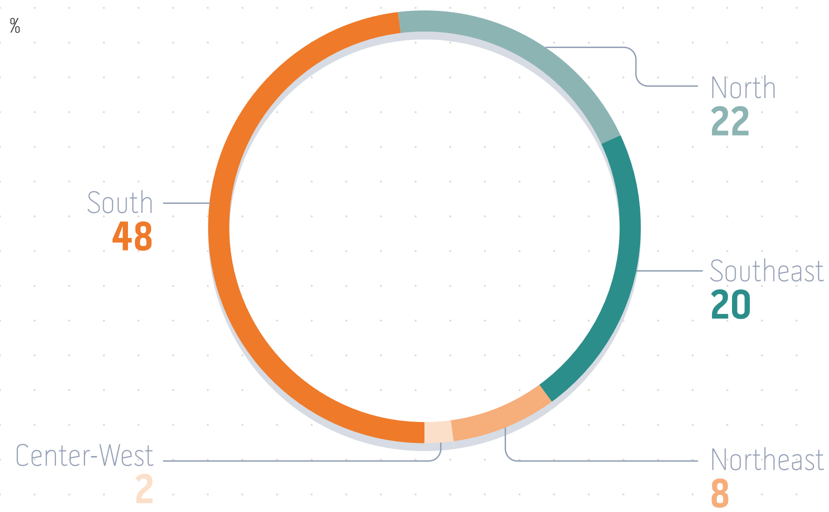
PEOPLE AFFECTED BY DROUGHTS AND FLOODS IN BRAZIL: 2013 – 2016



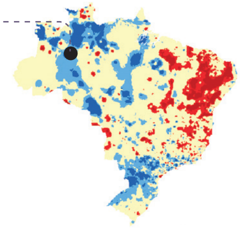
FLOODS IN BRAZIL: 2013 – 2016



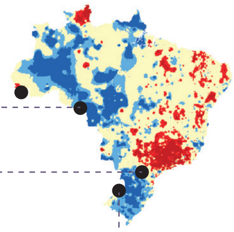
FLOODS BY REGION: 2013 – 2016



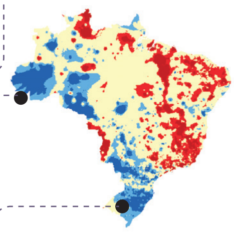
In 2013, flooding along the **Negro river reached the Amazonas State capital, Manaus**. Although the highest water level was lower than the all-time high recorded the previous year, this river remained above the emergency flooding level for 48 days.



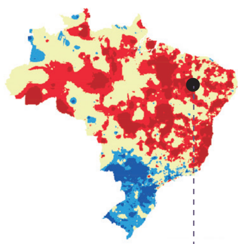
Rainfall of 300, 100 and 200 mm above the respective monthly averages was recorded from January through to March 2014 in northern Bolivia, and the water level in Madeira river reached more than two meters above its previous record in 1967. The **Rondônia State capital, Porto Velho**, was among the cities most severely affected, as the BR- 364 highway remained flooded for almost two months, cutting off overland access to **Acre State**, which was affected by widespread shortages of essential goods, including food and fuel.



Southern Brazil was affected in June 2014 by rainfall totals ranging from 100 to 200 mm above the mean, leaving thousands of people homeless in **União da Vitória, Paraná State**, due to flooding along the Iguaçu river that was the fourth-highest since 1930. The water level on the Uruguay river at **Iraí in Rio Grande do Sul State** was the third highest since 1941.



On March 4, 2015, the water level in Acre river reached 18.40 meters at Rio Branco, the highest level ever recorded since monitoring began in 1967. The reaches of the Acre river at **Assis Brasil, Brasileia, Epitaciolândia and Rio Branco** are extremely **vulnerable to flooding**, due to severe impacts on infrastructure and essential services or significant risks to life.



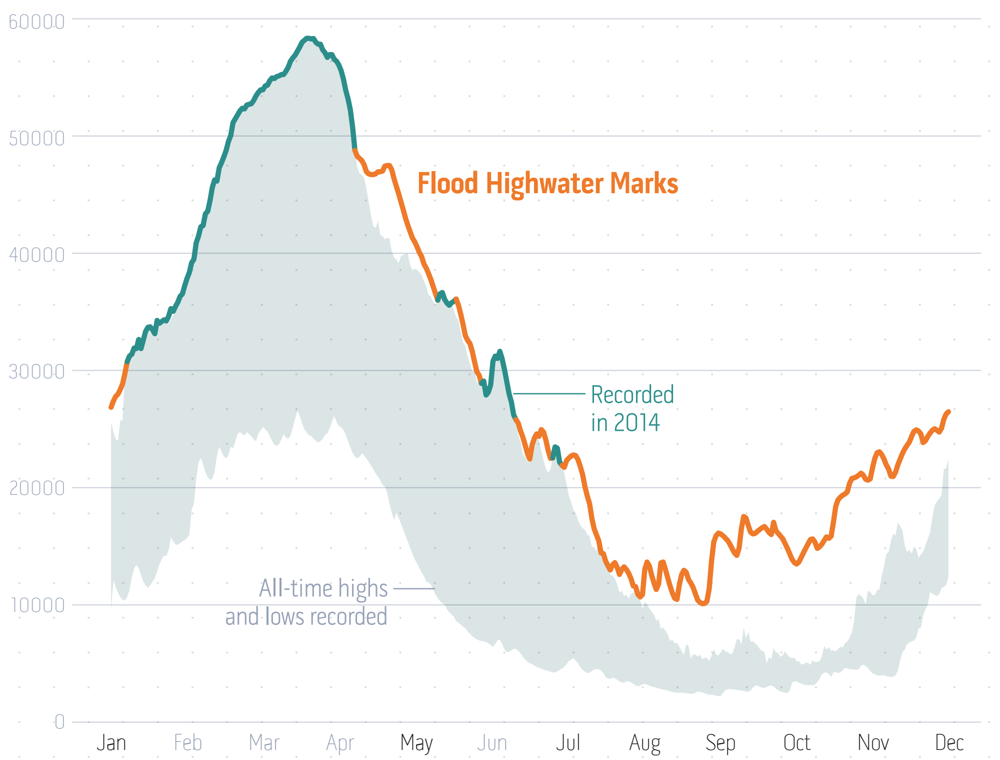
During October 2015, flooding affected more than a hundred towns in Santa Catarina and Rio Grande do Sul States, mainly in the **Jacuí and Itajaí-Açu** river basins. In December that same year, more than a hundred thousand people – mainly in Paraguay – were affected by floods in the region shared by Argentina, Brazil, Paraguay and Uruguay, due to flooding along the Paraguay river.

In 2016, floods affected around 1.3 million people in Brazil, although with no severe impacts on human life. In contrast, droughts assailed 18 million people in 2016, mainly in Northeast Brazil (home to 84% of these).

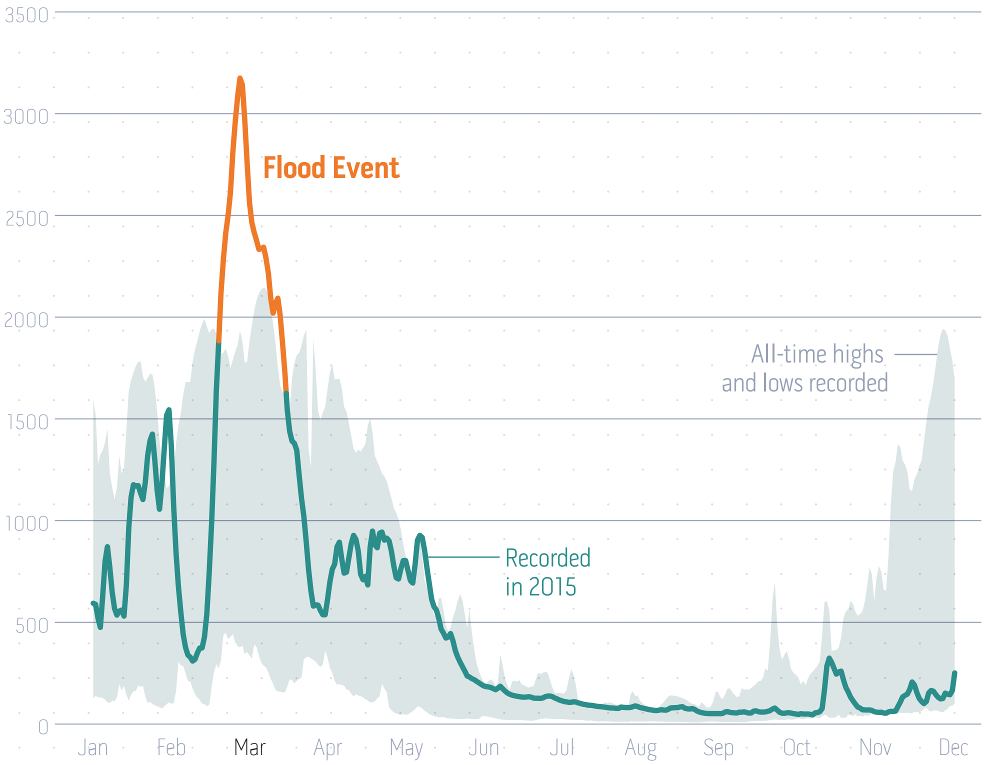
Some river basins in Amazônia recorded harsh dry seasons, including the Acre river basin, which is usually subject to heavy flooding.

The Flood Vulnerability Atlas mapped out in detail the vulnerability levels of floodable segments of major rivers in Brazil. Available at: ***goo.gl/MPkiX8***.

FLOODING ALONG THE MADEIRA RIVER IN PORTO VELHO (2014)



FLOODING ALONG THE ACRE RIVER IN RIO BRANCO (2015)

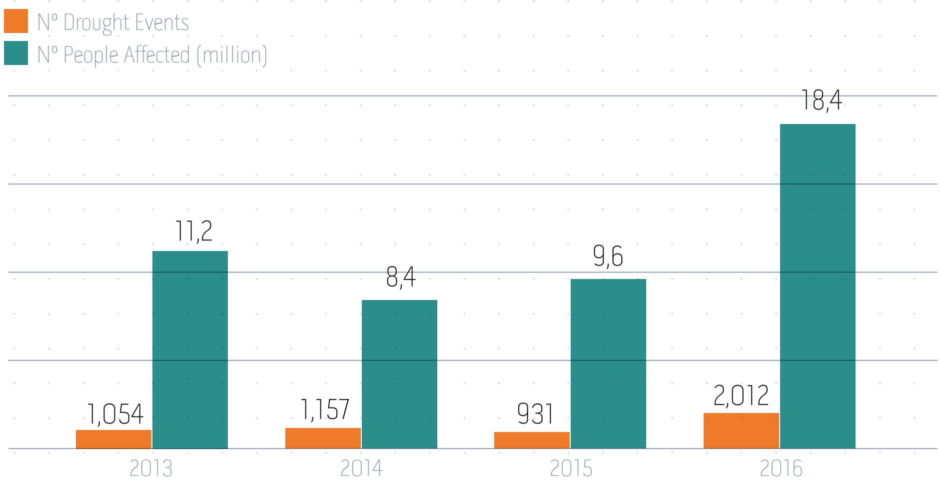


Between 2013 and 2016, 48 million people were affected by droughts and dry seasons in Brazil – six times the number of flood victims – with 4,824 recorded drought events associated with harm to human beings: almost three times the harm caused by floods (1,738). The most critical year for the impacts of drought on the population was 2016.

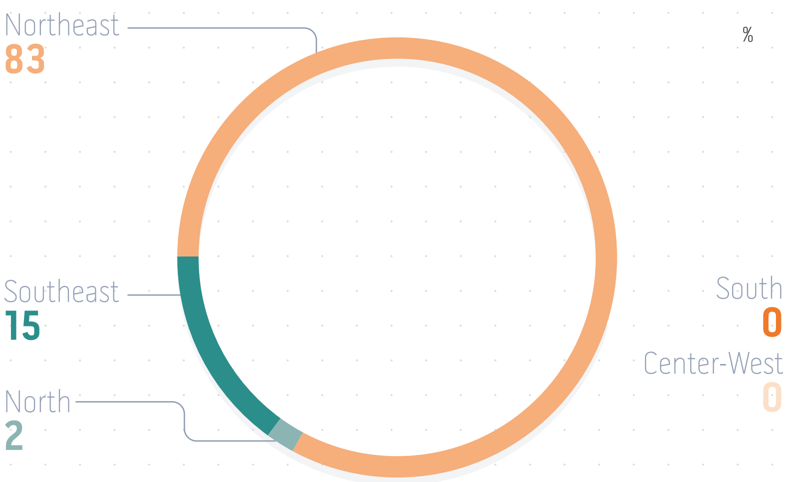
Compared to floods, droughts are more frequent and long-lasting, affecting more people but with lighter impacts on human life, with the most evident harm being diseases triggered by these events.

Based on monthly records, October, was the driest month recorded, followed by April and May, while December and June posted the fewest droughts. Among people affected by droughts between 2013 and 2016, 83% live in in Northeast Brazil, with Ceará, Minas Gerais and Bahia States accounting for 61% of these records in Brazil. The highest average number of people affected by an event was recorded in Acre State: 58,000.

DROUGHTS IN BRAZIL: 2013 – 2016



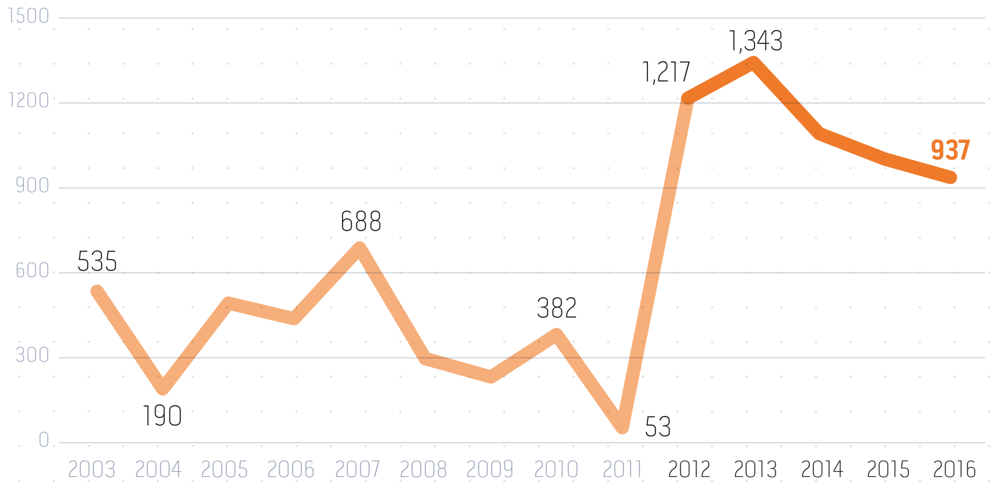
DROUGHTS BY REGION IN BRAZIL: 2013 – 2016



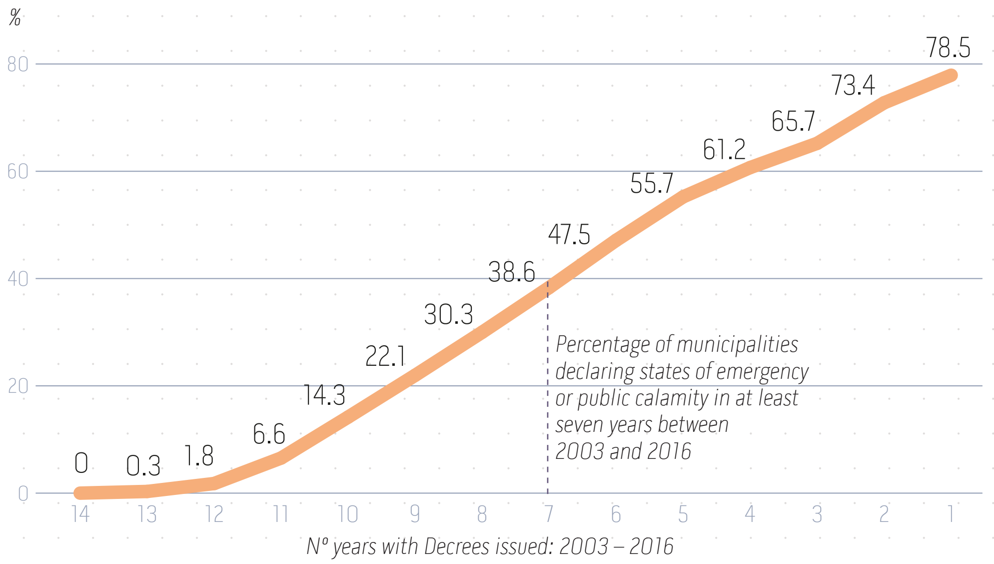
Droughts and dry seasons recorded all over Brazil since 2012 significantly undermined water supplies to the public and also user sectors that depend on water stored in reservoirs, particularly for irrigation, hydropower generation and navigation.

In Northeast Brazil, 1,409 (78.5%) of its 1,794 municipalities declared states of emergency or public calamity due to droughts during the fourteen years between 2003 and 2016, with around 50% of these municipalities issuing these decrees in at least seven years.

Nº MUNICIPALITIES IN NORTHEAST BRAZIL DECLARING STATES OF EMERGENCY OR PUBLIC CALAMITY DUE TO DROUGHT: 2003 – 2016



PERCENTAGE OF MUNICIPALITIES IN NORTHEAST BRAZIL DECLARING STATES OF EMERGENCY OR PUBLIC CALAMITY DUE TO DROUGHT: 2003 – 2016



As water runs scarce, production tapers off and the economy slows down. With river streamflows decreasing, hydropower plants generate less electricity and heavier industrial demands are imposed on their thermopower counterparts, pumping up energy prices. In parallel, river transportation may no longer be feasible at some locations.

Regardless of extreme events, critical management situations result from an unfavorable water balance in some parts of Brazil. Consisting of the ratio between the **quantitative and qualitative** aspects of **water use demands** and the **amount of water available**, the **water balance** is drawn up to underpin **water management** activities. It is crucially important for drawing up diagnoses of rivers and river basins in Brazil.

One of the main outcomes of the water balance is the identification nationwide of **critical areas**, in terms of water quantity and/or quality, steering the planning and management activities addressed in the National Water Resources Policy. Water stress may be seasonal for some uses (particularly irrigation) with heavier water demands in drier months, varying widely throughout the year.

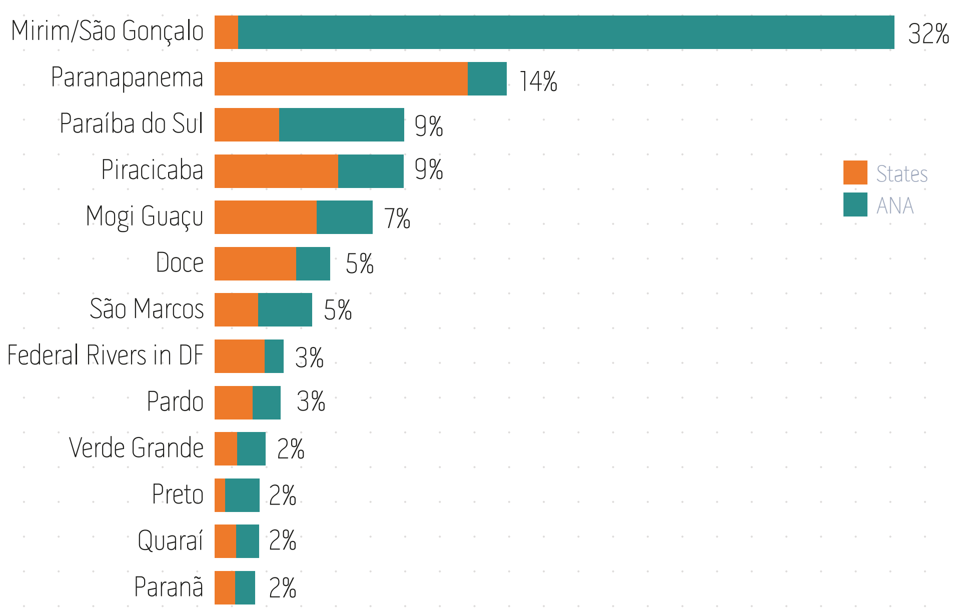
River basins and federal river reaches whose critical status endows them with particular management interest are defined through Edict Nº 62 issued by ANA in 2013. Available at: ***goo.gl/qLe995***

Water management may be handled by ANA or the States for areas where critical situations require special attention.

Five of the 24 river basins containing critical federal river segment accounts for 71% of their total licensed flows: Lagoa Mirim/São Gonçalo, Paranapanema, Paraíba do Sul, Piracicaba and Mogi Guaçu.

STREAMFLOWS LICENSED (WATER PERMITS) IN CRITICAL BASINS BY ANA AND THE STATES

%



In critical river basins, 71% of the water use permits for irrigation are located in the following basins: Lagoa Mirim/São Gonçalo, Paranapanema, São Marcos and Mogi Guaçu. Flows in the Piracicaba and Paraíba do Sul river basins correspond to 53% of the water allocated for public supplies in critical river basins. For the industrial sector, 65% of the allocated flows runs through the Paraíba do Sul, Piracicaba and Mogi Guaçu basins.

A set of water use rules must be established for critical basins, defined through **regulatory frameworks**.

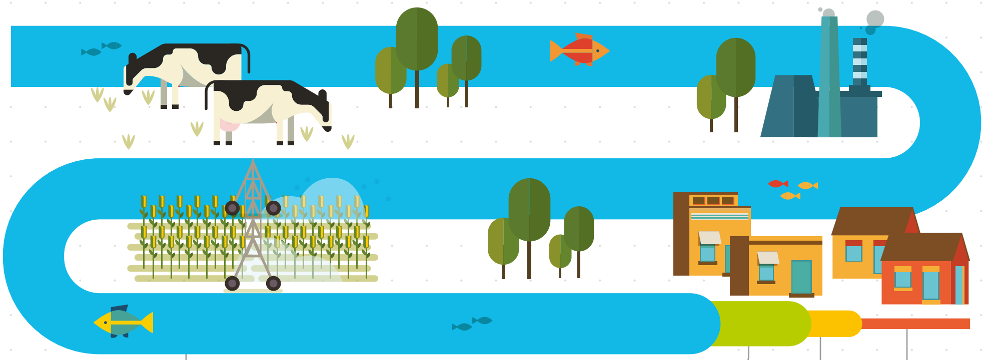
Regulatory frameworks consist of a set of general rules on water use in a water body, defined by the grantor authorities with input from water users. Information on regulatory frameworks is available at: ***goo.gl/CVbHDQ***

Since 2004, fifteen regulatory frameworks have been established in river basins and water supply systems throughout Brazil, with ten of them effective in 2016.

6 CLEAN WATER AND SANITATION

Freshwater withdrawals as a proportion of available freshwater resources constitute one of the SDG 6, measuring water stress levels.

FEDERAL RIVER EXTENSIONS ACCORDING TO CLASSES OF QUANTITATIVE WATER BALANCE

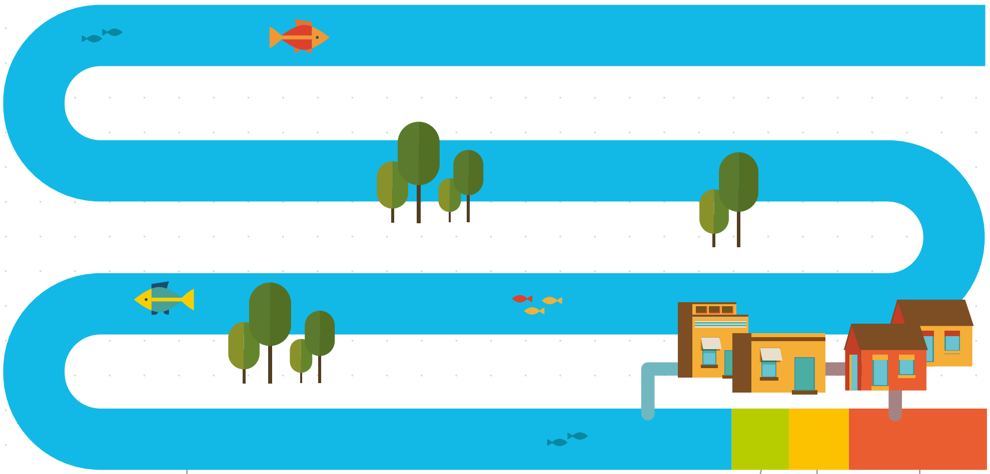


Around 4.5% (83,450 km) of Brazil's water-courses hold quantities of organic matter pushing the Class 4 limits, severely curtailing possible uses for their waters. Polluted segments are located close to **more densely populated urban areas** or with very limited dilution capacities.

The estimate was drawn up on the basis of the Q 95 streamflow and the BOD limits established for the different classifications established in Resolution Nº 357/2005 issued by the National Environment Council (CONAMA). Data from the Sewage Atlas: River Basin Clean-Up, available at ***goo.gl/ahYL7N***

Brazil's largest urban populations are not located in areas with ample water supplies, ramping up the challenges of handling sewage and the resulting impacts on receiving water bodies.

BRAZILIAN RIVER EXTENSIONS ACCORDING TO BOD OBJECTIVES (CLASSIFICATION OF WATER BODIES)



There are 524 municipalities in Brazil that require joint solutions for the treatment and disposal of wastewater within their respective river basins tailored to the dilution capacities of their receiving water-bodies and major water uses. Among basins with these characteristics, are particularly noteworthy those along the Tietê river basin (including the Piracicaba, Capivari and Jundiaí – PCJ), Sinos, Alto Iguaçu, Paraíba do Sul, Velhas, Descoberto, Meia Ponte and Ipojuca basins. In turn, municipalities located in headwater areas require **complementary solutions**, due to the wide gap between population density and water availability. This also applies to municipalities in the semi-arid regions where rivers are intermittent and reservoirs are frequent.

High vulnerability resulting from an unfavorable water balance and low investments in the corresponding infrastructure (particularly water production systems) may worsen the situation, particularly in unusually dry rainy seasons, leading to water shortages and even crises.

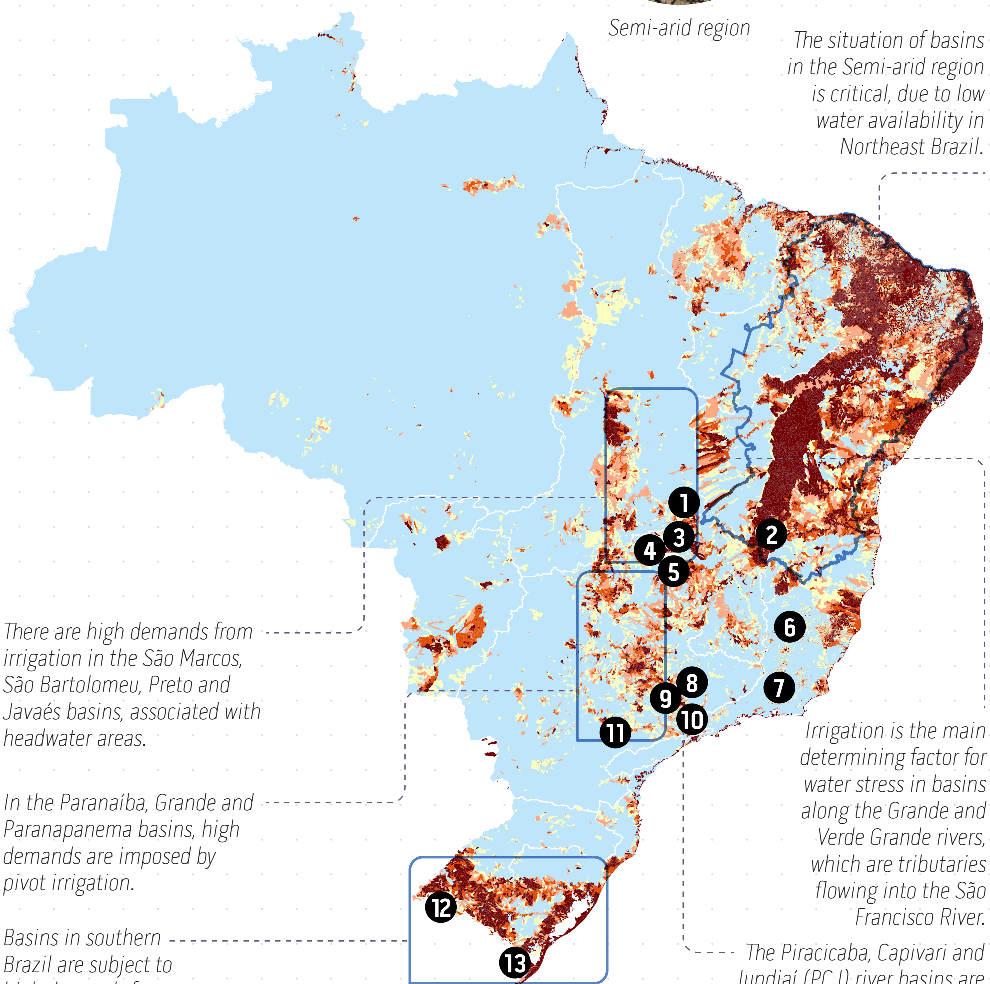
QUANTITATIVE WATER BALANCE SITUATION BY MICRO-BASIN

- Excellent
- Good
- Alert
- Critical
- Severe

1. Paranã
2. Verde Grande
3. Preto
4. Federal Rivers in DF
5. São Marcos
6. Doce
7. Paraíba do Sul
8. Pardo
9. Mogi Guaçu
10. Piracicaba
11. Alto Paranapanema
12. Quaraí
13. Lagoa Mirim/São Gonçalo

Semi-arid region

The situation of basins in the Semi-arid region is critical, due to low water availability in Northeast Brazil.



There are high demands from irrigation in the São Marcos, São Bartolomeu, Preto and Javaés basins, associated with headwater areas.

In the Paranaíba, Grande and Paranapanema basins, high demands are imposed by pivot irrigation.

Basins in southern Brazil are subject to high demands from irrigation, mainly rice paddies.

Irrigation

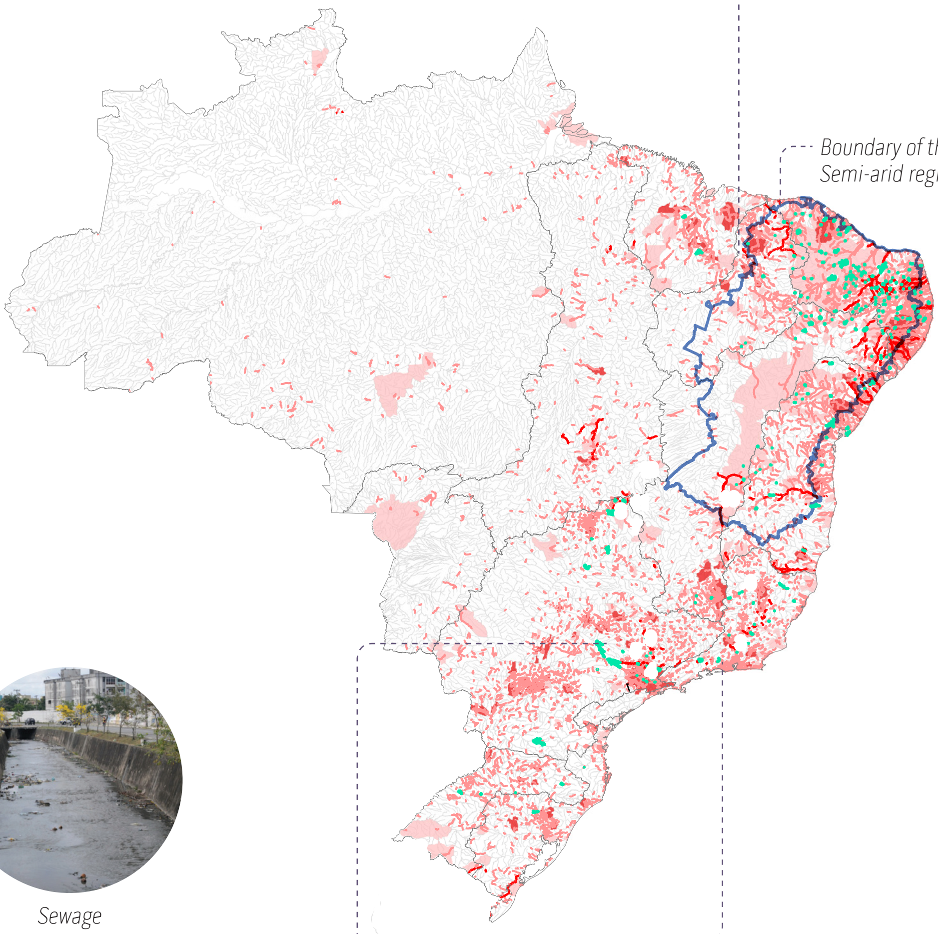
Irrigation is the main determining factor for water stress in basins along the Grande and Verde Grande rivers, which are tributaries flowing into the São Francisco River.

The Piracicaba, Capivari and Jundiaí (PCJ) river basins are subject to significant demands for urban water supplies, due mainly to streamflow transfers in headwater areas.

Metropolitan Regions

IMPACTS OF ORGANIC LOADS ON WATERCOURSES IN BRAZIL

Severe impacts are also noted in river basins along the northeast coast and in headwater areas with major urban hubs.



Boundary of the Semi-arid region

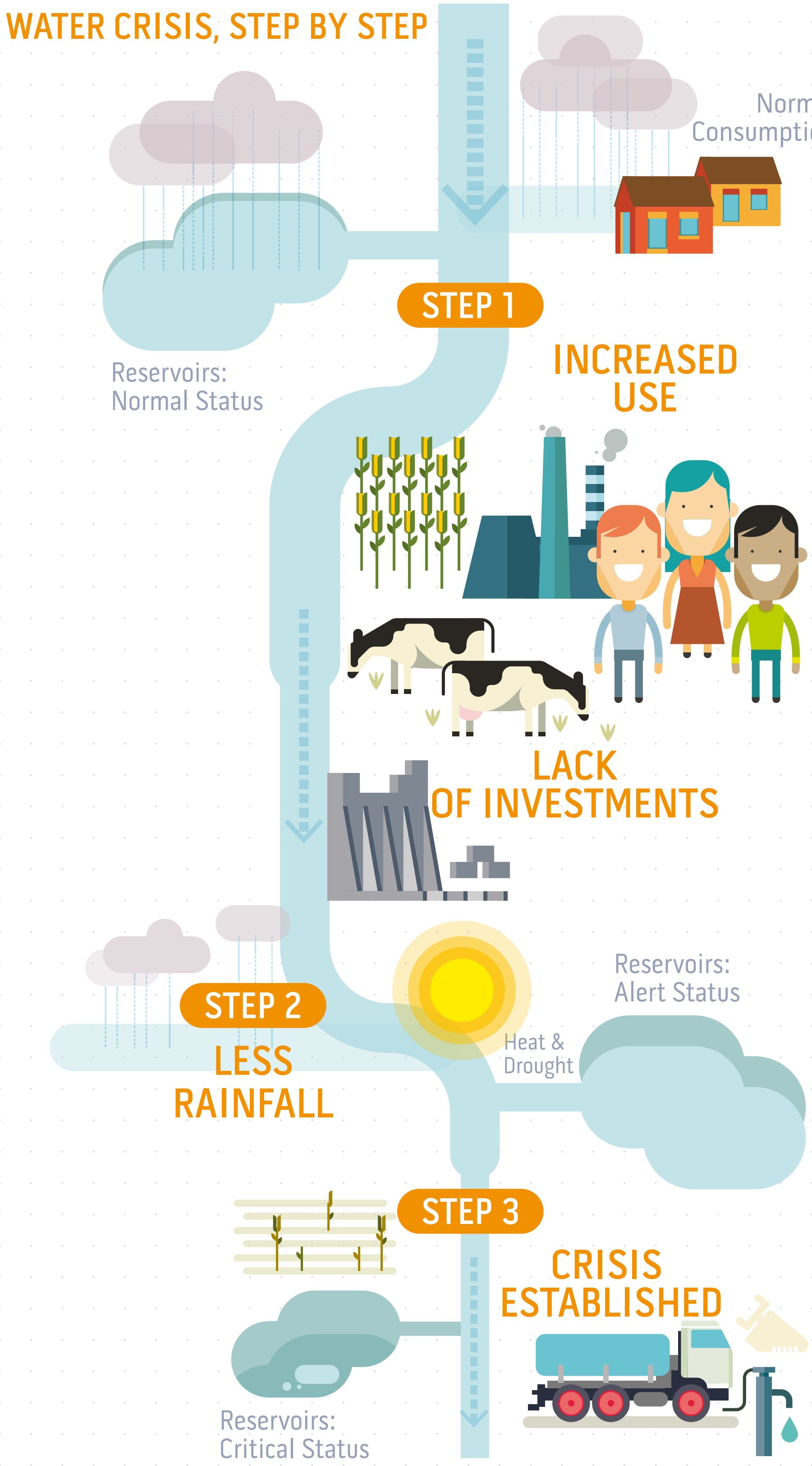
Eutrophication

- Reservoirs with potential phosphorus load impact resulting from urban sewage disposal.
- Municipalities requiring joint solutions for sewage treatment.
- Municipality requiring complementary solution and/or Semi-arid solution
- Federal river non-compliant with water quality objectives.
- State river non-compliant with water quality objectives.

Sewage

In the São Paulo and Campinas Metropolitan Regions, water body streamflows are unable to assimilate the loads generated by large populations.

Along the Rio de Janeiro State coast, the remaining amount of sewage reaches almost 70% of the load generated by its population.


WATER CRISIS, STEP BY STEP
Normal Consumption
Reservoirs: Normal Status
STEP 1
INCREASED USE
LACK OF INVESTMENTS
Reservoirs: Alert Status
Heat & Drought
STEP 2
LESS RAINFALL
STEP 3
CRISIS ESTABLISHED
Reservoirs: Critical Status

The vulnerability of a river basin may derive from its inherently critical status in terms of water availability, due either to natural characteristics, as well as heavy demands and/water pollution. **Deforestation and soil erosion**, decreasing rainfall and rising demands for water, among other factors, impose **pressures** that may well lead to water shortages. These crises affect all water uses to a greater or lesser extent, even those not requiring consumption, such as navigation, fishing, tourism and recreation.

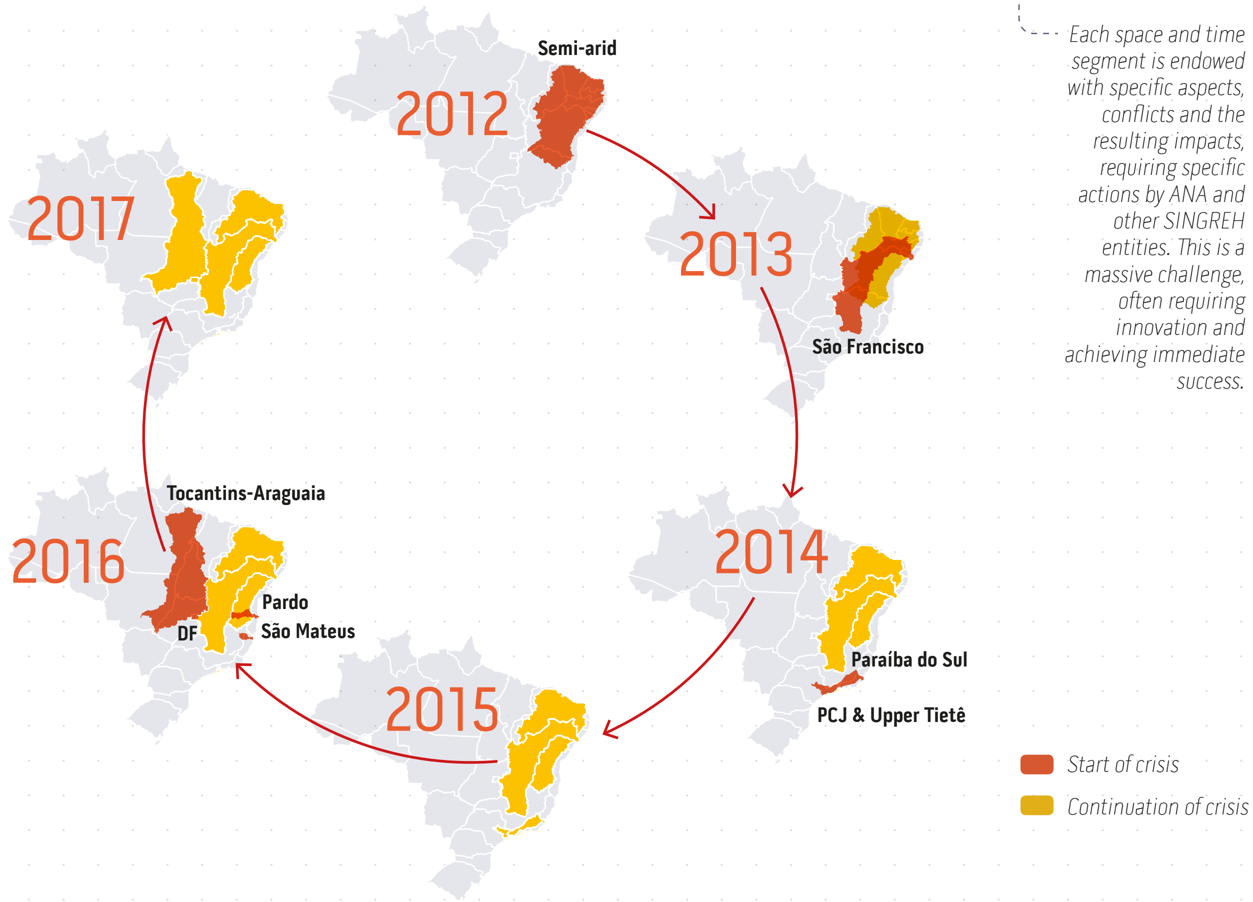
It is vital to encourage headwaters preservation. In this context, the Water Producer Program implemented by ANA is particularly noteworthy, underpinned by the Environmental Services Payments Policy and focused on reducing erosion and the silting-up of sources in rural areas, needing to better water quality, with expanded supplies and their regularization. Further information on this Program is available at: ***goo.gl/WrMEfF***

Understanding the reasons for low rainfall levels and trends in inter-annual precipitation dynamics is still limited, due mainly to the short time during which these anomalies have been recorded. The causes of the water crisis cannot be blamed only on lower rainfall levels during the past few years, as other factors related to **guaranteed water supplies and water demands management** are also important for underpinning or counteracting its these events.

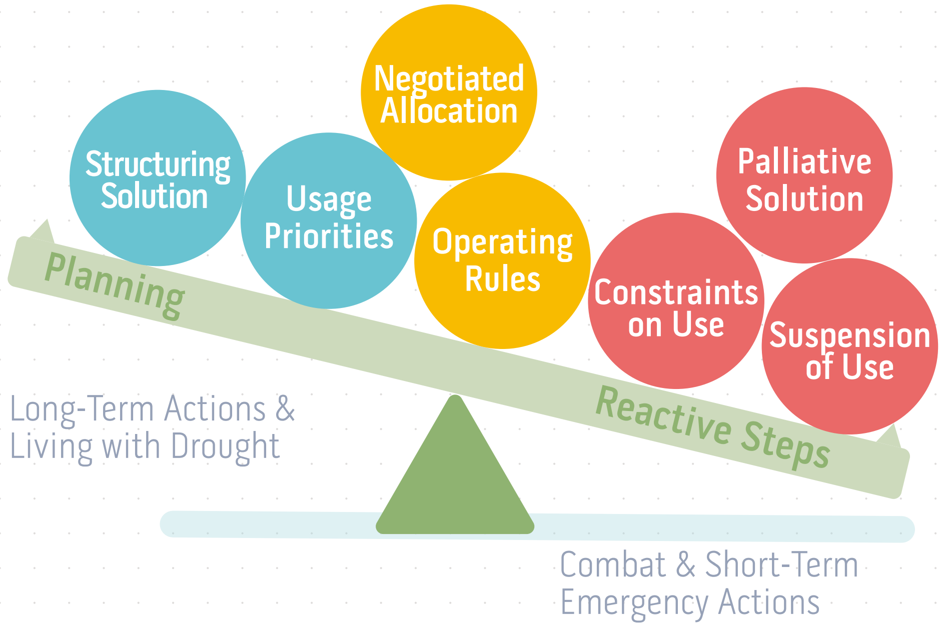
Brazil's water crisis can be characterized in general terms, together with development in space and time, as the meteorological, hydrological, demographic and institutional factors causing it are generally the same. With the crisis established, a set of **actions** has been undertaken during the past few years, intended to prevent/and or remedy the effects of water shortages in **different parts of Brazil**.

Each space and time segment is endowed with specific aspects, conflicts and the resulting impacts, requiring specific actions by ANA and other SINGREH entities. This is a massive challenge, often requiring innovation and achieving immediate success.

THE ONGOING CRISIS MERELY SHIFTS LOCATION – IT IS BASICALLY CYCLIC



ACTIONS PURSUING WATER SECURITY



Home to more than 24 million people, Brazil's **Semi-arid region** are subject to factors such as low rainfall (below 900 mm), irregular weather patterns, limited groundwater availability, high temperatures throughout the year with few variations, strong sunshine and high evapotranspiration rates that normally outstrip total precipitation, all contributing to an unfavorable water balance.

This is naturally a critical area at high risk of drought, with special management requirements that encompass permanent interventions structuring water supplies, such as building reservoirs that underpin life and supporting activities in this region. More particularly, 87.8% of the land area of States in northern Northeast Brazil (Ceará, Rio Grande do Norte, Paraíba and Pernambuco) is located in the Semi-arid regions, scourged by a water crisis since 2012, caused by the longest and most severe drought since the early XX century.

The water volume status of reservoirs in Northeast Brazil is presented in Chapter 2.

Total rainfall volumes were well below average during the wet seasons from 2012 to 2016, resulting in limited reservoir storage replenishment. As a result, their levels decreased drastically, depleted through responding to demands for a wide variety of uses, and are now **extremely low**.

Between 2014 and 2016, **204 reservoirs in the Semi-arid region** were studied, of which 154 are sources for towns supply and 198 serve rural communities, providing water for more than 10 million people, with 51 servicing around 50,000 hectares of irrigable land in 43 public irrigation projects. The reservoirs are graded by usage intensity in order to assess their status, together with rational planning for using them water and defining new **operating rules**. Only 85 reservoirs have the capacity to respond to new demands, with the remaining 119 either operating at full capacity already failing frequently to keep pace with current demands.

The study entitled Reservoirs of Brazilian Semi-Arid: Hydrology, Water Balance and Operations encompassed reservoirs with a total storage capacity of 31.2 billion m³, more than 80% of the water volumes stored in this region. Available at: ***goo.gl/8pkQ4d***

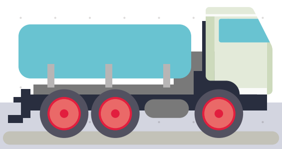
In December 2016, water supplies reached a state of collapse in 132 towns in northern Northeast Brazil, with a total population of 1.46 million inhabitants.

Collapse is defined as the depletion of surface sources that are normally used, or when the supply system is subject to rationing or rota distribution schemes more frequently than four days a week (water supplies suspended for four days a week or more).

In this situation, many municipalities were forced to seek emergency water supplies through tanker trucks, having exhausted alternative solutions such as emergency well drilling, using desalination units and laying fast-coupling water pipelines in order to bring in water from remote sources.

The number of municipalities serviced through the Federal Government's Operation Tanker Truck reached 812 in 2016, costing more than USD 300,000 million (BRL 1 billion).

OPERATION TANKER-TRUCK RUN BY THE FEDERAL GOVERNMENT: 2012 – 2016



	2012	2013	2014	2015	2016
Municipalities Serviced	540	794	798	797	812
Tanker Trucks in Operation	3,000	5,403	6,364	6,733	6,788
Population Serviced (million)	2.87	3.62	3.74	3.75	3.59
Total amount – decentralized (million USD/BRL)	137.58/ 454.02	214.24/ 707.18	253/ 835.21	279/ 921.38	312.12/ 1,030

At the Federal level, Operation Tanker Truck data are organized by the National Risk and Disaster Management Center (CENAD) under the National Civil Defense and Protection Bureau (SEDEC). These figures do not include tanker trucks brought into operation by States and Municipalities.

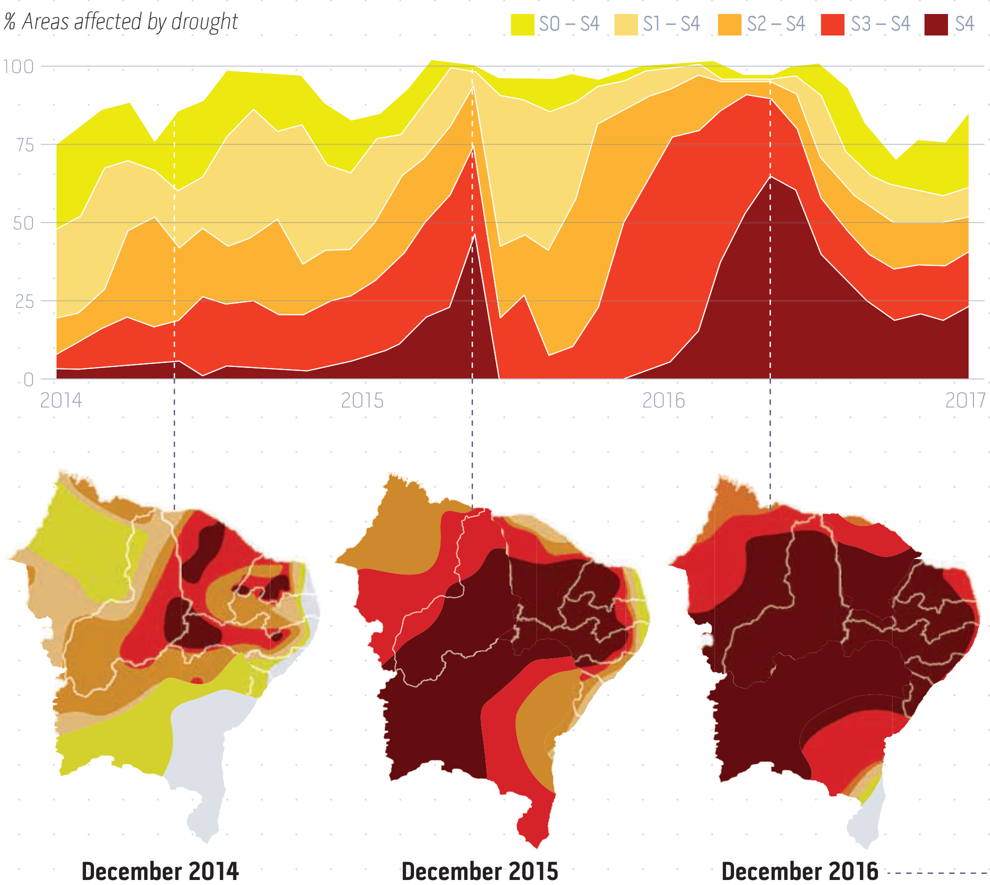
Drought Monitor data show the huge areas scourged by unusually severe droughts in Northeast Brazil in 2016, covering 60% of this region in December.

The Drought Monitor is updated on a monthly basis, with data available at: ***goo.gl/RYQXvb***

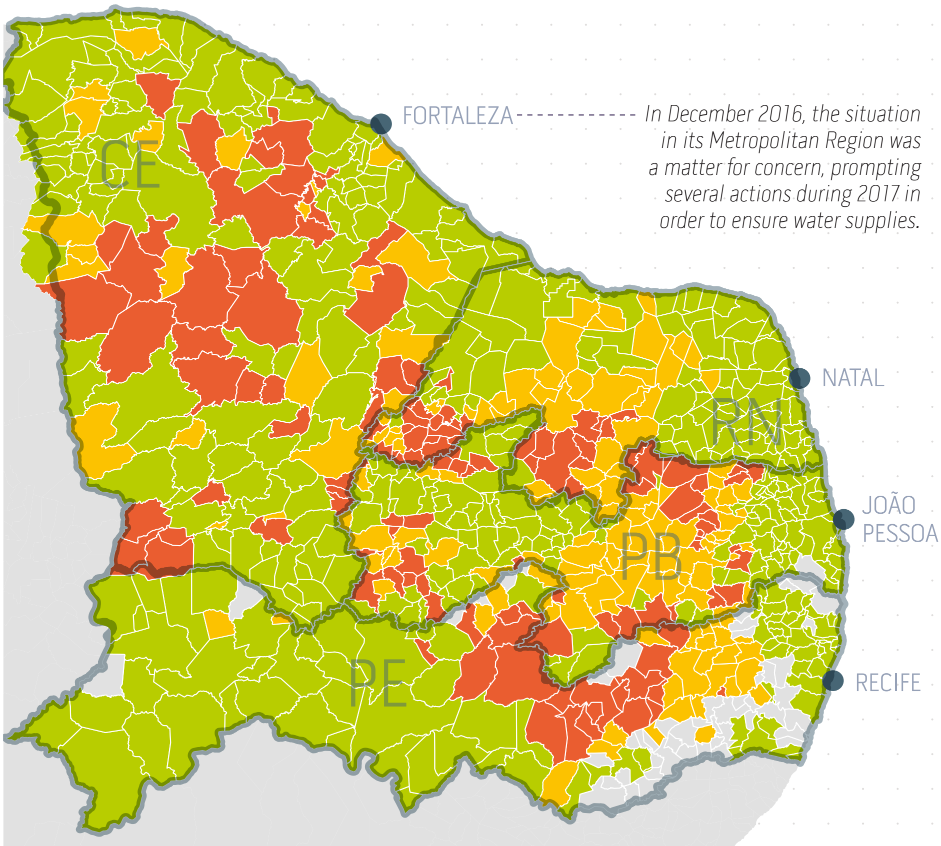
DROUGHT MONITOR – NORTHEAST BRAZIL

Drought Severity Ranking

S0	**Mild Drought**	Dry season begins: brief summer with less time for sowing and growth of crops or grazing lands. Dry season ends: some prolonged water shortages, grazing lands or croplands not fully recovered.
S1	**Moderate Drought**	Some damage to crops, grazing lands; low water levels in streams, reservoirs or wells; some water shortages looming or imminent; voluntary constraints on water use requested.
S2	**Severe Drought**	Probable losses of crops or grazing lands; frequent water shortages; mandatory constraints on water use imposed.
S3	**Extreme Drought**	Massive losses of crops and grazing lands; widespread water shortages or constraints.
S4	**Exceptional Drought**	Exceptional widespread losses of crops and grazing lands; water running short in reservoirs, streams and wells, leading to emergency situations



WATER SUPPLY STATUS FOR CITIES IN NORTHERN NORTHEAST BRAZIL: DECEMBER 2016

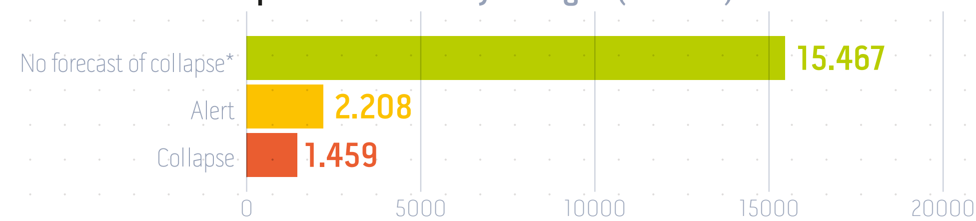


DROUGHT STATUS

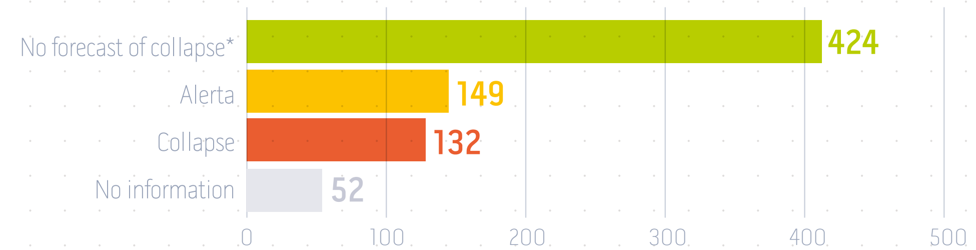
- **No collapse forecast through to 1Q 2017**
- **Alert**
- **Collapse**
- **No information**

Based on information from the States in northern Northeast Brazil and reservoir levels monitored by, ANA, the current situation can be outlined, drawing up a short-term prognosis of the water supply status for all municipal hubs in this region.

Status of Urban Population Faced by Drought (million)



Status of Municipalities Faced by Drought



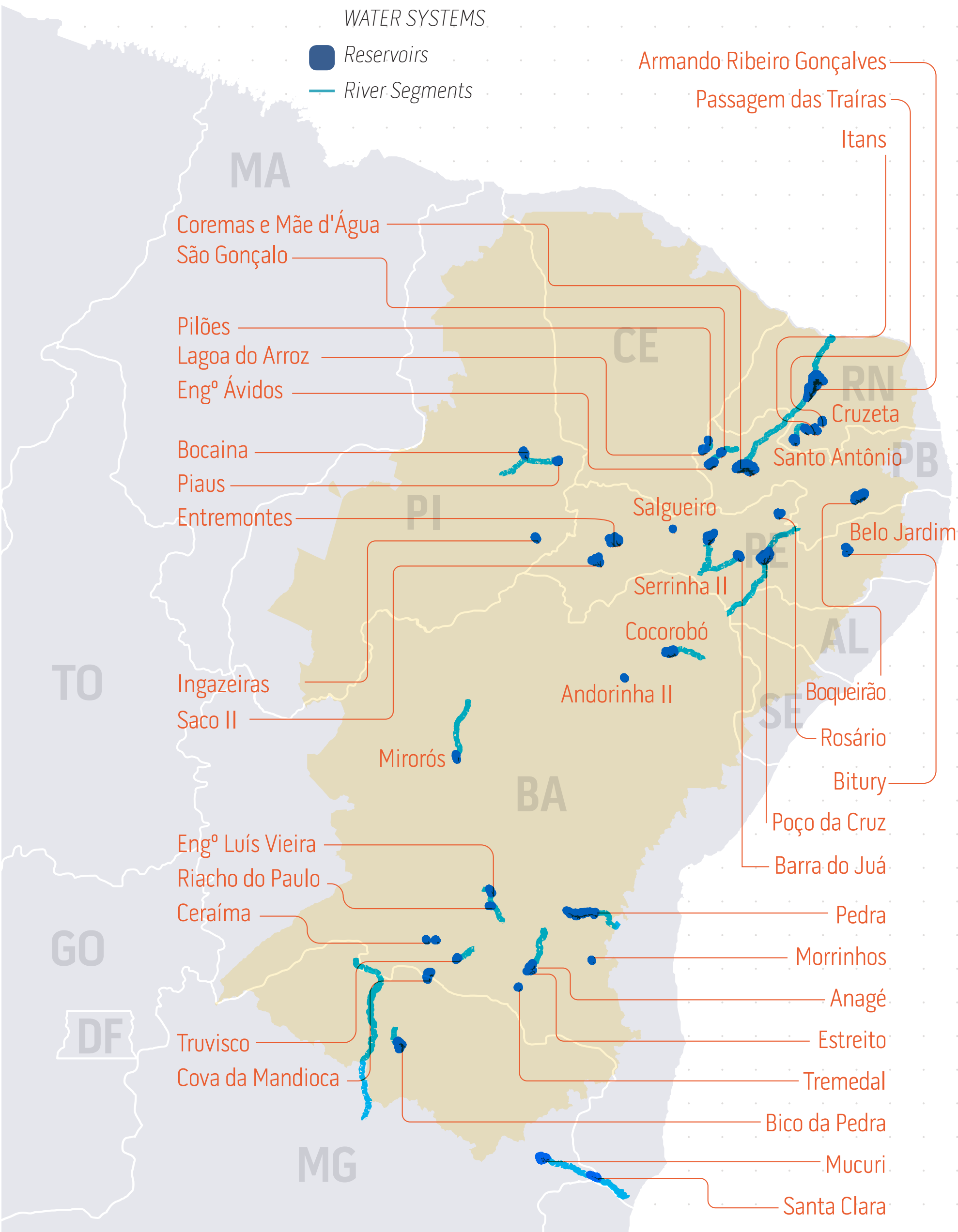
* Up to 1Q 2017

The Water Allocation process encompasses a diagnosis of disputes and the introduction of rules for harmonious coexistence among users (regulatory frameworks), examining structural and non-structural actions required to underpin management sustainability, and holding public meetings attended by management entities, water users, damn operators and society in general. Actions required for management purposes include setting up local water commissions and water infrastructure operation, maintenance and oversight programs.

A water system is generally comprised of a set of infrastructure such as one or more reservoirs and segments of rivers, channels and/ or canals whose flows have been perennized or regularized. In these systems, the statistical criteria used for granting licenses may be excessively optimistic during prolonged water shortages, thus being unable to minimize sources collapse if they are not recharged as planned by the end of the rainy season.

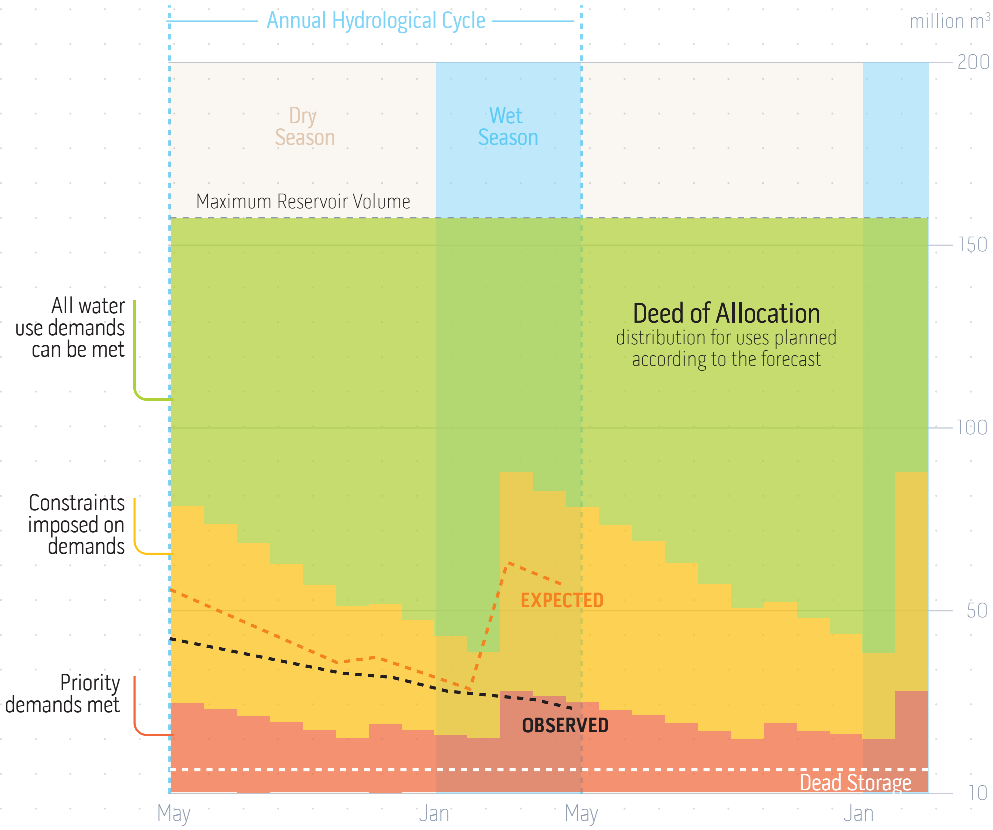
In order to deal with shortages and ensure that water is available for all uses, **negotiated allocation** agreements may be drawn up for specific reservoirs and systems. **Water allocation** is a managements deployed to regulate uses in **water systems** assailed by severe droughts, in emergency situations or with a strong likelihood of disputes.

WATER ALLOCATION AGREEMENTS



Water allocations are established on the basis of monitoring the hydrological status of each reservoir and/or water system.

HYDROLOGICAL STATUS & WATER ALLOCATIONS



Between 2014 and 2016, 34 Water Allocation agreements were firmed up by ANA with state management entities, dam operators and water resource users, working closely with Basin Committees.

In Ceará, negotiated water allocations were also undertaken by management entities jointly with ANA, for 95 reservoirs and water systems that are strategic for responding to water demands in this State.

Prompted by prolonged droughts and low reservoir levels, ANA and State management entities introduced **rules curtailing water uses** in some river basins, in addition to the water allocation agreements, in order to preserve and prolong water availability, ensuring supplies for the high-priority uses defined by the National Water Resources Policy (PNRH), in addition to human consumption and drinking water for livestock.

Between 2013 and 2016, 17 resolutions or other regulations curtailing or suspending water uses were issued in Brazil, seven of them in 2016.

Oversight activities checking compliance with use curtailment rules were stepped up in the Semi-arid region, especially in the **Piancó-Piranhas-Açú** river basin, due to low water levels in reservoirs that ensure year-round water in these rivers, jeopardizing public water supplies in **Paraíba and Rio Grande do Norte States**, in parallel to negative impacts on the economy.

Water management and oversight actions have been deployed by ANA through a partnership with the Rio Grande do Norte State Water Management Institute (IGARN) and the Paraíba State Executive Water Management Agency (AESA), with the support of the Military Police and Environment Police in both these States.

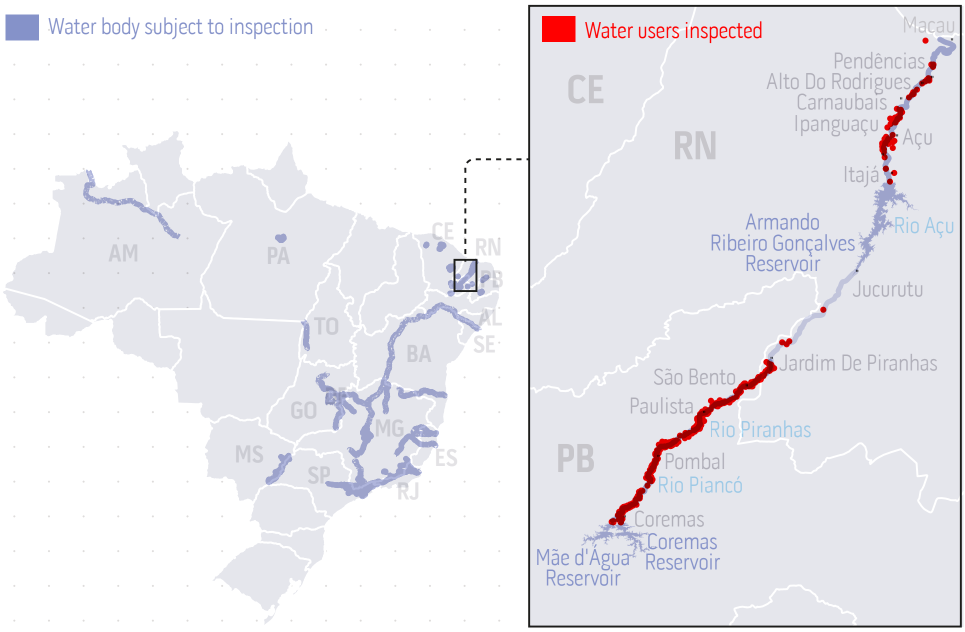
Drought in the Piancó-Piranhas-Açu basin caused **economic losses** over USD 909 million (over BRL 3 billion), equivalent to 3% of its GDP, from June 2012 to June 2017, adversely affecting many users. Almost 40% of the projected demands of the industrial sector were unmet, accounting for close on half (49%) of the economic losses, due to the higher added value of its output. Drinking water for livestock was the second most severely-affected economic use, with 21% of total losses, while some 20% of irrigation demands (the highest among all user sectors) remained unmet, accounting for 62% of the total water deficit in this basin.

Economic losses in this basin were analyzed through the study commissioned by ANA from the Getulio Vargas Foundation (FGV). Secondary economic losses may be 6.6 times higher than their primary counterparts, topping USD 6.4 billion (BRL 21 billion) or 20% of the GDP of this basin. Available at: ***goo.gl/8xy57V***

Between 2012 and 2016, 75 (29%) of the 258 water use oversight campaigns conducted by ANA in Brazil were located in the Piancó-Piranhas-Açú river basin, where water use demands are mainly for irrigation purposes. With 756 users inspected in this basin, 583 Notices of Infraction were served, including warnings, fines and embargoes.

FEDERAL WATER BODIES IN BRAZIL SUBJECT TO INSPECTIONS: 2014 – 2017

Water users inspected along perennized segments of the Piancó, Piranhas and Açu rivers: 2014 – 2017



Furthermore, **registration** campaigns were conducted in the Piancó-Piranhas-Açú basin, underpinned by high-resolution satellite imaging that allowed identification of properties and irrigated areas.

The methodology involved prior user identification and classification by irrigated area size, handled through interpreting satellite images taken at different times, inspection visits to properties, demarcation of irrigated areas in the field, assisted by users, and helicopter overflights pinpointing users not yet registered.

Along the stretch between the Coremas reservoir and the town of Jardim de Piranhas, irrigated areas shrank from 2,062 hectares in July 2014 to 938 hectares in July 2016, dropping to 515 hectares in October 2017. These reductions in irrigated areas were due to constraints on using water for irrigation purposes and more stringent oversight.

As the water crisis worsened in 2016 **oversight activities were stepped up in this basin**, confiscating water uptake and irrigation equipment used improperly, removing dams and closing unlicensed channels diverting water from perennized river reaches. In the Lower Açu river region, inspections focused on major users with devices installed for metering water uptake or pump use duration. Management steps similar to those in the Piancó-Piranhas Açu basin were implemented at the Boqueirão reservoir in the Paraíba river basin for coping with the drought. Supplying water to the population of Campina Grande and sixteen other municipalities in Paraiba State, the amount of water stored in the Boqueirão reservoir has decreased significantly since 2012, reaching an all-time low volume of 2.9% in 2017.

Through these oversight activities, it was possible to maintain water supplies to towns in Paraíba and Rio Grande do Norte State, as well communities located along the river, together with drinking water for livestock. Overall, around 400,000 people benefited directly.

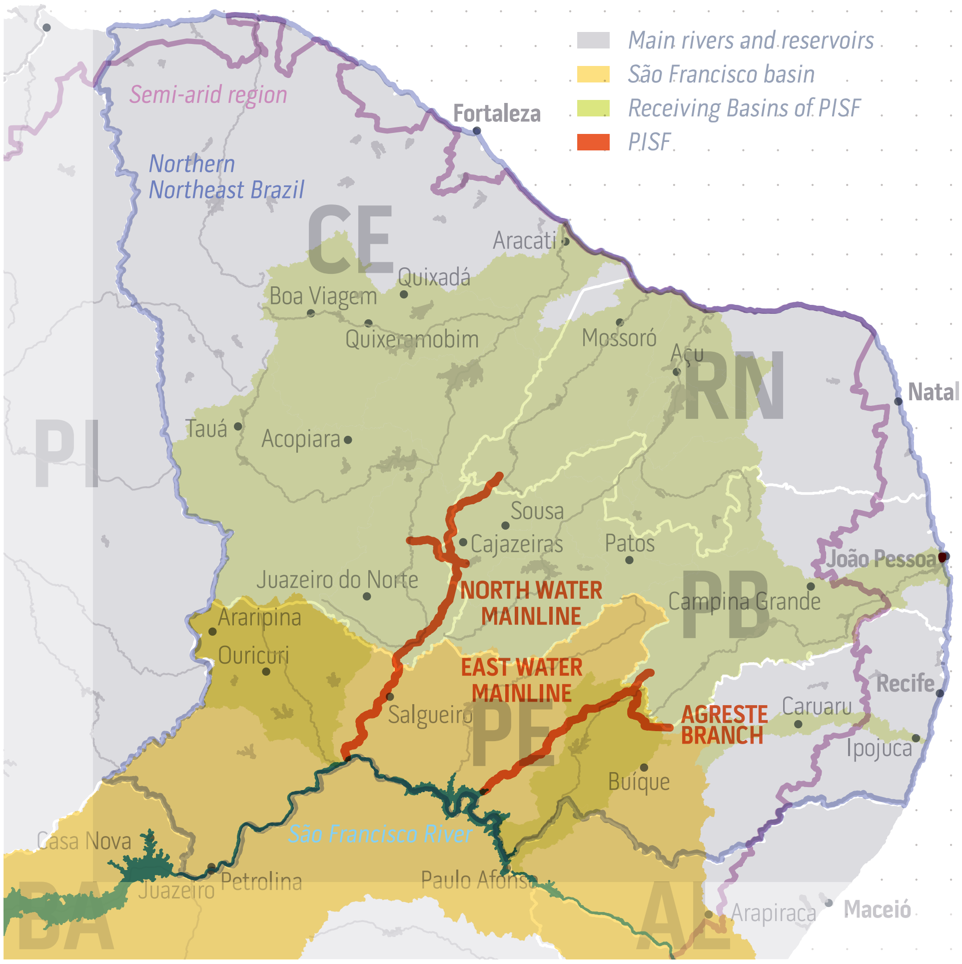
In order to eliminate constraints on water use in northern Northeast Brazil and endow water supplies with the necessary security for user sectors, the **São Francisco River Integration Project (PISF)** was launched, consisting of a set of infrastructure (civil construction) works such as canals, dams, pumping stations, aqueducts, tunnels, galleries and two uptake points along the São Francisco river, downstream from the Sobradinho reservoir.

In March 2017, water deliveries along the Eastern Water Mainline of this Integration Project at Monteiro in Paraíba State underpinned the possibility of once again irrigating subsistence crops (on no more than half a hectare). In August, as the water level rose in the Boqueirão reservoir, water rationing ended for the population of Campina Grande and its surrounding region, in place since December 2014. The start-up of commercial operations by the Eastern Water Mainline is scheduled for March 2018.

In 2016, ANA was engaged in the preparation of studies defining the calculation methodology for the water charges under this Integration Project, in addition to granting licenses for new enterprises, including 28 dams encompassed by the water system with the safety of their structures and their water uptake points under inspection.

Associated branches runoff from the main water conveyance structure of the PISF: the Salgado Branch (35 kms), the Apodi Branch (113 kms) and the Entremontes Branch (103 kms) on the Northern Water Mainline and the Agreste Branch (71 kms) on the Eastern Water Mainline.

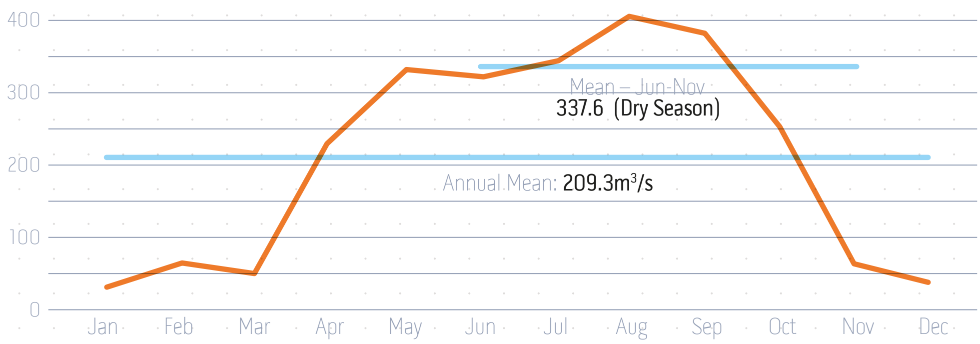
PISF WATER INFRASTRUCTURE



Vital for the volumes of water transported to the to the Semi-arid region, agriculture is a major economic activity throughout the **São Francisco river basin**, where irrigation demands intensify during the dry season, usually between April and October. The regularization of the flows of the São Francisco river through large reservoirs offers operational safety for water supplies in several areas.

In terms of storage capacity, the main reservoirs in this basin are: Três Marias, Sobradinho and Itaparica. Together, they form the equivalent reservoir of the basin, with an active storage volume of 47.5 million m³, of which 60% is stored in Sobradinho and 32% in Três Marias.

SEASONAL VARIATIONS IN WATER DEMANDS IN THE SÃO FRANCISCO BASIN

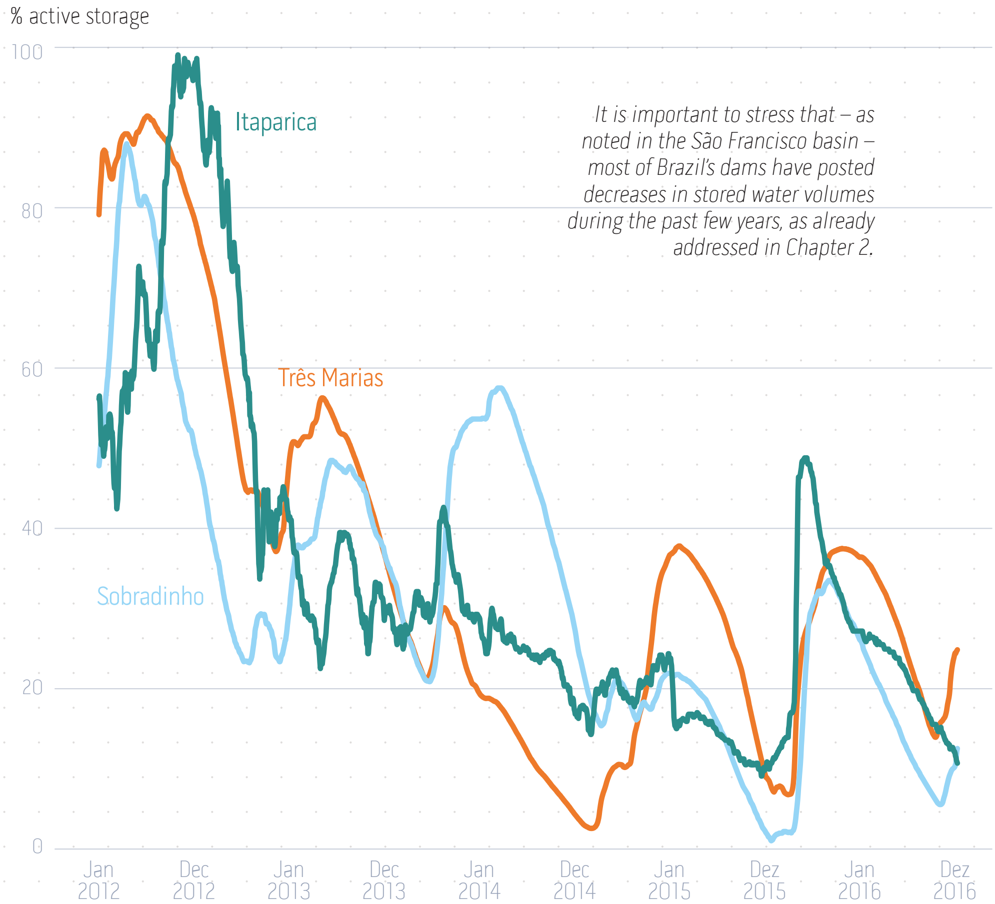


Since 2012, the São Francisco basin has been coping with adverse hydrological conditions, with streamflows and rainfall lower than average, adversely affecting storage levels in its reservoirs. Between 2014 and 2016, the lowest natural mean annual streamflows were recorded in the Sobradinho reservoir since 1931. In this situation, **reservoir operating rules** are defined through specific Resolutions that are intended to ensure water for a wide variety of uses **Between 2013 and 2016, ANA published 42 Resolutions reducing outflows from certain reservoirs in Brazil during specific periods.**

According to the natural monthly streamflows dataset that extends back to 1931, drawn up by Brazilian National Electrical System Operator (ONS), the natural annual mean streamflow at Sobradinho has been below its historical mean over the past few years.

Since 2012, weekly meetings have been held to monitor the operating conditions at reservoirs along the São Francisco river, attended by ANA, State water resource management entities, Basin Committees, the Ministry of Mines and Energy, the Ministry of Integration, the Ministry of Transport, the Public Prosecutor's Office, Brazil's Power Sector Regulator (ANEEL), Brazilian National Electrical System Operator (ONS), the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA) and the Brazilian Navy, as well as CEMIG, CHESF and CODEVASF in order to define operating rules during the crisis period.

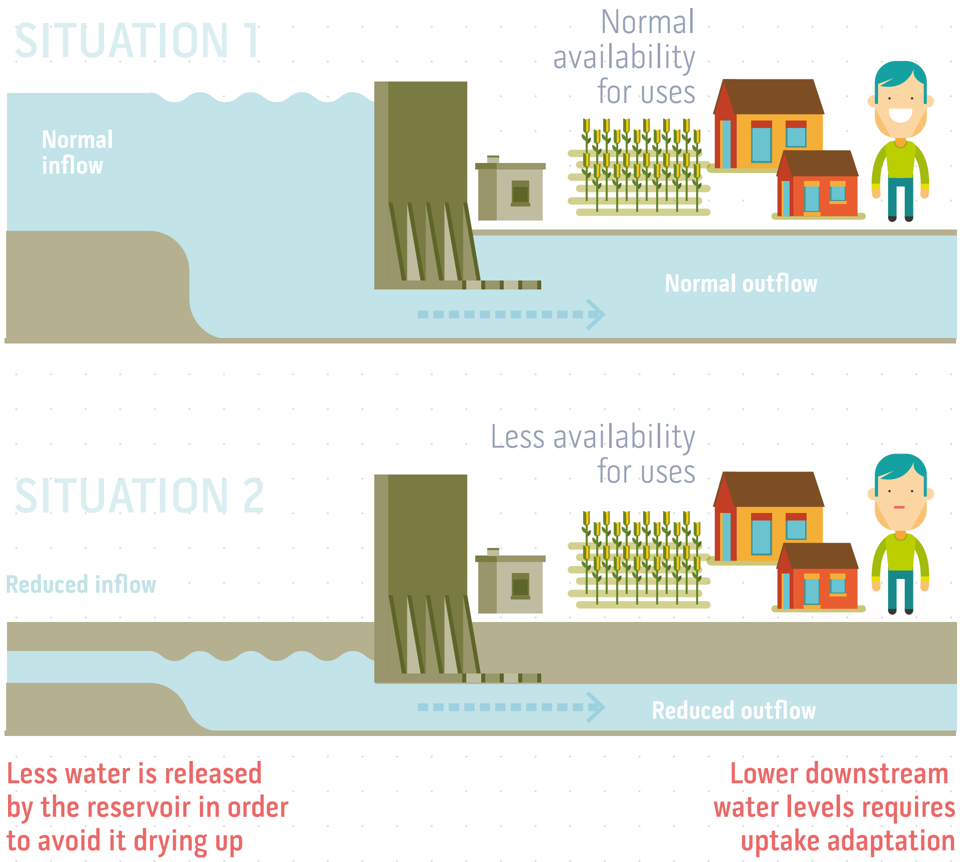
PROGRESS OF RESERVOIR VOLUMES IN THE SÃO FRANCISCO BASIN



The need to keep water stocks available in reservoirs in the São Francisco basin – in view of its importance for responding to a variety of uses, particularly supplies for several towns including the Aracaju Metropolitan Region – has prompted **reductions in flows released** from the Sobradinho and Xingó reservoirs, with the latter located along the lower reaches of the river, to less than 1,300 m³/s, as well as the Três Marias reservoir, although without adverse effects on uses along the reach running some 1,150 kms between this reservoir and Sobradinho.

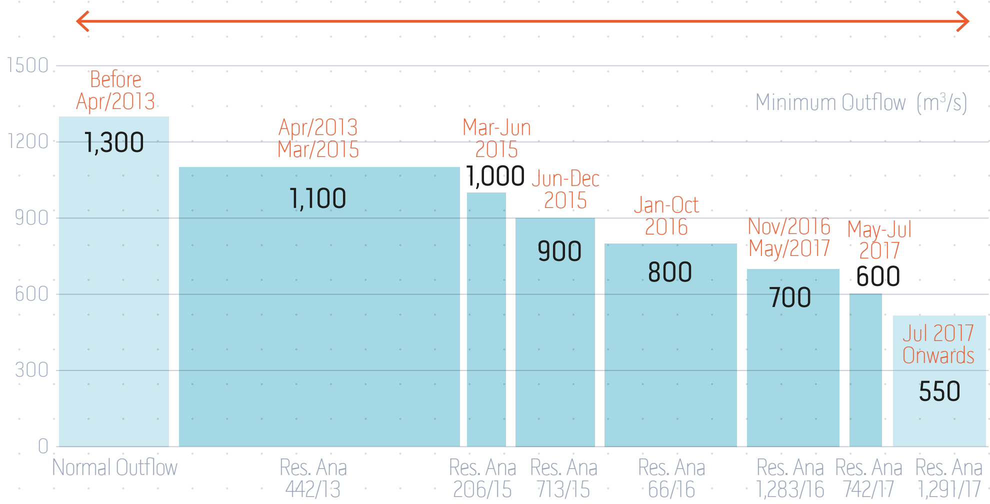
Reservoir outflow reductions are requested by the São Francisco Hydropower Company (CHESF) and authorized by ANA through specific Resolutions, after technical studies conducted jointly with the ONS and IBAMA, with special permission.

LOWER OUTFLOWS



If minimum flows had not been reduced, Sobradinho would have depleted its active storage volume by November 2014, which would have forced this reservoir to operate under severe water release constraints, adversely affecting.

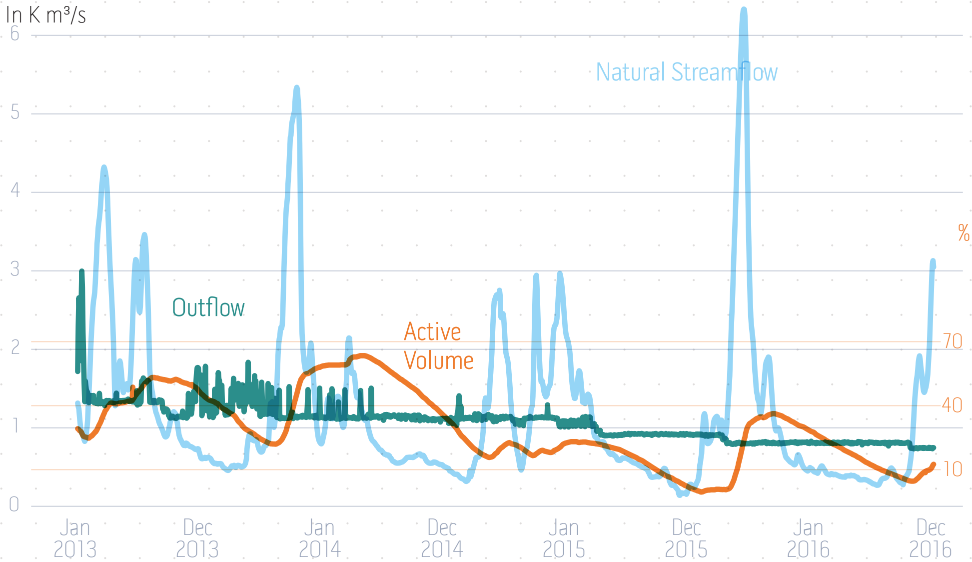
OUTFLOW REDUCTIONS AT THE SOBRADINHO AND XINGÓ HYDROPOWER PLANTS



Despite reduced outflows, by December 2015 the equivalent reservoir volume had dropped to under 4%, with Sobradinho down to around 1% of its active volume, the lowest storage volume ever recorded. In 2016, January rains and even lower released flows increased volumes, but natural flows dropped from March 2016 onwards, resulting in considerable decrease in outflows (at that time around 800 m³/s), while the active volume fell to just over 2%.

The natural streamflow is the flow along a reach of river that would occur if there were no upstream anthropic activities in its watershed, such as regularization through reservoirs, streamflow transfers and water uptakes for a wide variety of uses.

NATURAL STREAMFLOWS, OUTFLOWS AND ACTIVE VOLUMES AT SOBRADINHO



Streamflow reductions may heighten some impacts, such as intrusion of a saltwater wedge along the segment closest to the river mouth, with uptake difficulties caused by low water levels in public irrigation perimeters managed by the São Francisco and Parnaiba Valleys Development Company (CODEVASF) on the Northern Water Mainline of the PISF and pipelines, which may step up the number of communities serviced by tanker trucks. Uptake for the Eastern Water Mainlines of the PISF is drawn from the Itaparica reservoir and is not, in principle, affected by streamflow reductions along the river.

During several periods between 2013 and 2016, **natural streamflows** were well below the outflows. If not for regularization through the reservoirs, streamflows between Sobradinho and the mouth of the river would have been far lower than those actually measured, jeopardizing water uses even more. Although curtailed, released outflows been sufficient to respond to licensed flows along this river, reaching some 120 m³/s, including flows channeled to the São Francisco Integration Project (PISF).

However, steady reductions in streamflows caused **operating difficulties** related to uptake water levels, requiring **adaptations to water intake facilities** through engineering solutions, such as the implementation of floating uptake systems.

In June 2017, Wednesdays were established as River Days, when uptakes from Federal water-courses in this basin were suspended through to November 2017, except for priority uses. The estimated impact is a drop of 40 m³/s in demands, affecting 3,506 irrigation permits.

River Day was introduced by ANA in 2017 through Resolutions Nº 1,043 and 1,290, in close cooperation with the States and the River Basin Committees. It is intended to maintain strategic water volumes and reservoirs, underpinning the integrated operations during the dry season, with regular adjustments of outflows tailored to hydrometeorological and storage conditions, in order to avoid imposing even more restrictive rules or even permanent suspension of some water uses.

In December 2015, a Working Group was set up – consisting of ANA, State management entities and the Basin Committee – in order to draft an outline of the operating conditions for the main reservoirs in this basin. The final result is scheduled for December 2017, will be published in a Resolution issued by ANA that establishes reservoir operating ranges based on storage security curves, with the possibility of sporadic releases as required by environmental issues.

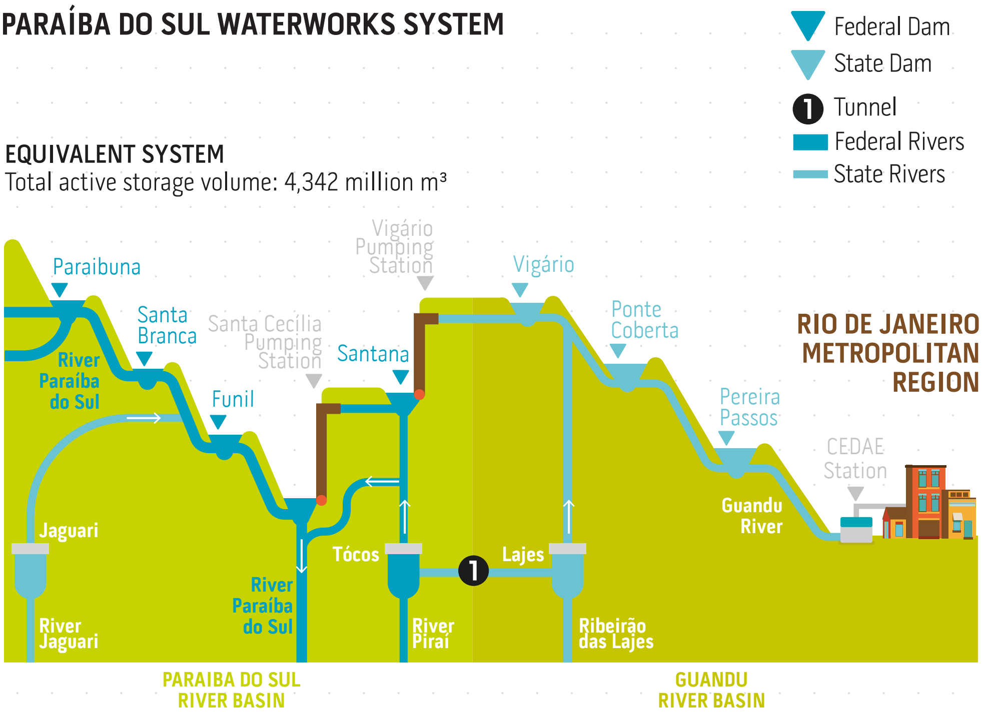
Uptake rates must be adapted to the possibility of operations at even lower flows, as the water crisis continues in this basin during the second half of 2017. It may be necessary to step up outflows from Três Marias in order to even out reservoir storage. In contrast to Sobradinho, Três Marias does not have a bottom outlet, meaning that it is not possible to use water volumes below its minimum operating level through gravity. **Joint reservoir operations** are vital for ensuring water security in this basin. Power dam operations also require special management in Southeast Brazil, which was assailed by a water crisis in 2014 and 2015.

The water crisis in Southeast Brazil adversely affected the water supply systems in more heavily populated regions with higher water demands in Brazil, such as the **Paraíba do Sul basin**, which naturally sees disputes among water users, being located between the largest industrial hubs and most densely populated urban areas in Brazil. Through a complex set of waterworks, up to 160 m³/s of water is transposed to the Guandu river basin, including a **mean streamflow of 43 m³/s to the Guandu Water Treatment Station** serving some nine million residents in the Rio de Janeiro Metropolitan Region.

Streamflows are transferred through the Santa Cecilia Pumping Station at Barra do Piraí in up state Rio de Janeiro. Due to operating constraints and water quality problems, the inflow reaching the Guandu Water Treatment Station must be than the amounts effectively used.

The main reservoirs in this basin are Paraibuna, Santa Branca, Jaguari and Funil, with a total storage capacity (equivalent reservoir) of 7,295 million m³, with a total active storage volume of 4,342 million m³.

PARAÍBA DO SUL WATERWORKS SYSTEM



From 2014 to 2015, rainfall and streamflows recorded were far lower than average, significantly decreasing water stocks in reservoirs. By February 2015, the equivalent reservoir reached an all-time low active storage volume of 0.33%. The Paraibuna and Santa Branca reservoirs were even functioning below their minimum operating levels, using **dead storage volumes**.

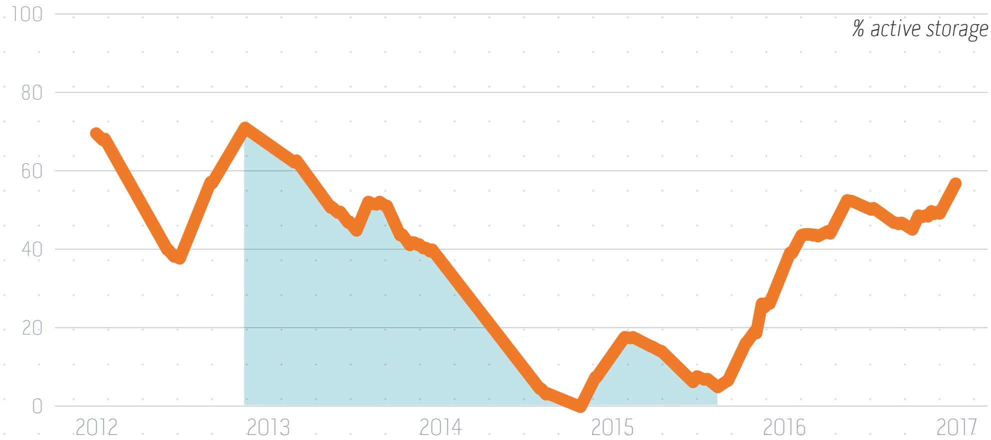
Dead storage or technical reserve consists of the amount of water stored below the floodgates of a reservoir that must be pumped for use. In critical situations when storage levels are low, this may serve as a water reserve for emergency uses.

In order to preserve water stocks and ensure supplies for a variety of uses, gradual reductions of **minimum streamflows** into the Santa Cecilia dam were authorized, overseen by regular assessments of impacts on downstream uses and pumping into the Guandu river.

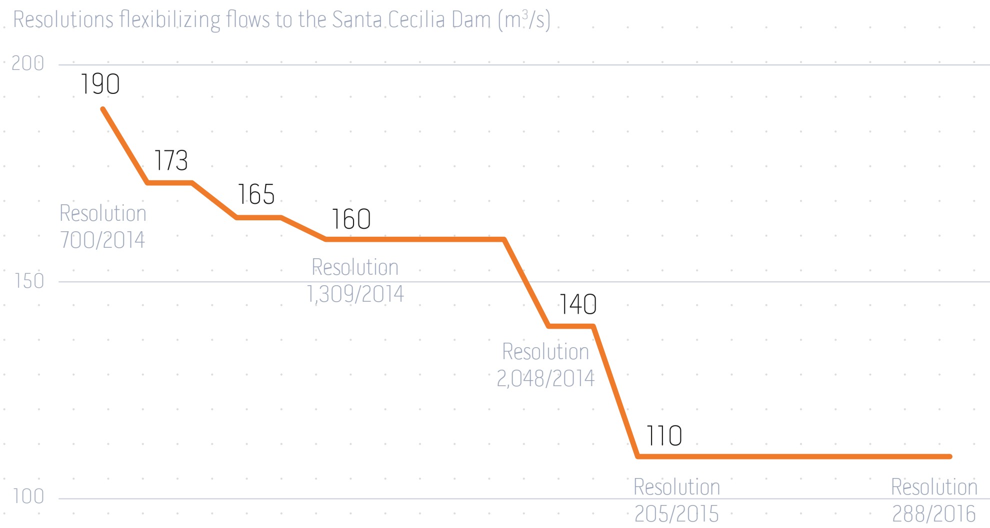
Resolutions were drawn up on the basis of recommendations submitted by the Permanent Working Group Overseeing Aterworks Operations in the Guandu River Basin (GTAOH).

In 2016, rising inflows and dropping outflows underpinned the recovery of active volumes stored, rising from 18.2% in December 2015 to 49.4% in December 2016.

PROGRESS OF THE PARAÍBA DO SUL EQUIVALENT RESERVOIR



INFLOW REDUCTION TO THE SANTA CECILIA PUMPING STATION



In São Paulo, the **Cantareira System** also adversely affected by the 2014 and 2015 water crisis. A series of internal disputes occurred at the State level, involving water supplies to the São Paulo Metropolitan Region (SPMR) in the Upper Tietê basin and the Campinas Metropolitan Region in the Piracicaba, Capivari and Jundiaí (PCJ) basin. In 2010, a **study conducted by ANA** that was aligned with projects for the Water Resources Usage Master Plan for the São Paulo Macro Metropolitan Region indicated that São Paulo had poor water guarantees through to the 2015 horizon, already identifying the need for investments and other source sin order to lessen the risk of shortages.

The Brazil Atlas – Urban Water Supplies (Atlas Brasil – Abastecimento Urbano de Água) analyzed water supplies in all Brazilian towns and cities. Study is a planning tool designed to provide input for the structuring actions needed to ensure water supplies to urban areas in Brazil. It is available ***goo.gl/Pkfbnb***

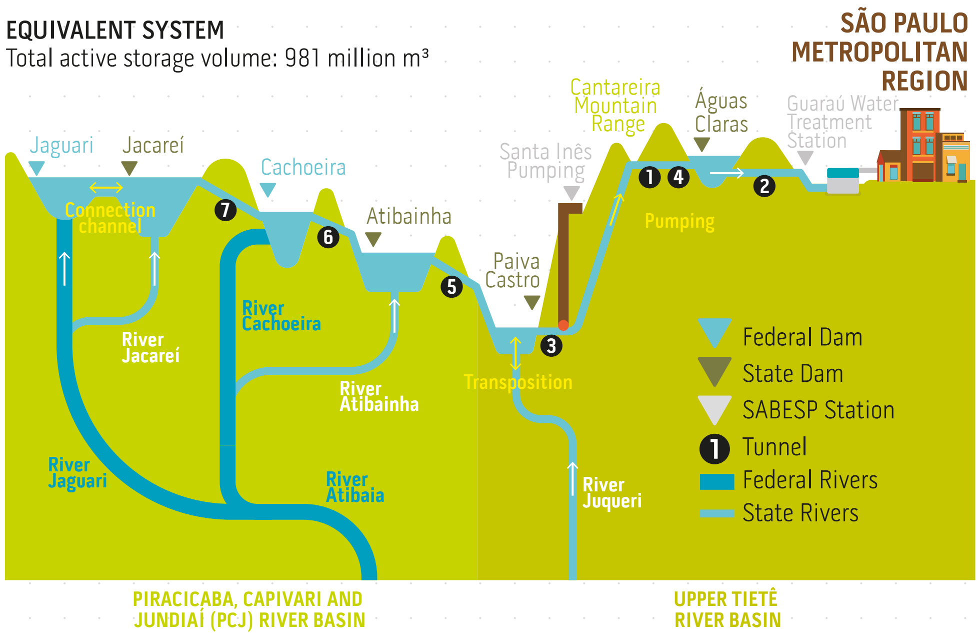
Through the **Cantareira System** that traps and keeps water within Federal and State domains, transfers of 31 m³/s are conveyed from the Piracicaba basin to the Upper Tietê, influencing sources stream flows. Most of the source shave problems with water quality, particularly during the dry season, requiring massive investments in sewage collection and treatment.

The Cantareira System is the largest of the eight water production systems that constitute the integrated supply system for the São Paulo Metropolitan Region, and is one of the world's largest production systems. Under normal conditions, it is sure water supplies for some 9 million people – half the SPMR are population – in addition to releasing significant amounts of water into the Piracicaba basin.

During the rainy months in this region (October to February) water builds up in the reservoirs, ensuring sufficient volumes for use during the subsequent dry season. However, between October 2013 and November 2015, there was a significant decreasein rainfall volumes, reducing reservoirs inflows.

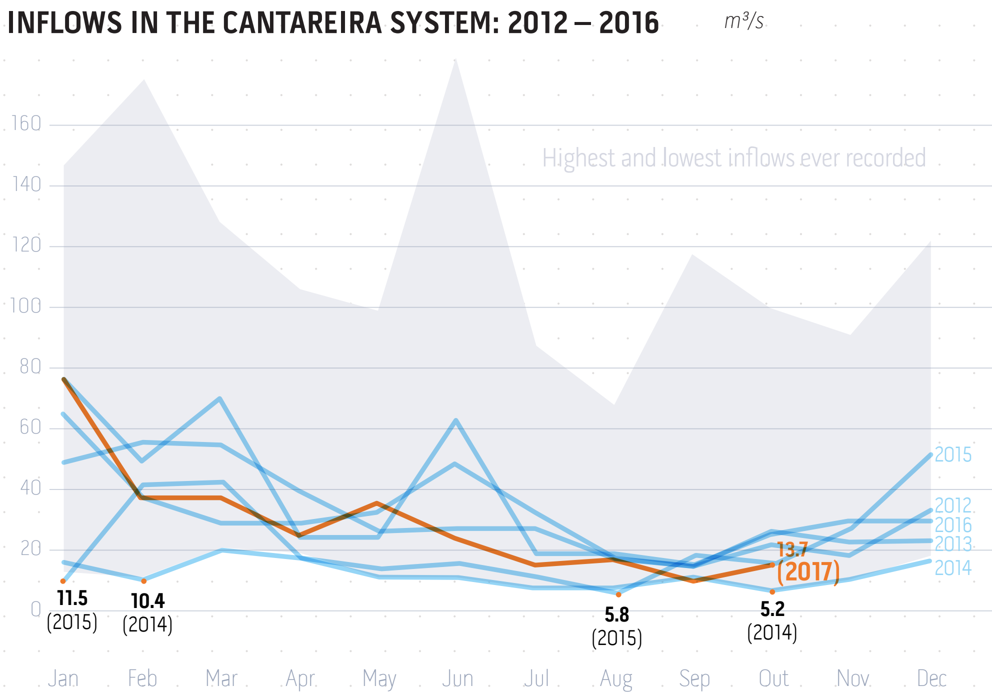
Between 2013 and 2015, mean monthly inflows were below the average for the Cantareira System. The mean inflow in 2014 was 8.7 m³/s, the lowest flow recorded since 1930, equivalent to 22% of the historic mean and 40% of the 1953 mean, which was the lowest ever recorded until then. In 2015, the mean inflow which 19.67 m³/s, which was the second-lowest ever recorded.

RESERVOIRS IN THECANTAREIRA SYSTEM AND CONNECTION STRUCTURES



The Cantareira System consists of the Jaguari-Jacarei, Cachoeira and Atibainha reservoirs, interconnected by tunnels and canals that function together as an equivalent reservoir with a capacity of 1.5 billion m³, of which 981 million m³ are within the normal operating range (total active storage volume) and maybe was drawn by gravity.

INFLOWS IN THE CANTAREIRA SYSTEM: 2012 – 2016

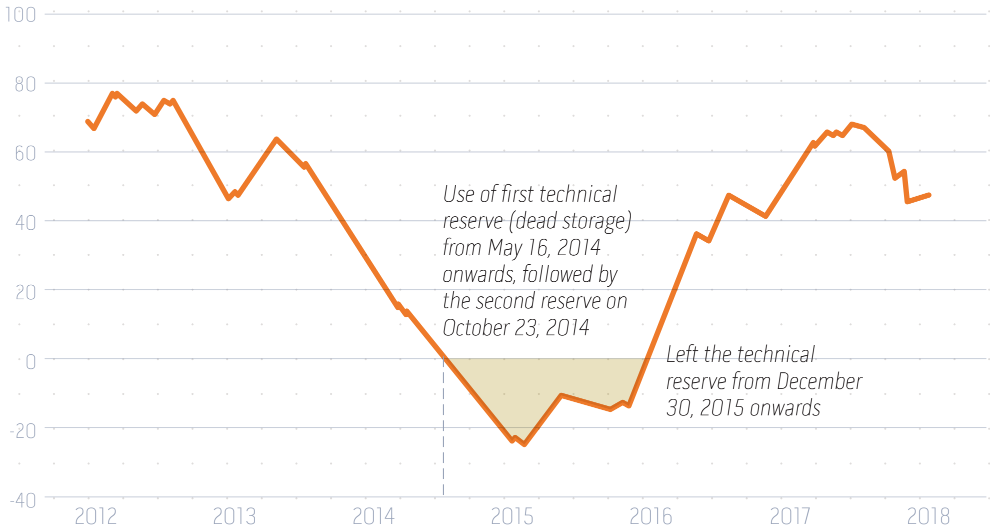


Lower rainfall volumes and streamflows affected water volume stored in reservoirs. From May 2014 onwards, it was necessary to use the dead storage in this System, which accounts for around 33% of its storage capacity, at two different stages, in order to maintain water supplies during the most critical dry season of the year.

In 2016, inflows were higher and, in parallel to lower withdrawals, underpinned a significant recovery in the active volume of the System, up from 485 million m³ (0.01%) in December 2015 to 935 million m³ (46.1%) in December 2016. By June 2017, the System had reached 68% of its active storage volume.

The original water usage permit for the Cantareira System was granted to the São Paulo State Basic Sanitation Company (SABESP) in 1974, for a 30-year term, with authorization to withdraw up to 33 m³/s. In 2004, ANA delegated licensing powers to the Power and Water Department (DNAEE), which then granted SABESP a water usage permit valid through to August 2014.

PROGRESS OF ACCUMULATED VOLUME IN THE CANTAREIRA SYSTEM



Between February and June 2014,GTAG prepared reports assessing reservoir status and recommending flows for release to the SPMR and the PCJ basins, in addition to suggesting regulatory actions for the management entities. Since February 2014, ANA and the DAEE have been publishing joint System Monitoring Bulletins every day.

Due to the water crisis, the **renewal of the System water use permit** planned for August 2013 was suspended, and the permit was extended twice, to October 2015 and then to make 2017. These extensions did not hamper the operations, as the **Cantareira System Management Advisory Technical Group (GTAG)** was set up in February 2014.

In parallel to curtailing flows released for public supplies, rules imposing constraints on other uses and suspending the issue of permits were introduced by ANA, together with the São Paulo and Minas Gerais State management entities. Oversight activities were stepped up around reservoirs and other sourcesin the PCJ basins,including overflights and the identification of irregular uses and damning through satellite imaging, with field inspections of water levels and flows of monitoring points.

The process of **renewing the permit and defining the operating conditions of the Cantareira System** involved a complex and unparalleled process of discussion among theentities involved and civil society in the affected basins, ensuring transparency and the engagement of a broad range of sectors. The **system operating ranges** were defined, together with the maximum flows withdrawnby SABESP and those released to the PCJ basins, with seasonal variations permitted, and **tighter constraints on lower volumes**, gradually indicating that the situation is worsening and suggesting additional demand management steps.

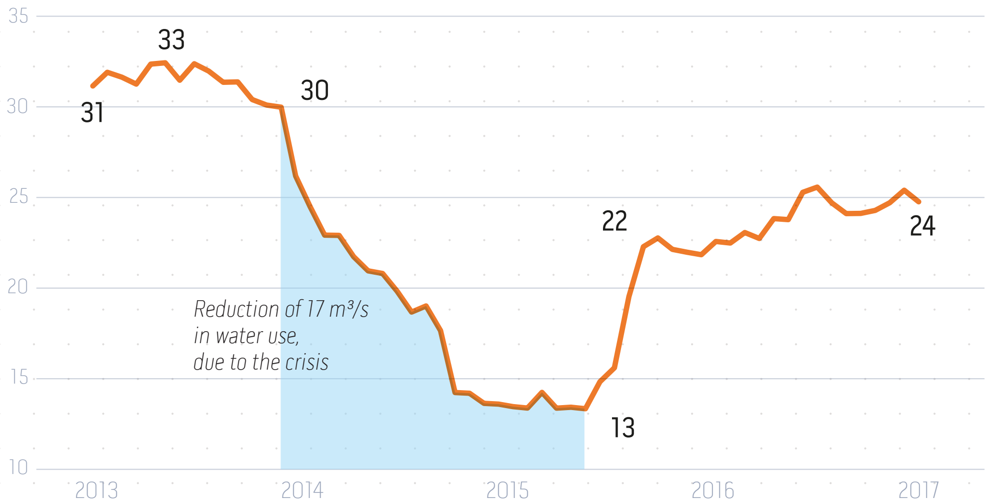
On May 29, 2017, Joint Resolution Nº 926 was issued by ANA and the DAEE, ruling on the operating conditions for the Cantareira System and issuing a water use permit to SABESP covering public supplies. Additional information is available at: ***goo.gl/h9aChZ.***

Defining the maximum monthly mean flows for each range ensures that demands will be met, even under the worst-case scenario of the lowest inflows ever recorded. Specific withdrawals are allowed, depending on the hydrological period, whether wet or dry, associating the natural streamflow status with expected use in the basin.

Crisis management implies adopting emergency measures such as purchasing and installing pumps to draw water from the storage areas, easing pressures on the network and reducing distribution losses, with great bonuses for lower consumption, halting water supplies from SABESP and other permit-holders; and switching some the population serviced by the Cantareira system to other production options through integration projects with the distribution areas of other systems.

WATER USE IN THE CANTAREIRA SYSTEM

Flow pumped by the Santa Inês Pumping System (m³/s)



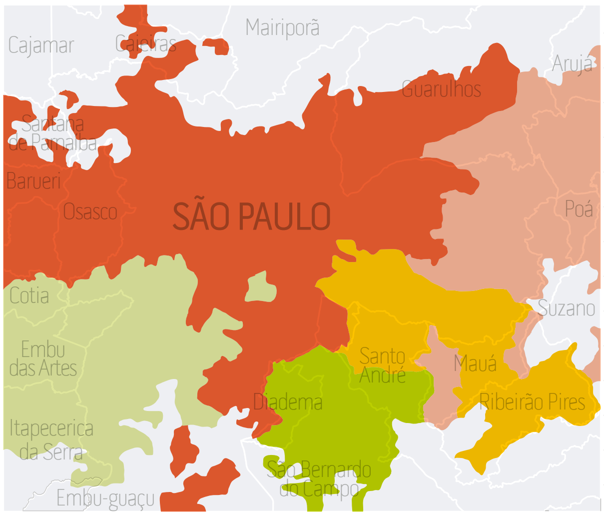
The water crisis in the **Cantareira System** prompted some São Paulo State to transfer water from the Jaguari reservoir in the Paraiba do Sul basin to the Atibainha reservoir in the PCJ basins. This proposal prompted an interstate battle with Rio de Janeiro and Minas Gerais that was mediated by the Brazilian Federal Supreme Court. After a hydrological feasibility technical study, it was **settled** in December 2015. These two reservoirs are being connected through a tunnel bored by SABESP, with 80% of the work completed in July 2017.

Issued in 2015 by ANA/DAEE/IGAM, Joint Resolution Nº 1,382 establishes the operating conditions for reservoirs in the Paraiba do Sul Basin and structures for transferring water to the Guandu basin.

EXPANSION OF WATER SUPPLY SYSTEMS IN THE REGION SERVED BY THE CANTAREIRA SYSTEM

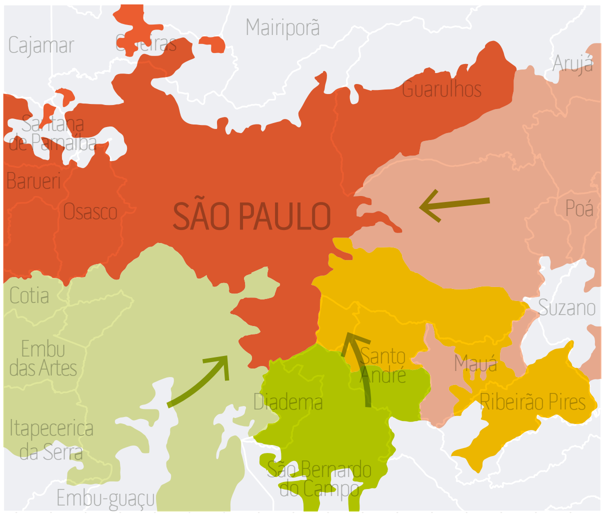
SYSTEMS

- *Upper Tietê River*
- *Cantareira*
- *Claro River*
- *Grande River*
- *Guarapiranga*



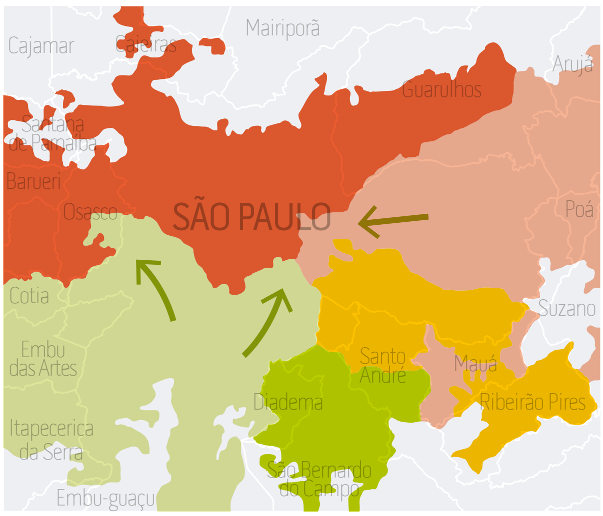
DECEMBER 2013

Area covered by each system



SEPTEMBER 2014

Expansion of Guarapiranga, Upper Tietê River and Grande/Claro River systems



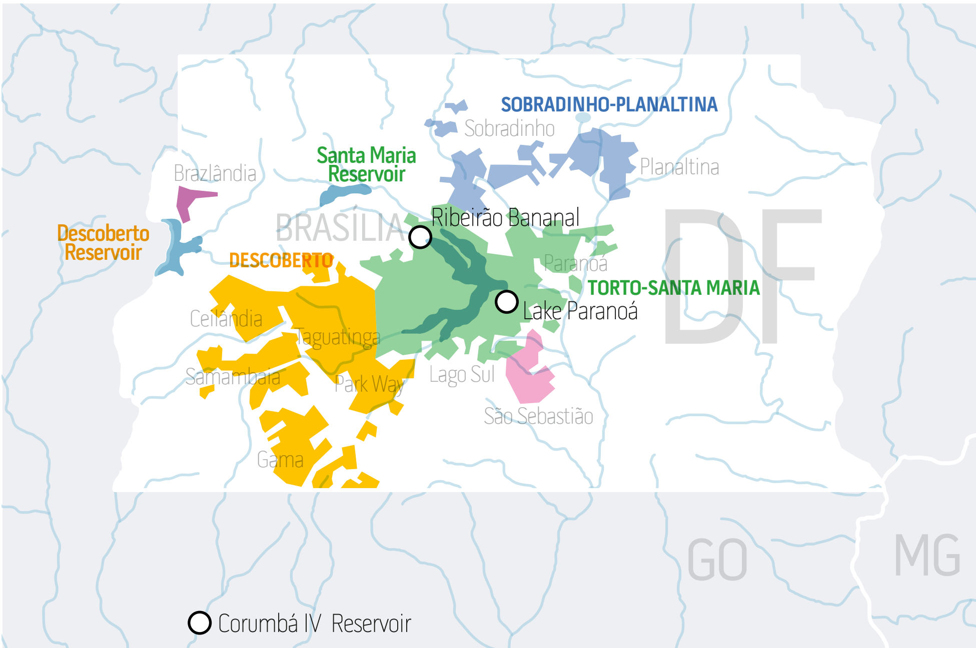
MARCH 2015

Expansion of Guarapiranga, Upper Tietê River systems

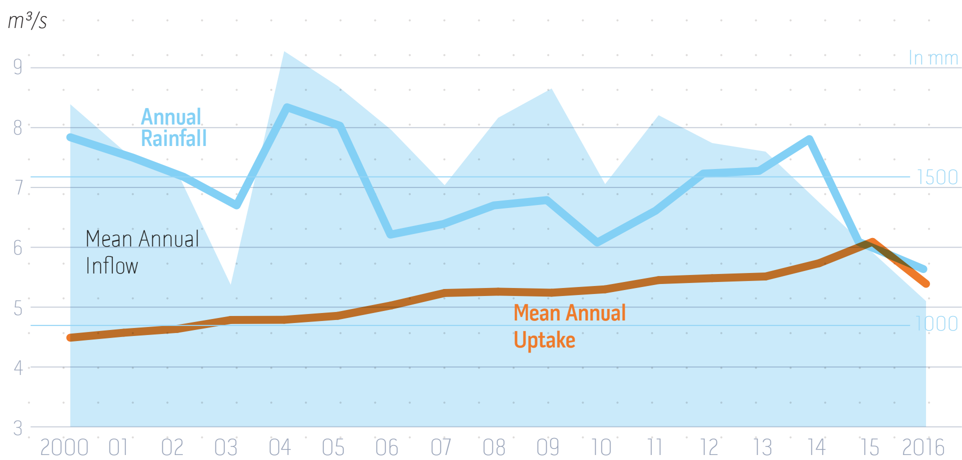
In the **Distrito Federal**, the combination of lower than average rainfall, high temperatures, clandestine uptake, and control settlement and a population expanding at around 60,000 people a year on average, according to the IBGE, together with the absence of structuring construction works for over sixteen years directly impacted water supplies in Brasilia during 2017, mainly for the population supplied by the **Descoberto and Santa Maria** reservoirs.

These two reservoirs provide 89.3% of treated water in the Distrito Federal, supplying 81.7% of the population serviced by the Distrito Federal Environmental Sanitation Company (CAESB).

WATER SUPPLY SYSTEM COVERAGE IN THE DISTRITO FEDERAL



RAINFALL, INFLOWS AND WATER UPTAKE IN THE DESCOBERTO RESERVOIR



Similar to São Paulo, in 2010 the Brazil Atlas noted that there were poor water guarantees in Brasilia for 2015, with investments required in **new and existing sources**, in order to lessen the risk of water shortages.

Along these lines, two major enterprises were proposed: the Corumbá IV and Paranoá Lake production systems, in addition to providing structuring support for the Santa Maria-Torto system that includes the Bananal subsystem.

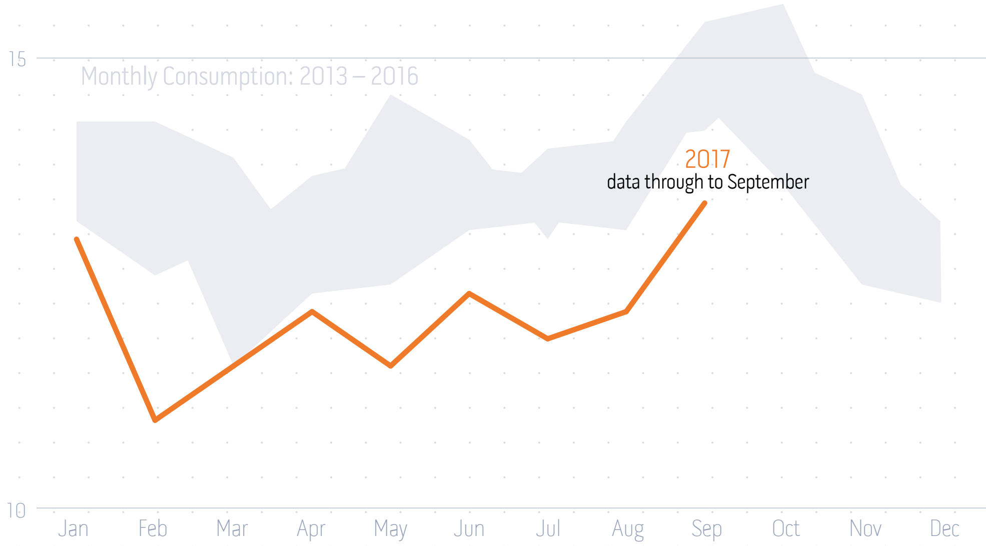
Initially imposed in the area serviced by the Descoberto System in January 2017, rationing was extended to the area serviced by the Santa Maria System in March 2017, and then to areas serviced by other systems in the Distrito Federal in August 2017.

The emergency actions implemented by the Distrito Federal Government through the Distrito Federal Water, Energy and Basic Sanitation Regulator (ADASA) to deal with the crisis included suspending licenses to bore artesian wells and build cisterns and water withdrawals by tanker trucks. After pressure decreased in the distribution network, **water rationing** was implemented on a rotation system, in order to lessen consumption.

A contingency rate was also introduced, and an emergency uptake plan was prepared for drawing water from Lake Paranoá, including the construction of a provisional water treatment station and connecting up the Santa Maria-Torto and Descoberto Systems, in order to buttress supplies in areas serviced by the latter. Operations started up at the water treatment station in October 2017.

Data released by CAESB through the Distrito Federal Water Resources Information System is available at: ***goo.gl/uaAFJU***

TREATED WATER CONSUMPTION IN THE DISTRITO FEDERAL *million m³*



In 2016, other river basins in Southeast Brazil were assailed by water crises, including the **São Mateus (Minas Gerais and Espírito Santo States) and Pardo and Mucuri (Minas Gerais and Bahia States) basins.** In these basins, there were restrictions of use and intensification of the inspection. Due to the dropping streamflow of the Pardo river, 41 water users were registered, located upstream from the intake point that supplies Taiobeiras in Minas Gerais State, for regularization purposes. The total irrigated area covers 68.3 hectares, and is less than one hectare on most of these properties. The water crisis in this region has caused problems for water users, including supplies to towns in northeast Minas Gerais State, North Espírito Santo State and even southernmost Bahia State.

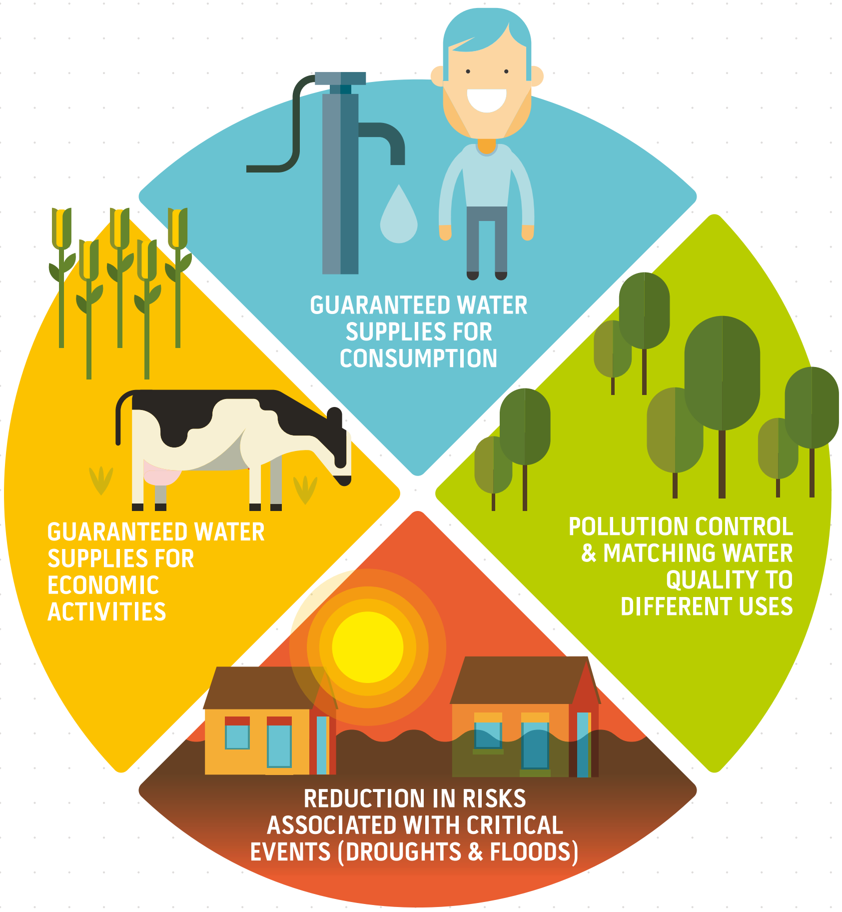
In the Center-West and North Regions, great river basins such as the **Tocantins and Araguaia** have been coping with by significant reductions in streamflows and volumes stored in reservoirs is 2016. As a result, a basin oversight group was set up in August 2017, similar to that monitoring the São Francisco, with water intake facilities regularized and upgraded, including those supplying the town of Imperatriz in Maranhão State, among other actions.

The water crisis ushers in a critical view of the ability to foresee conditions that must be dealt with by engineering systems, striving to find an even balance between guaranteeing water supplies and minimizing social or environmental costs. This overview shows that several parts of Brazil require infrastructure for boosting **water security**, knowing that climate change is paving the way for an uptrend in droughts in these regions.

Water security is defined as adequate availability of water in adequate quantities and qualities as required for health, means of life, ecosystems and production activities, associated with an acceptable level of risks related to water in terms of people, the economy and the environment.
goo.gl/FdoJii

Several lines of action underpin the application of the water security concept, such as guaranteed supplies of good quality water in adequate quantities for human supplies and production activities, while complying with the boundaries imposed by environmental conservation and reducing vulnerability to extreme events in river basins. Normally, for a region to maintain or restore its water security level in terms of demands, structuring actions are required, together with institutional mechanisms.

MAIN WATER SECURITY COMPONENTS



The challenge of water security varies by regional characteristics: physical, environmental, social and cultural, or political and institutional. It is important to analyze water suppliers at the strategic level, as well as locally. In many metropolitan regions throughout Brazil, the current sources are unable to respond to future demands, with structural adaptations and operating capacity upgrades required for supply systems. In some cases, local water availability must be stepped up by transposing streamflows from neighboring river basins, requiring well-coordinated approaches at the sectoral level, in parallel to the operations of a complex infrastructure needed to ensure water supplies.

Among the interventions planned there are dams, adductor systems, channels and integration branches. One of the directives of the Plan is that interventions have structuring nature and comprehensiveness interstate or regional relevance, besides ensuring long-lasting results in terms of water security.

Investments in infrastructure focused on water security must be starred as top priority, in order to ensure greater storage capacity and better access to water. Rising pressures on sources, constraints on availability and groundwater management difficulties are the main factors driving the quest for new sources, necessarily seeking out sources that are steadily further away, requiring waterworks infrastructure whose complexity is constantly increasing, in order to respond to demands.

Faced by this situation, ANA is drawing up Brazil's **National Water Security Plan (PNSH)** jointly with the Ministry for National Integration (MI), intending to define major structuring interventions in strategic water resources in order to ensure water security nationwide, while lowering the risks associated with critical events such as droughts and floods.

In partnership with ANA and cooperating with the Ministry of Integration and the Ministry of the Environment, the Ministry of Cities has been conducting a specific project for introducing a Treated Sewage Reuse Policy in Brazil. This project is designed to pinpoint hurdles and explore the potential benefits of its implementation, defining quality standards for repurposed water, assessing the available technologies, discussing institutional aspects and proposing financial models and/or subsidized rates. The recycling water capacity installed in Brazil was estimated at around 2 m³/s 2017, of which only 1.6 m³/s would reused in fact.

In this context, it is vital to draw up contingency plans for dry seasons and droughts, particularly for areas that are heavily dependent on a single source, with water production systems that could have serious impacts on water supplies, if halted, as occurs in large towns and metropolitan regions. Furthermore, the integration of water production systems in order to supply major urban hubs is strategic, lessening dependence on single sources while offering greater operational flexibility and reliability for responding to demands. **Seawater desalinization** and **reuse** are other options for dealing with the crisis that will certainly be more widely used in the future in Brazil.

Seawater desalinization studies are being commissioned by Ceará State, in order to supply the Fortaleza Metropolitan Region. With a planned capacity of around 1 m³/s (some 12% to 15% of consumption in Fortaleza), the first unit in this system is scheduled to start up operations in 2020. This step is part of the State strategy of diversifying its water matrix in order to cope more effectively with drought.

Discussions are also continuing under the aegis of Brazil's National Water Resources Council, listing water use priorities in river basins and involving areas with usage constraints, as a tool for territorial planning and, in addition to licensing guidelines.

Understanding the water crisis that has assailed Brazil during the past few years, boosting the value of water as a finite public asset and heightening awareness of the need for more sustainable use, are essential steps for firming up broader guarantees of water supplies for different uses. In addition to institutional actions, a set of steps must be taken by individuals in order to rationalize water use, thus avoiding the effects of shortages.

Brazilian Water Resources Report 2017

Chapter 6

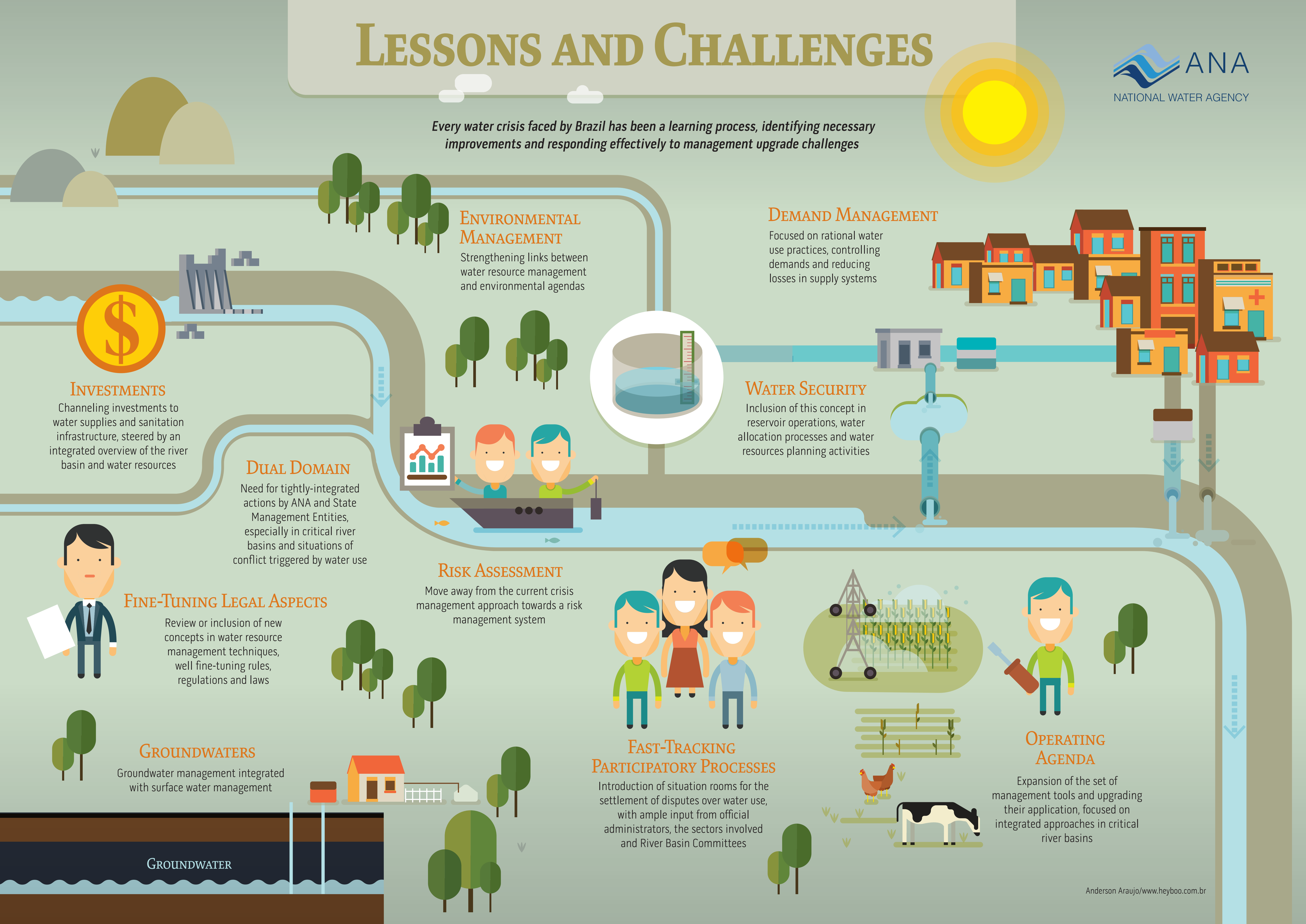
Lessons & Challenges

After coping with crises and other emergency situations, water resources management in Brazil is now endowed with in-depth knowledge, seizing opportunities to redesign elements and this is being better prepared for future events.

Lessons learned are incorporated. **How?**

Click on this tab to see the infographic we have prepared for you to understand this, quite simply!

Open here


LESSONS AND CHALLENGES
ANA
NATIONAL WATER AGENCY
Every water crisis faced by Brazil has been a learning process, identifying necessary improvements and responding effectively to management upgrade challenges
ENVIRONMENTAL MANAGEMENT
Strengthening links between water resource management and environmental agendas
DEMAND MANAGEMENT
Focused on rational water use practices, controlling demands and reducing losses in supply systems
INVESTMENTS
Channeling investments to water supplies and sanitation infrastructure, steered by an integrated overview of the river basin and water resources
WATER SECURITY
Inclusion of this concept in reservoir operations, water allocation processes and water resources planning activities
DUAL DOMAIN
Need for tightly-integrated actions by ANA and State Management Entities, especially in critical river basins and situations of conflict triggered by water use
RISK ASSESSMENT
Move away from the current crisis management approach towards a risk management system
FINE-TUNING LEGAL ASPECTS
Review or inclusion of new concepts in water resource management techniques, well fine-tuning rules, regulations and laws
GROUNDWATERS
Groundwater management integrated with surface water management
FAST-TRACKING PARTICIPATORY PROCESSES
Introduction of situation rooms for the settlement of disputes over water use, with ample input from official administrators, the sectors involved and River Basin Committees
OPERATING AGENDA
Expansion of the set of management tools and upgrading their application, focused on integrated approaches in critical river basins
GROUNDWATER
Anderson Araujo/www.heyboo.com.br

Lessons and Challenges

Brazil's National Water Resources Policy (PNRH), which was promulgated through Law Nº 9,433 in 1997, has celebrated its twentieth anniversary of enforcement – a land mark of the efforts undertaken by all members of the National Water Resources Management System (SINGREH), striving to ensure the full implementation of the Water Act in Brazil. This public policy must be appreciated for its social, environmental and economic dimensions, focused on managing water resources in a fair, decentralized and participatory way to guarantee this special natural resource for current and future generations. Much progress has been made, but now is a timely moment for reflections and analyses of the **necessary improvements and challenges to be surmounted**, reflected in many different situations over these years, especially those related to the water crisis.

Hosted by Brasilia in 2018, the **VIII World Water Forum** is a major milestone in this reflection moment, placing water and water security at the heart of technical and political discussions engaging Brazilian society. The observed climate variability over the past five years has reached extremes at some locations, particularly in terms of rain fall decrease and high temperatures, causing longer and more severe droughts with direct effects on water availability, affecting the water security of many water user sectors. These events which occurred, successively, in the Northeast, then in the Southeast and, lastly, in the Center-West of Brazil have consolidated the concept of "water crises".

The World Water Forum is the largest global event on the topic of water, organized by the World Water Council, which is an international multi-stakeholder platform clustering together people and entities interested in this issue. Its Mission is To promote awareness, build political commitment and trigger action on critical water issues at all levels, including the highest decision-making level, to facilitate the efficient conservation, protection, development, planning, management and use of water in all its dimensions on an environmentally sustainable basis for the benefit of all life on earth." Further information on the VIII World Water Forum is available at: ***goo.gl/FjZwHc***

Decreasing river levels, reduction of water stored in reservoirs and sources, and more severe pollution impacts are just a few problems generated by the variations in water availability. Some river basins, already vulnerable due to the stress caused by high demands and the disposal of massive pollutant loads, have been more severely undermined by the water crisis. The series of water crisis events, from 2012 onwards, drew attention to these vulnerabilities which have been, since then, triggering intensifying disputes over water uses. The whole water framework down grades the quality of life in local communities, and may have adverse effects on public health. From a long-term standpoint, their ripple effects may curb Brazil's social and economic development.

The Legacy Project is an institutional drive to consolidate proposals for upgrading Brazil's National Water Resources Policy and the constitutional, legal and info-legal frameworks underpinning water management in Brazil. Drawn up during 2017 and based on the systematization ofearlier studies and diagnoses, together with reflections produced by ANA and consultations forwarded to SINGREH and other players, it will be discussed during the VIII World Water Forum. Versions of this document may be accessed at: ***goo.gl/jhYUbe***

Since 2013, ANA has maintained a partnership with the OECD to develop analysis about the water resources management in Brazil. The first publication called "Water Resources Governance in Brazil" addresses improvements to governance and allocation of water in Brazil. The second publication called "Water Charges in Brazil: the Ways Forward" deal with constraints still existing in this management tool and lists proposals for improvement.

Studied and described for more than a decade by regions and sectors, the impacts on global climate change cannot be ignored. Despite uncertainties over climate trends predicted by different models, these scenarios generally outline critical situations involving water shortages and more severe events related to droughts and floods. Losses resulting from these events may account for environmental damages, harm to human beings and to society and economy may lead to water conflicts. This would be enough to enact preventive and adaptive steps. It is vital for water resource management to pay closer and more constant attention to risks associated with climate change. To do so, focusing on planned actions and their implementation must be the rule for anticipating adverse events and their impacts, thus ensuring that crisis responses are steered by meticulous planning, identifying even contingency situations, all with properly dimensioned responses.

Ensuring water supplies for human consumption and productive activities, while reducing risks associated with critical events (droughts and floods) are goals pursued through approaches steered by the current **water security concept**. Planning and implementing adequate waterworks infrastructures that are connected to systems operated through integrated risk management, focused on optimising water use and storage options, are necessary steps that must be taken by the water resources sector.

Several proposals on improving water law and regulation have been discussed under the aegis of SINGREH, attempting to upgrade governance and integrated water resource management. The **Legacy Project** is one of these initiatives, intended to underpin necessary improvements to the system. A debate on whether the basic water resource management unit should be only the river basin, as established by the PNRH, is an instance of a theme to be discussed. Alternative spatial configurations, which increase effectiveness to face problems, may be more beneficial, such as joint management of reservoirs in different basins or the need for management encompassing extended basins where water is transferred between donor and recipient basins.

The employment of management tools, the actions undertaken by management entities, the boards and councils encompassed by SINGREH and definitions of legal jurisdictions steered by water domains in Brazil are all matters to be debated and analyzed, examining the strong and weak points of the current status quo, which had been assessed by ANA and its partner institutions, among others the **Organization for Economic Cooperation and Development (OECD)**.

Lessons learned during this recent period of water crisis are opening up opportunities for change. Improvements must be sought through greater awareness of which mechanisms have worked (or failed) when responding to these challenges. From these conclusions, greater flexibility and innovation is possible.

Well-known characteristics of water availability and abundant rain in the Amazon Region, clearly-defined seasons in the Center-West, low availability and water shortages in the Semi-arid region and well-distributed rainfall in the South and Southeast Regions are factors justifying consideration of specific water resource management approaches for each of these regions, underpinning discussions of the need for innovations and adaptations of water resource management tools. Some of these debates took place under the aegis of the **Dialogs for Upgrading Water Resource Systems and Policy in Brazil**.

Conducted by ANA in partnership with the World Bank, the Institute for Applied Economic Research (IPEA) and the Water Resources and Environmental Quality Bureau under the Ministry of the Environment (SRHQ/MMA), the general purpose of this study is to provide input strengthening the PNRH and SINGREH, on the following topics: 1) management model tailored to hydrological and climate realities; 2) financial sustainability; 3) management entities at the Federal and State levels; 4) water resource plans; and 5) legal and institutional frameworks.

From the standpoint of institutional arrangements handling water resource management in Brazil, an interesting proposal seeks to set up an Interministerial Committee on Water Security and Infrastructure. This would encourage, regulate and buttress the feasibility of steps fostering Integrated Water Resource Management through fine-tuning reservoir operating rules and integrating sector planning activities, for example, thus fostering integrated and systemic approaches.

Joint actions undertaken by SINGREH members have encountered hurdles when dealing with these situations. There are weak points in the performances of basin committees, which are generally unable to respond satisfactorily, with stumbling-blocks hampering integrated activities involving ANA and State water resource management entities. Participatory water resource management processes need to be improved, with better representativity on collegiate bodies and the inclusion of mechanisms allowing broad-ranging consultations reaching out to Brazilian society, while moving steadily forward with capacity-building processes.

Strengthening **joint actions undertaken by water resource management entities** is an important initiative for unravelling legal and juridical tangles resulting from dual domain situations. The exclusive action reserved for the National Water Agency in basins, water-bodies and reservoirs falling under Federal domain has direct effects on water resource management by the States, and vice versa. As the Federal water resource management regulator, ANA must work even more seamlessly with State water resource management entities (whose jurisdiction is limited to State water-bodies and groundwaters) in an integrated (and negotiated, whenever possible) manner, pursuing management efficiency. Better teamwork between ANA and State management entities throughout the basin is rated as appropriate, particularly with the possibility of introducing exceptional measures on integrated bases.

Several other examples could be presented, as the challenges are massive. They include: the need for closer integration between water resource plans and other sector-specific policies, especially sanitation, the environment and water infrastructure; financial feasibility and sustainability underpinning the full functioning of the system; conservation and preservation of strategic water-bodies; fees for environmental services; water demand management through the encouragement of more rational use (reuse and more efficient irrigation technologies, among others); and the improvement of Brazil's National Dam Security Policy.

Some improvements to management tools – including innovations and adaptations – may unscramble gridlocks that are common to many parts of Brazil, including upgrades that would ensure better financial sustainability for management systems. Just a few of the aspects that could be enhanced through these tools are: fine-tuning collection methods for water charges in order to regulate the necessary monetary restatements and adjustments to unit values; extending defrayal possibilities through transferring these revenues in order to underwrite management services, including support for the efforts of collegiate bodies and water resource management entities; inspections and oversight activities; and setting up a data infrastructure, among other actions that are currently not covered directly by these funds. In a broader-ranging context, there is a pressing need to ensure seamless and coherent integration among financial planning for water resource management systems and sector-specific financial schedules, including environmental programs and the Federal Budget, through its Pluri-Annual Plan (PPA).

Water resource plans require improvements that will endow them with greater efficacy. Although there is no denying the significance of these tools for steering management actions intended to ensure good quality water nationwide in sufficient quantities over the longer term, low implementation rates have undermined their efficiency. Innovation is needed for the ways that plans are drawn up, proposing more pragmatic actions that reflect real-life situation sand taking financial feasibility into consideration for implementing actions. Other challenges to be surmounted include adjusting the scope of plans in different administrative spheres (Federal, State and basin); integrating them in order to prune redundant aspects; and dovetailing them more effectively in terms of complementary actions, all in parallel to the adoption of monitoring and oversight mechanisms during their implementation.

Innovations are also required for the process of issuing water rights. Greater flexibility is required, together with the introduction of more effective mechanisms for responding to needs, particularly as crises peak, including delegation of powers, issuing collective water rights, and temporary alterations to acts already issued through discussions with users that result in regulatory frameworks tailored to specific situations. In addition to quantity, water quality must be regulated even more strictly by licenses. Classifying water-bodies into water quality objectives and effluent discharges lead to situations where permitted parameter thresholds and ceilings are ignored, possibly leaving water unsuitable for some specific uses.

Definitions of **critical river basins** are crucial for the prioritization of water resource management actions. Factors such as unfavorable water balances in terms of quantity (when demands outstrip supplies) and quality (when effluent discharges exceed water-body dilution capacities) are criticality indicators reflecting long-consolidated circumstances of high demands and water pollution generated in specific river basins.

Steadily dropping rainfall recorded over the past few years has led to further deterioration of these situations in some regions. Management activities in these basins include the adoption of an operations agenda pursuing constructively integrated actions, while avoiding or at least alleviating disputes over water uses and side stepping institutional clashes fueled by centralizing activities undertaken by SINGREH members. Water allocations in these basins may be fine-tuned through setting up regulatory frameworks, together with water delivery control points, integrated surface and groundwater management, and the adoption of economic tools prompting positive effects in terms of enhanced water availability.

Through its management tools and the functional dynamics of SINGREH, Brazil's National Water Resources Policy must be attuned to reality, pursuingits purpose of dealing with current and future problems, in order to ensure that it attains its final goal: access to ample quantities of good-quality water resources for current and future generations. A successful public policy must be dynamic and open to alterations as deemed necessary, steered by adversities and opportunities springing up unexpectedly and involuntarily in many different ways and for a wide variety of reasons, with consequences that may not be ignored, although unforeseen.

Innovative alterations to this Policy and other water resource legislation must be examined at this time, with the intention of upgrading the legal and institutional framework underpinning water resource management in Brazil. In this context, the Brazilian Water Resources Report offers a broad-ranging overview of the nation's situation, while encouraging reflection and showcasing this crucial public policy to society in general, seeking systematic improvements and effective solutions to water crises today and in the future.

The 2017 Brazilian Water Resources Report commemorates the twentieth anniversary of the National Water Resources Policy with a new approach, in a drive undertaken by the National Water Agency (ANA) and its partners, **making this publication more accessible to society.**

This Report is the reference publication for the systematic monitoring of water resources in Brazil through a set of **water quantity and quality indicators and statistics, together with its management.**

This ninth edition also presents an analytical overview **of recent water crises and, based on the lessons learned,** highlights the challenges for fine-tuning this crucial public policy.

ANA
NATIONAL WATER AGENCY - BRAZIL

MINISTRY OF ENVIRONMENT

BRASIL
BRAZILIAN GOVERNMENT