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NATIONAL WATER SECURITY PLAN

MINISTRY OF
REGIONAL DEVELOPMENT

ANA
NATIONAL WATER AGENCY - BRAZIL

NATIONAL WATER SECURITY PLAN

FEDERATIVE REPUBLIC OF BRAZIL

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PRESENTATION

Water security is an essential condition for social and economic development, especially considering the impacts caused by the extreme hydrological events that have occurred in Brazil this decade.

In regions where water availability is naturally limited, as in the Semi-arid region, water crises have occurred for prolonged periods. However, in other parts of the national territory, where no significant imbalance between water supply and demand has occurred before, have lately faced water stress, affecting a great part of the population. In addition, other regions were subject to floods due to heavy rains.

The insertion of the water security theme within the Ministry of Regional Development (MDR) scope and the linkage of the National Water Agency (ANA) to this ministry, strengthen the institutional framework for planning, execution, operation and maintenance of the strategic water infrastructure of the country. This is a key element in ensuring water supply for human consumption and economic activities, as well as in reducing risks associated with droughts and floods.

The National Water Security Plan, carried out in an unprecedented and innovative way, becomes the fundamental decision-making instrument on this theme. The Plan leads to an investment program and the selected interventions were subject to a careful analysis as to their relevance, priority and effect on the main water security problems of the country.

The Ministry of Regional Development (MDR) and the National Water Agency (ANA) expect that the path to water security in Brazil, detailed in this Plan, will become a milestone in public policy and in the way water infrastructure investments are conceived and carried out. In order to achieve this goal, it is necessary to engage other government institutions and rely on the engagement of the states in the implementation efforts.

Ministry of Regional Development **National Water Agency**

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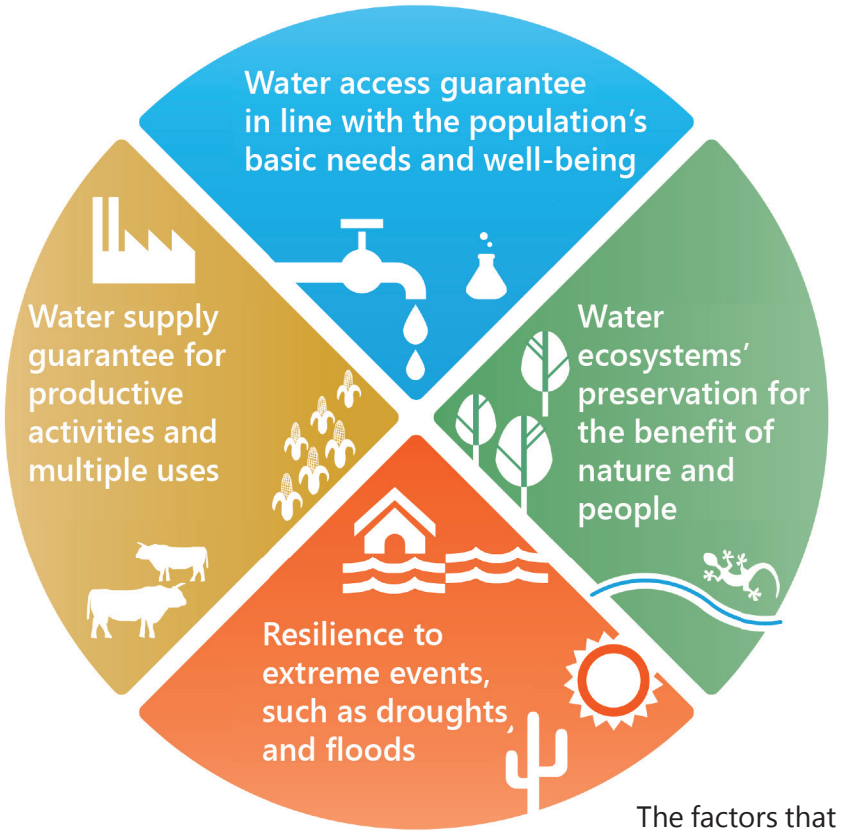
1 PNSH Overview

Canyon São Francisco River - Paulo Afonso/BA
Photo: Ministry of National Integration

1 National Water Security Plan (PNSH) Overview

CONTEXT AND GOALS

Water Security according to the definition proposed by the United Nations (UN) can be characterized by the availability of water to sustain human well-being, socio-economic development and the conservation of aquatic ecosystems accompanied by an acceptable level of risk related to droughts and floods. The four dimensions of Water Security should be considered as the basis for water supply and water use planning, in a national scale.



WATER SECURITY DIMENSIONS

Adapted from United Nations Water (UN-Water)

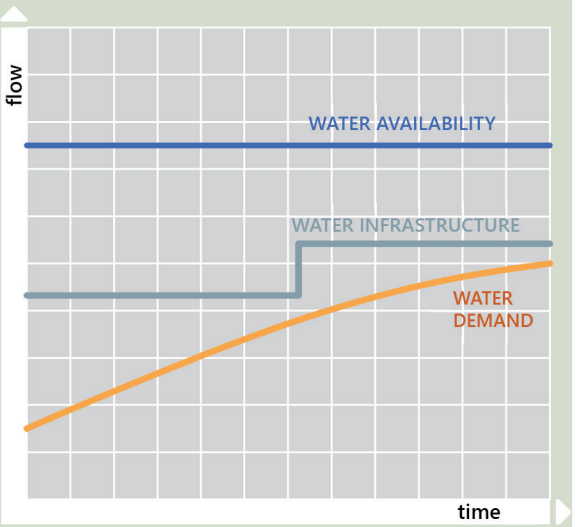
The factors that threaten the aimed water security equilibrium are: population growth, especially in urban areas, and economic growth, which generates increases in water demand, as well as climate change and its effects on extreme hydrological events. These factors conjugated with the lack of planning, lack of coordinated institutional actions and lack of investment in water and sanitation infrastructure trigger water insecurity scenarios and the outbreak of crises similar to the ones that affected Brazil in the last seven years.

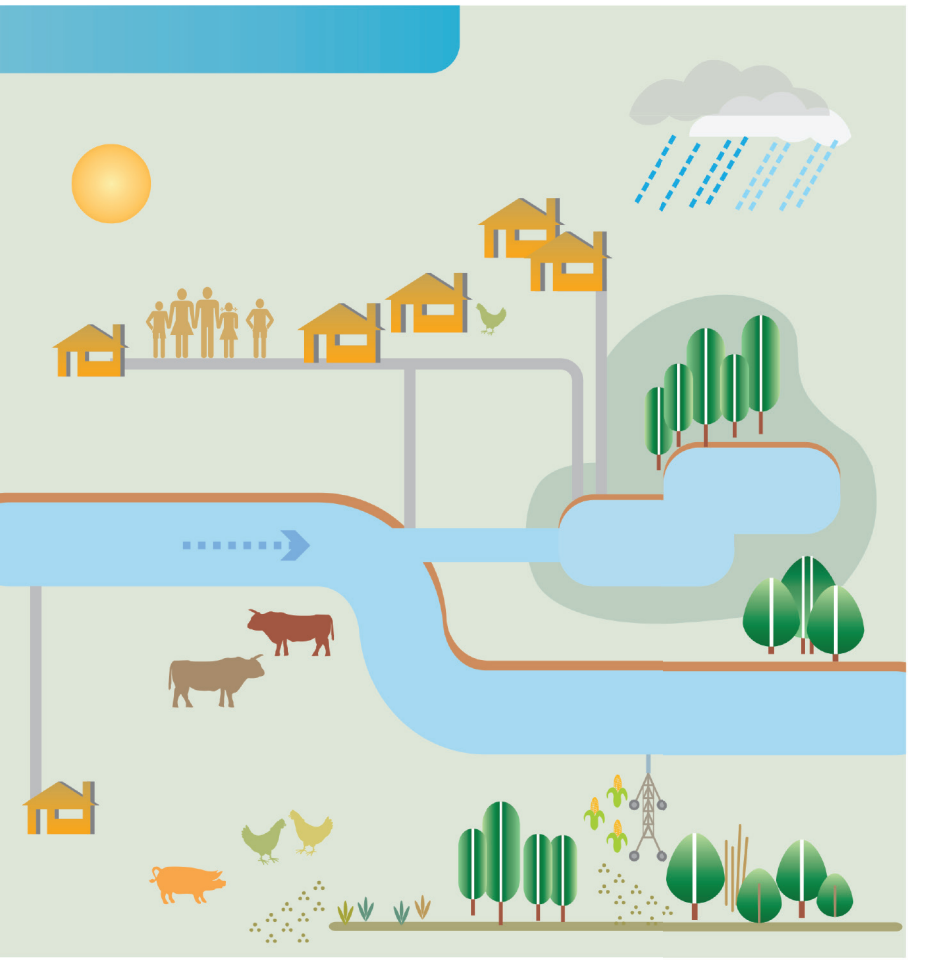
In order to reverse a water insecurity framework, the most common practice is to implement water infrastructure and to improve water resources management (planning, water use control, monitoring, water systems' operation and maintenance, etc.). Additionally, it is important to incorporate risk management measures (rather than focusing on crisis response). Starting from an in-depth knowledge of the environment's vulnerability and its exposure to a certain event, leading to the proposition of actions designed to increase resilience.

Thus, an ideal **Water Security** scenario should be sought, where the infrastructure is properly planned, sized, implemented and managed, fulfilling both the equilibrium between water supply and water demand as well as the contingency situations resulting from the extreme climate events vulnerability.

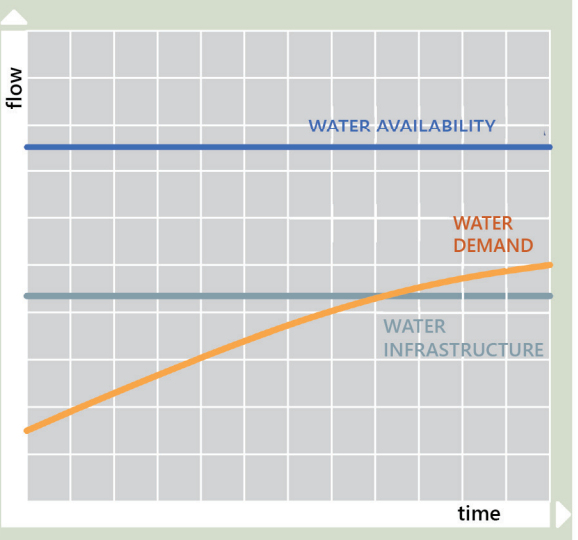
THE FACES OF WATER INSECURITY

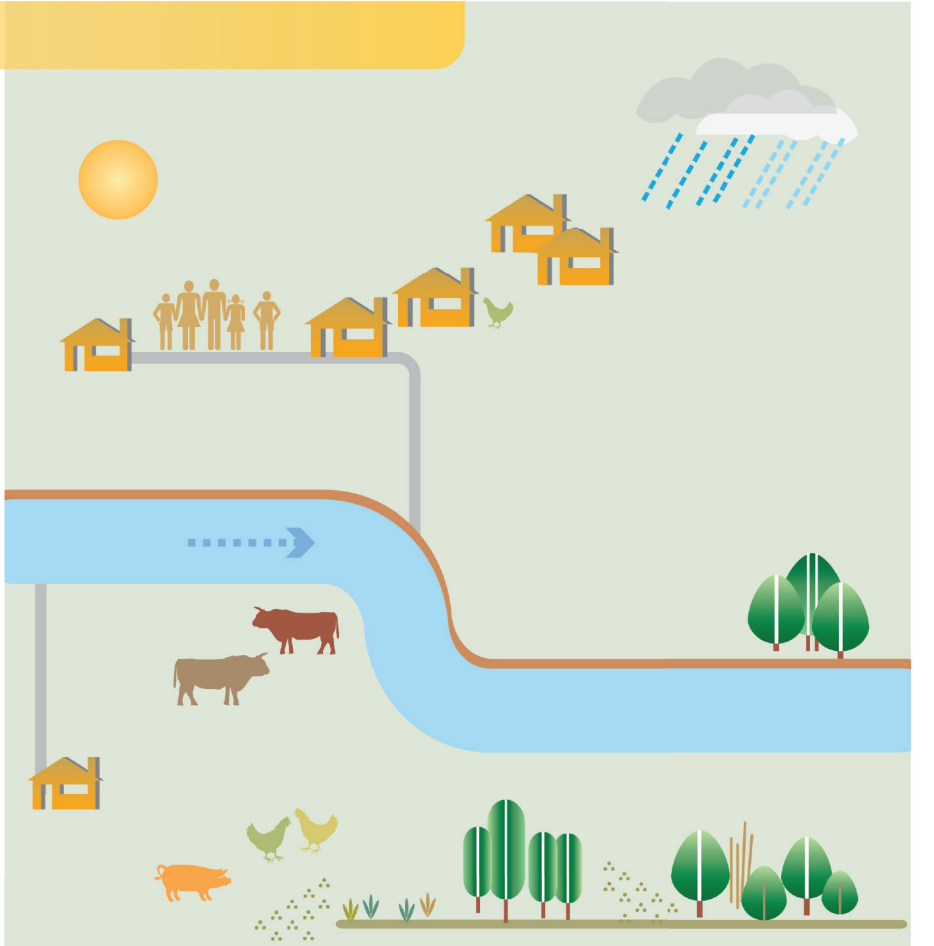
APPROPRIATE WATER BALANCE



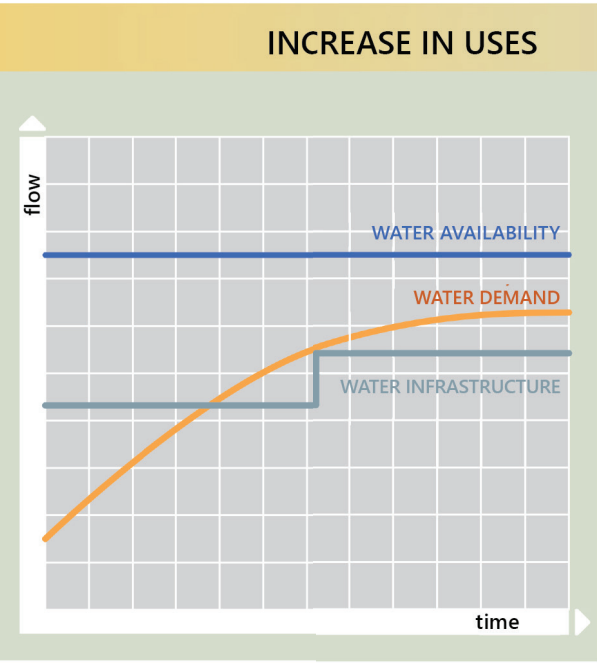


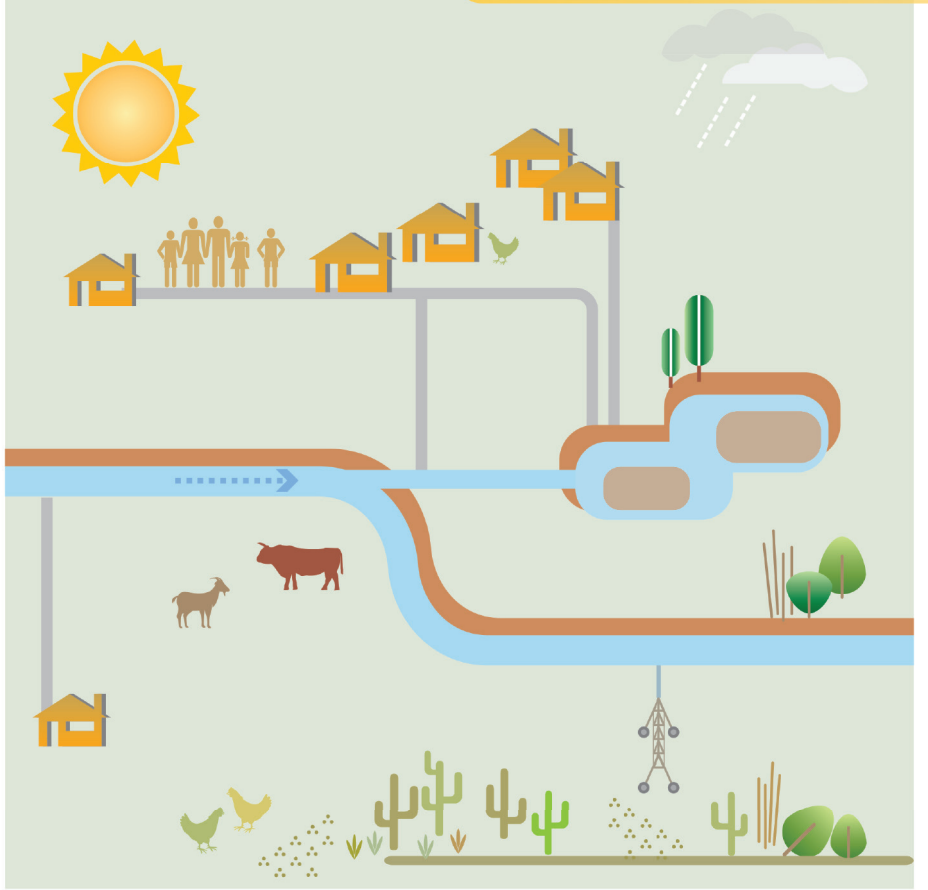
WATER INFRASTRUCTURE

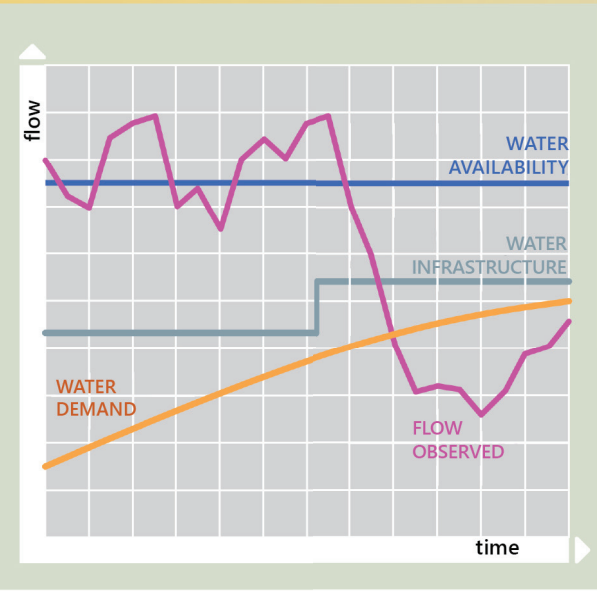




THE FACES OF WATER INSECURITY





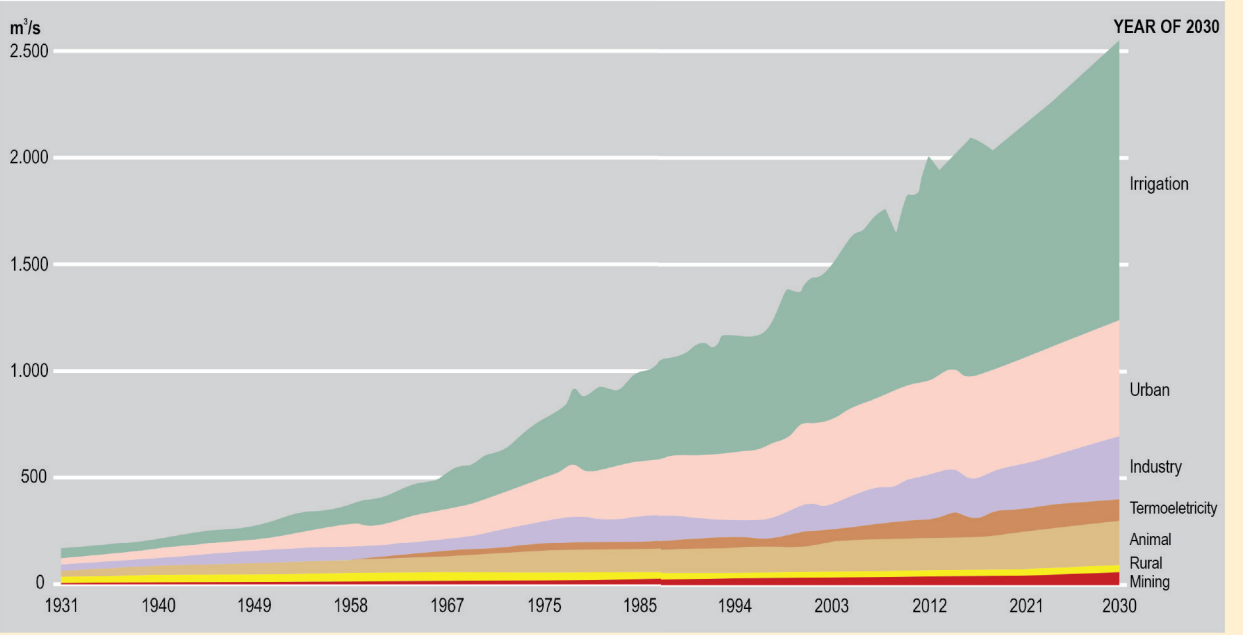


Recent Water Crises in Brazil

Large conurbations, urban sprawl, the gradual increase in water demand for consumption uses and the lack of investment in water infrastructure (including maintenance and operation) associated with periods of drought result in outbreaks of water crises such as the ones that affected Brazil between 2012 and 2017.

According to projections made by ANA, the water withdrawal amount to supply different sector users (including populations and economic activities) may reach 2,600 m^3/s in Brazil by 2030, representing an increase of almost 2,000% in relation to the demands estimated for the year 1931, that is, a 2,000% increase in a period of 100 years. This would result in a risk to the supply-demand balance for several regions of the country.

WATER WITHDRAWAL EVOLUTION IN BRAZIL (PER USER SECTOR) – 1931/2030



When considering large conurbation effects on water resources, a rapid growth was noticed in Brazil's urbanization rates between the 1960s and the 1980s. In 2010 that rate was 84% and it is expected to reach 90% by 2020. Furthermore, increasing conflicts over water use in urban areas and worsening of water quality will occur if preventive or corrective measures are not taken.

During the severe recent water crises Brazil has gone through, several measures have been taken. Most of them were contingency measures such as water rationing, negotiations on reservoir water allocation, implementation of emergency works and, in extreme cases, water supply cut off.

In December 2016, 132 cities in the Northeast region (about 1.5 million inhabitants) faced a supply collapse, and 812 municipalities had to be, totally or partially, provisioned by water trucks, generating costs of more than 1 billion BRL to the Federal Government, in that year.

In addition to the Semi-arid region, which is historically subject to droughts, the water crisis also struck the Southeast region. The most populous and with the highest water demand areas in the country, such as the South Paraíba River Basin and the São Paulo Metropolitan Region, suffered consequences for both human consumption and economic activities.

Historically, Brazil lacks a national water security plan that would gather traditional actions and risk management to determine the decision-making processes about strategic water infrastructure investments. In spite of the many interventions that have taken place over the last decades, it is still fundamental to have a common roadmap to guide investments. This roadmap should be based on a single diagnosis and in a methodology of integrated analysis of the water deficits and the recommended solutions throughout the national territory.

In this context and considering its duties within the National Water Resources Policy as to the planning and promotion of actions to prevent or minimize the effects of droughts and floods and the elaboration of studies to contribute to a better investment of Government resources in water infrastructure, ANA has developed the **National Water Security Plan (PNSH)** in partnership with the Ministry of Regional Development. The Plan is an unprecedented initiative, aligned with the international Water Security concept and with the ministry's new institutional mission

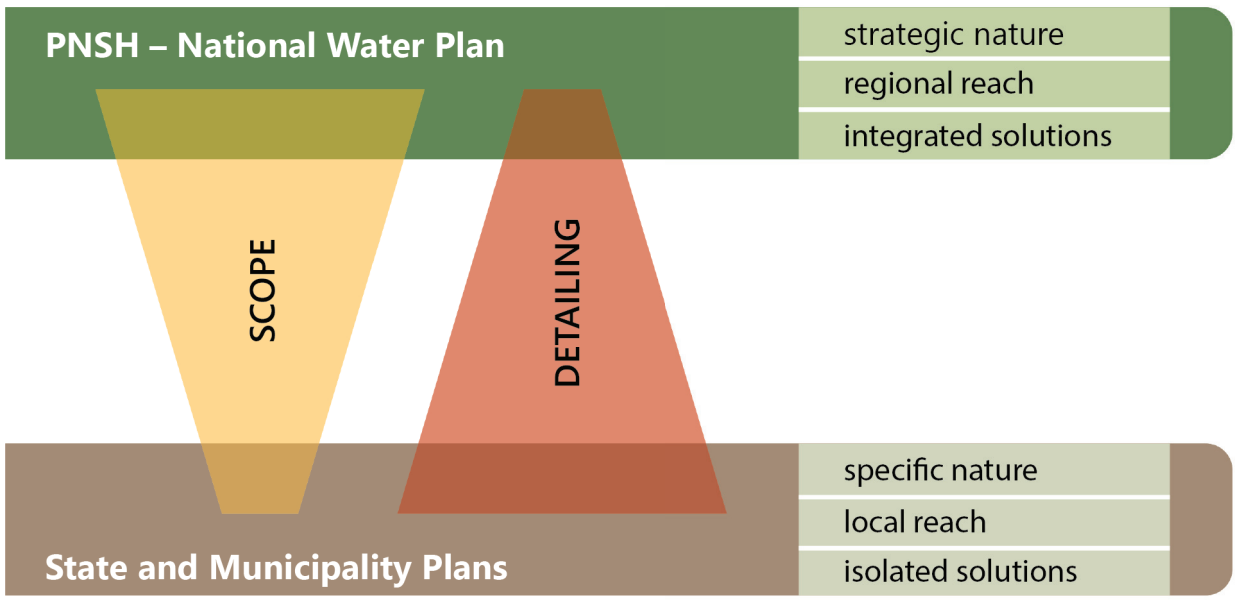
Derived from the guidelines criteria issued from the concept of Water Security concept the Plan offers Brazilian society an integrated, consistent, strategic and regionally relevant water infrastructure planning until the year 2035, in order to reduce the impacts of droughts and floods. Specific additional studies and projects have also been indicated either to assess the feasibility or to fill knowledge gaps on infrastructure works or on areas of low water security.

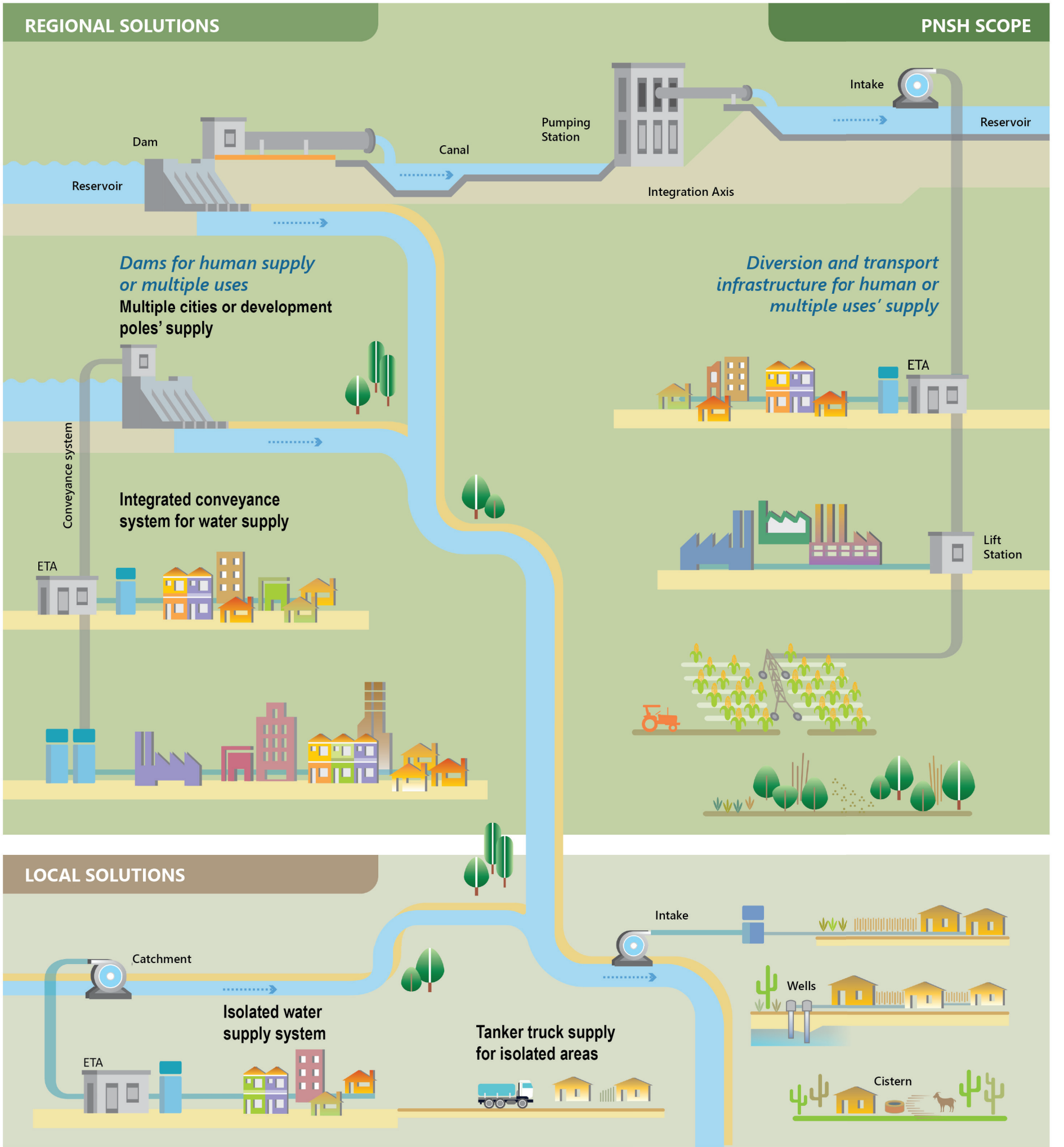
The performed analyses focused on the biggest water security problems in Brazil, which are characterized by unmet effective demands (existent and projected). The analyses furnished a broad and integrated perspective in order to select a set of structuring interventions that are able to guarantee lasting results. The interventions include:

- Regulating dams to supply human demands or multiple uses, and dams for flood control.
- Water transport and diversion infrastructure for human supply or multiple uses – water piping systems, canals and integrated water conveyance system.

Local and emergency works are not part of the PNSH's scope but may be recommended by the Plan as possible alternatives.

PNSH RANGE




REGIONAL SOLUTIONS
PNSH SCOPE
Intake
Reservoir
Pumping Station
Canal
Dam
Reservoir
Integration Axis
Dams for human supply or multiple uses
Multiple cities or development poles' supply
Diversion and transport infrastructure for human or multiple uses' supply
ETA
Conveyance system
Integrated conveyance system for water supply
Lift Station
ETA
LOCAL SOLUTIONS
Intake
Catchment
Wells
Isolated water supply system
Tanker truck supply for isolated areas
ETA
Cistern

Ottobasins are the subdivision of river basins into highly detailed smaller areas carried out according to the methodology developed by ANA based on the watercourses coding method developed by Otto Pfastetter.

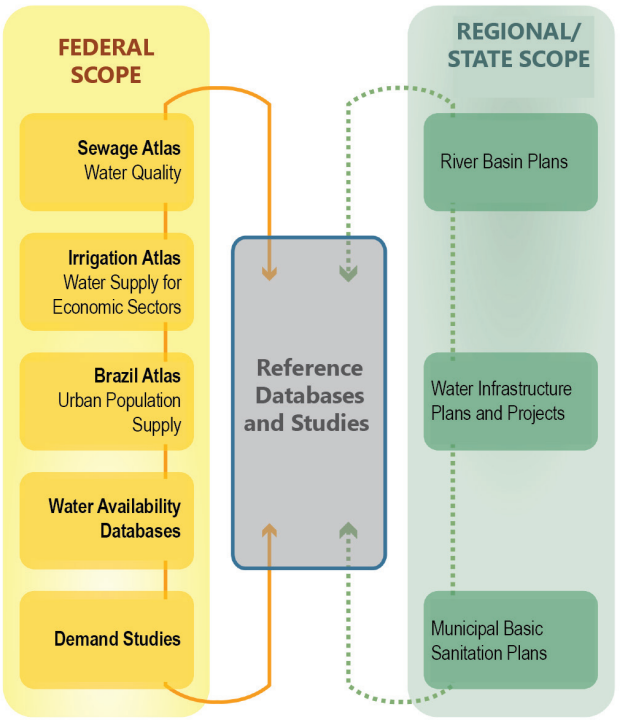
PNSH CONSTRUCTION

The development of the PNSH started with a thorough analysis of the water security grades throughout the national territory. The grades were defined by a Water Security Index (ISH) whose innovative methodology was developed with data from several pre-existing studies carried out by ANA and related institutions and applied to small scale in great detail (ottobasins).

At the same time, a comprehensive inventory of the existent Studies, Plans, Projects and Works (EPPOs) at different planning and implementation stages was also carried out. The EPPOs were identified among water user sectors and state and federal organizations and entities with involvement in water resources and water infrastructure.

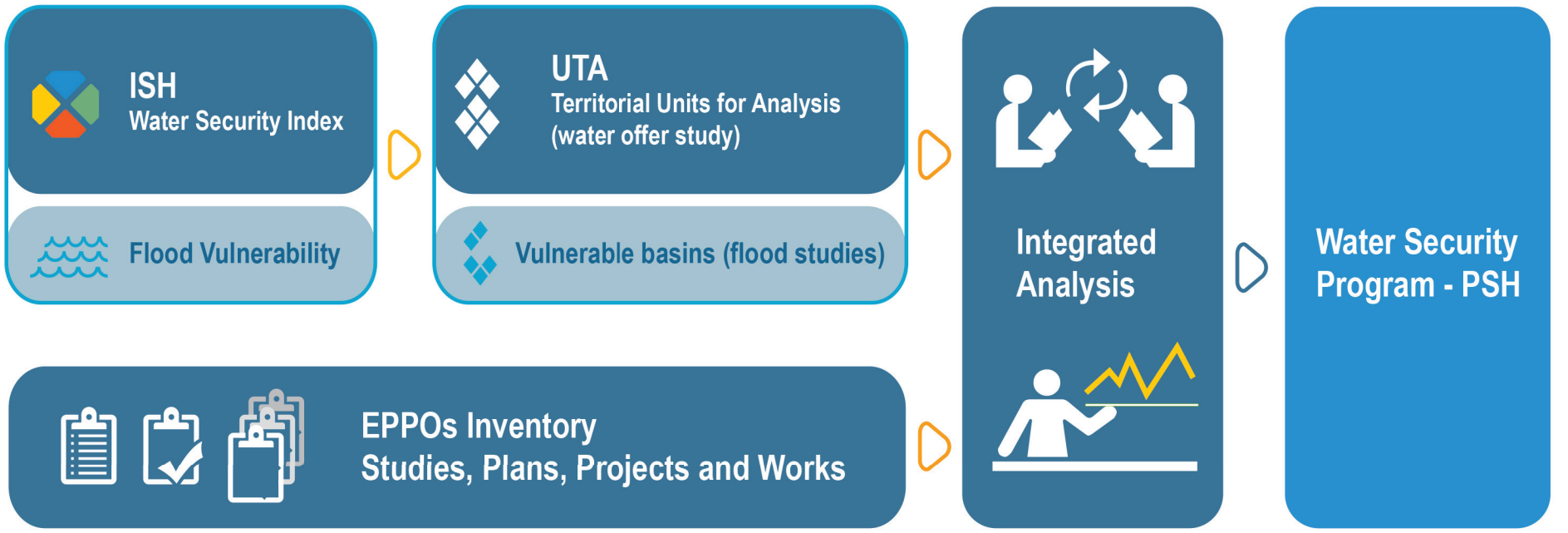
Through spatial analysis of areas with medium to minimum water security, river basins were grouped providing the delimitation of specific areas called Territorial Units for Analysis (UTAs). An integrated analysis was then carried out in these units starting with a comparison between water security problems characterized by the Water Security Index (ISH) and the water supply interventions planned for that area, aiming to identify strategic solutions that would meet the PNSH requirements. A similar methodology was applied when studying flood control problems.

Selected interventions at different stages (studies, plans, projects and works), compose the **Water Security Program - PSH**.



INTERRELATIONS BETWEEN THE PNSH AND OTHER STUDIES

PNSH DRAFTING PROCESS



Water Security Index - ISH

The **Water Security Index** was designed within the PNSH framework, in order to portray the different water safety dimensions with simplicity and clarity, incorporating the risk concept of water uses. This index may be updated and systematically applied throughout the national territory since it is based on objective space and time metrics.

Risk Concept in the PNSH

Exposure and vulnerability to a particular event are the key elements when studying risk or security. Thus, if there is a region where the population depends on water for survival and for developing economic activities and it is, therefore, exposed to the impact of extreme events, it would be appropriate to address engineering and risk management measures to reduce its vulnerability.

For the purposes of the PNSH, water risk (based on the water supply-demand balance approach) was divided in two major typologies:

- **Post-deficit risk:** corresponds to the value at risk when a portion of the demand is not being supplied - the ratio between water demand and water availability greater than 100%.
- **Imminent Risk:** corresponds to the value at risk that may occur at the deficit threshold (before it actually occurs). It becomes progressively greater as the water demand and availability ratio approaches 100%.

These risks were calculated in terms of a population exposed to water deficits (human dimension of the ISH) and monetary values lost in economic production due to unmet demands (economic dimension).

THEORETICAL RISK CONCEPT

The concepts involved in the calculation of the Water Security Index were structured according to the following dimensions, indicators, variables or attributes:

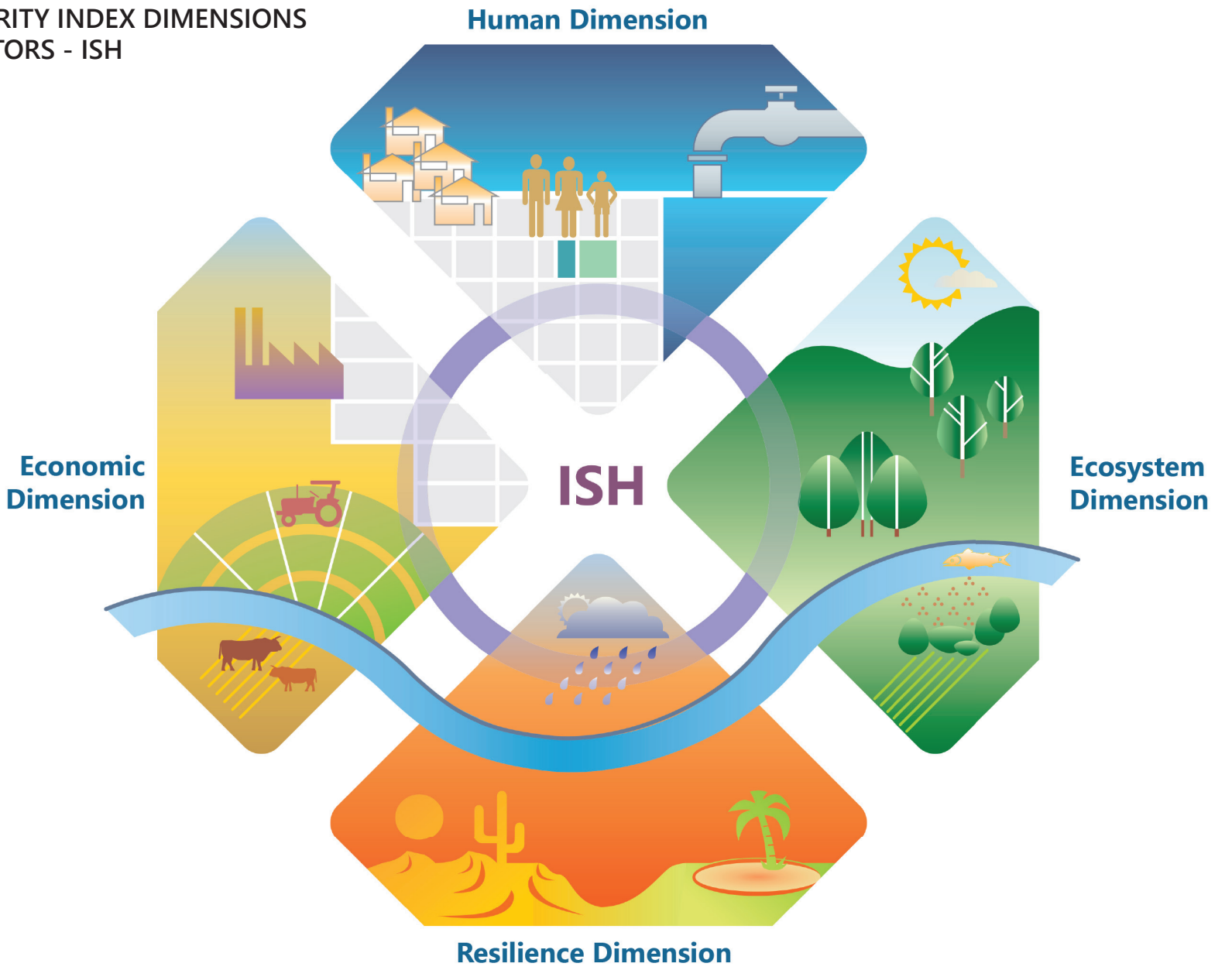
- The four Water Security dimensions (Human, Economic, Ecosystem and Resilience) were considered and combined to form the Water Security Index.
- Each dimension is composed of one or more indicators capable of quantifying its relevant aspects.
- Each indicator is formed by a combination of measurable variables or attributes.
- The indicators values are classified into five ranges with the attribution of natural numbers from 1 to 5 in descending order of the water security level. With the exception of the safety indicator of the mine tailing dams, which ranges from 1 to 3.

Weights were attributed to the respective indicators in each dimension in order to calculate the weighted average and to perform the normalization of the Index. Classes and weights were assigned according to experts judgement and tests of correspondence to reality, based on the role that each aspect plays in the water security representation.

The human and economic dimensions make it possible to quantify the deficits in meeting effective demands (human supply and productive sector) and of associated risks, while the other dimensions - ecosystemic and resilience - enable the identification of the most critical and vulnerable areas.

The composition of a single and standardized ISH has the intrinsic advantage of facilitating communication and allowing readings in cutouts at different levels (river basin, region, state, municipality, etc.) and direct comparisons between these groups.

WATER SECURITY INDEX DIMENSIONS AND INDICATORS - ISH

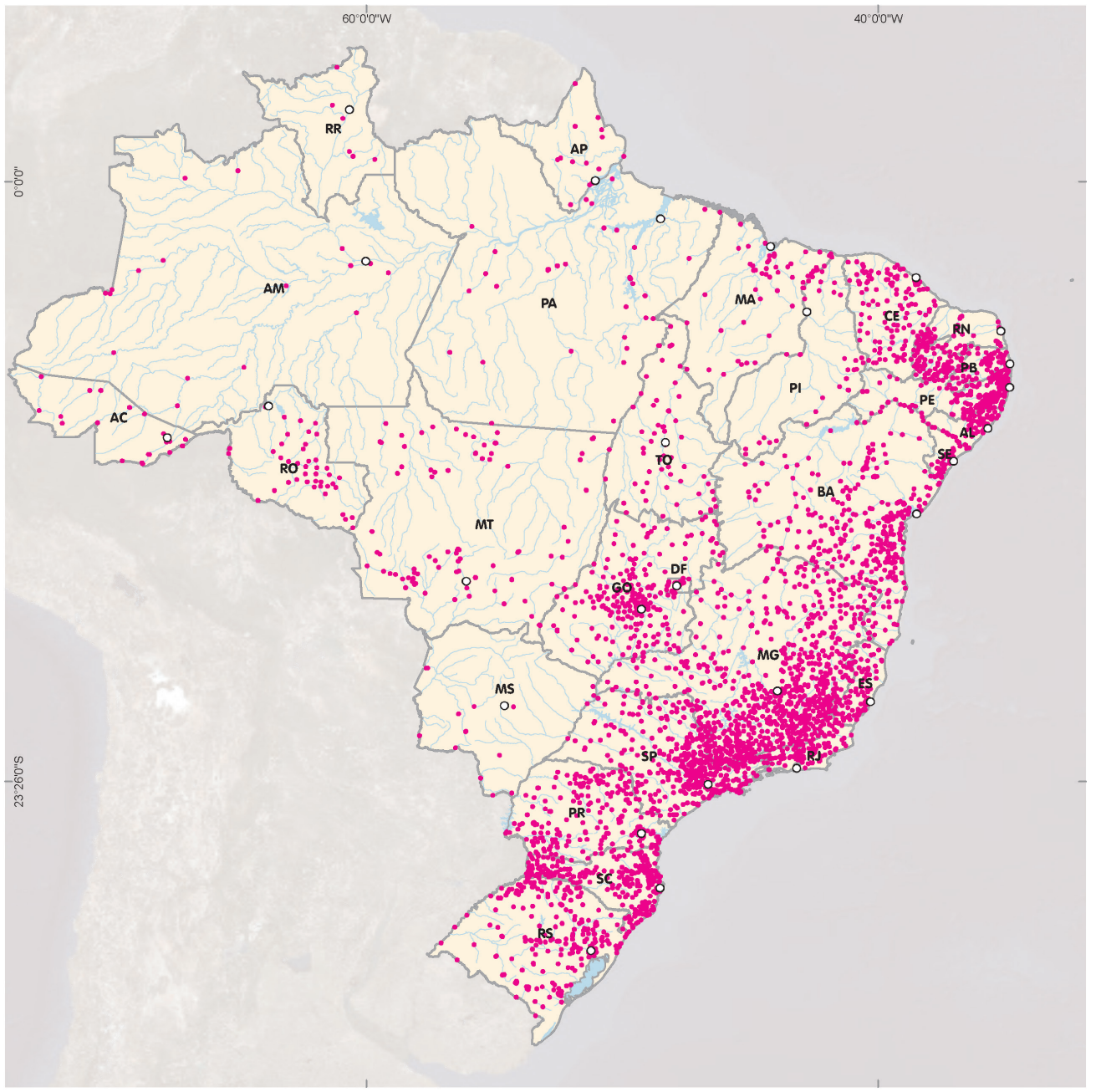


ISH Indicators	
DIMENSION	**INDICATOR**
Human	Water supply for human consumption is guaranteed
Economic	Water supply for irrigation and livestock is guaranteed Water supply for industrial activities is guaranteed
Ecosystem	Water quality is appropriate for natural uses Water quantity is appropriate for natural uses Mine tailing dams are secured
Resilience	Artificial storage Natural storage Potential groundwater storage Rainfall variability

Most of the variables and indicators that make up the ISH are derived from the National Water Resources Information System (SNIRH) database and from studies developed by ANA.

In order to calculate the human dimension index, for example, the reference used was the municipalities' spatialized demands database, distributed among the existing surface and groundwater intake points, according to information from the Urban Water Supply Atlas consolidated in 2010 and being currently updated.

This study included a water supply analysis and the proposition of technical alternatives to guarantee the supply of all cities of the country.

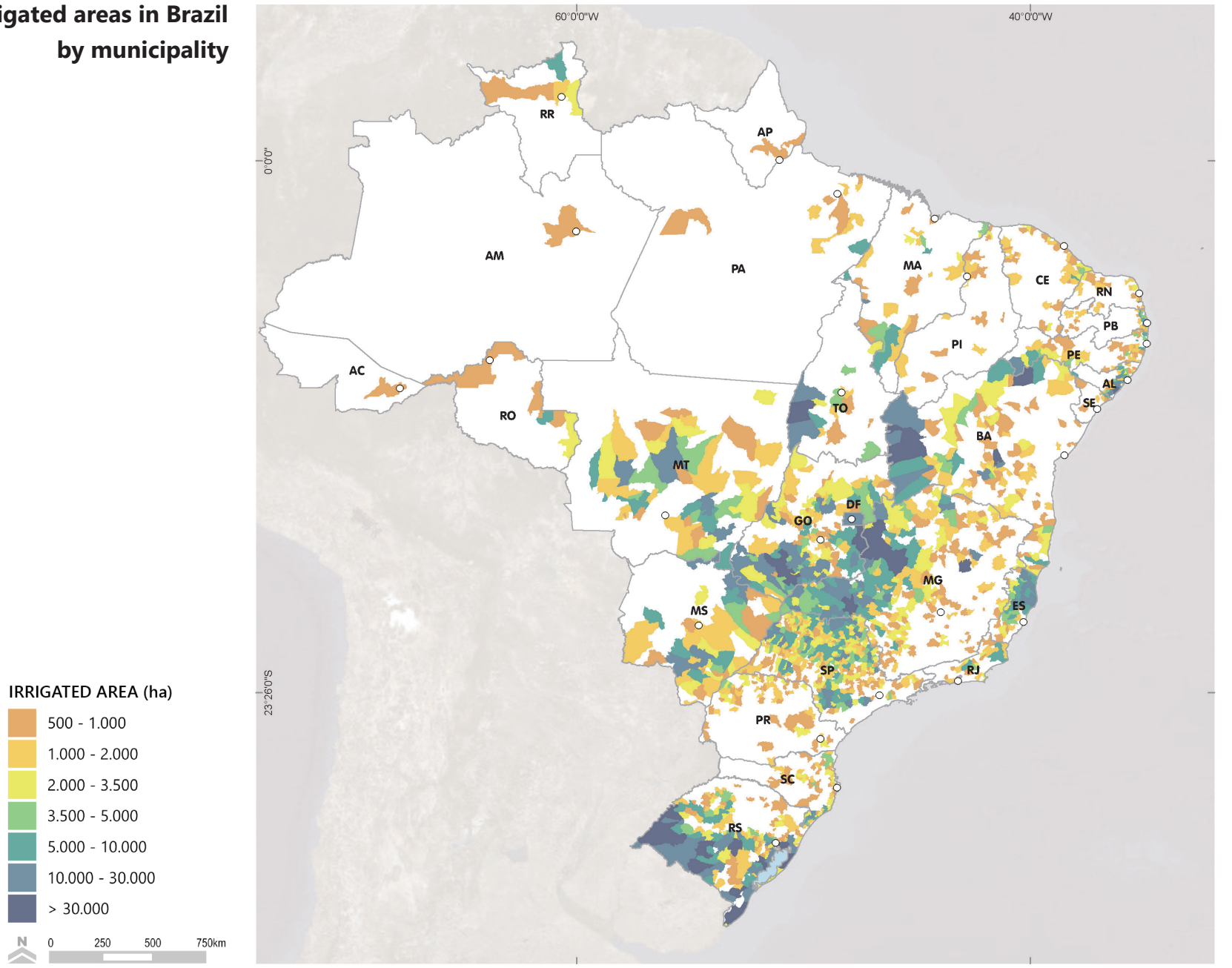


Superficial urban water supply intake points in Brazil

The Atlas - of Irrigation Water Use, completed in 2017, mapped the water demands for irrigation use allowing the calculation of the economic dimension of the water security index.

The irrigation data, including the methodology used for estimating irrigated areas, incorporated updates of specific maps of center-pivots irrigation areas and sugar cane irrigation areas, and also a re-evaluation of the irrigation census projections.

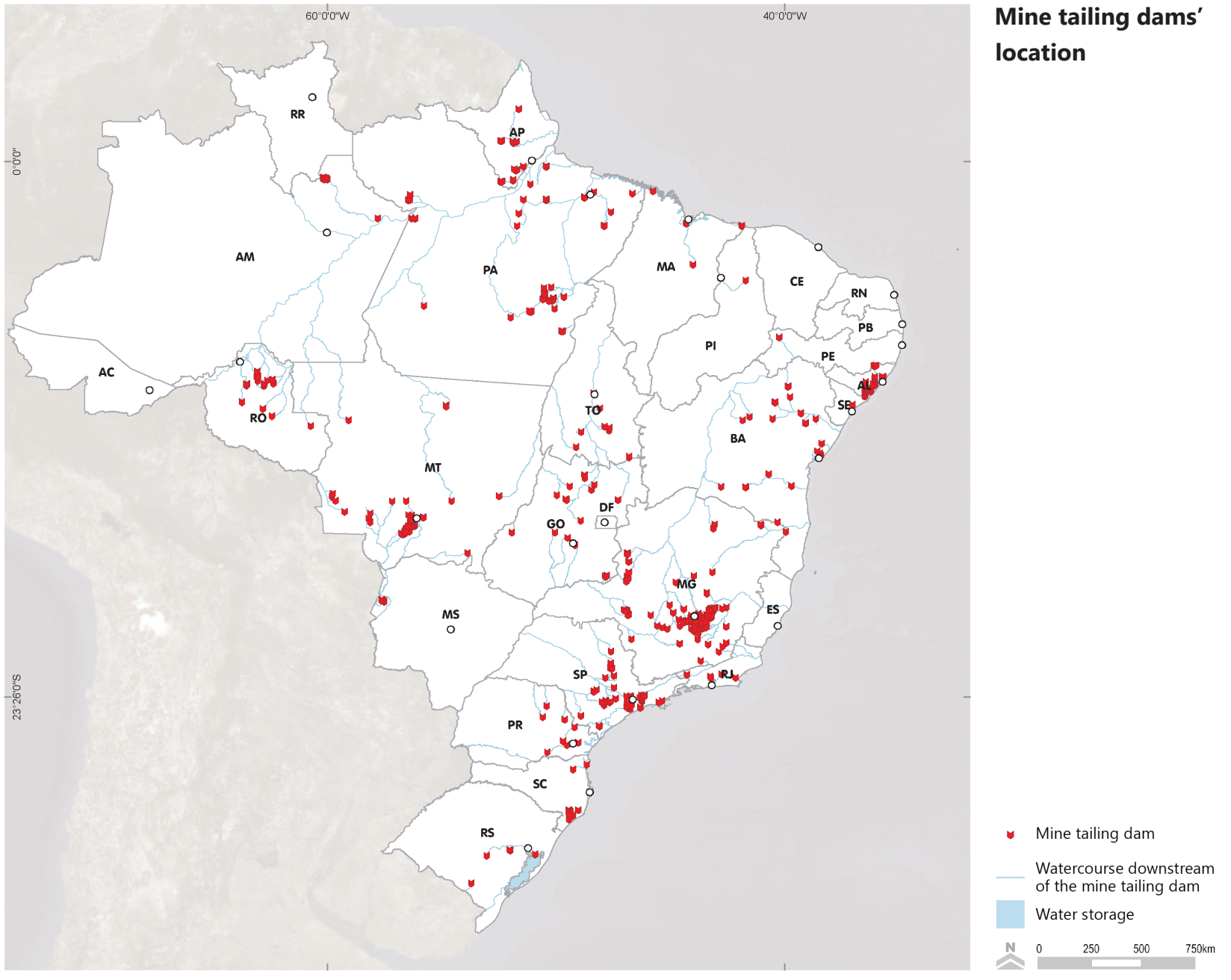
Irrigated areas in Brazil by municipality



The water quality data used in the ecosystemic dimension assessment were obtained from the Sewage Atlas - River Basin Cleanup, also completed in 2017, while the data on mine tailing dams was extracted from the Dam Security Report, 2017.

The Wastewater Atlas gathers diagnoses of the sewage treatment for all urban centers in the country including the impact of the effluent loads discharged on the receiving water bodies, as well as the planning of new sewage treatment plants. The Dam Security Report (RSB) is one of the National Dam Security Policy (PNSB) instruments and presents an overview on the security management evolution in Brazilian dams and on the PNSB implementation, it also provides action guidelines for the supervisors and entrepreneurs.

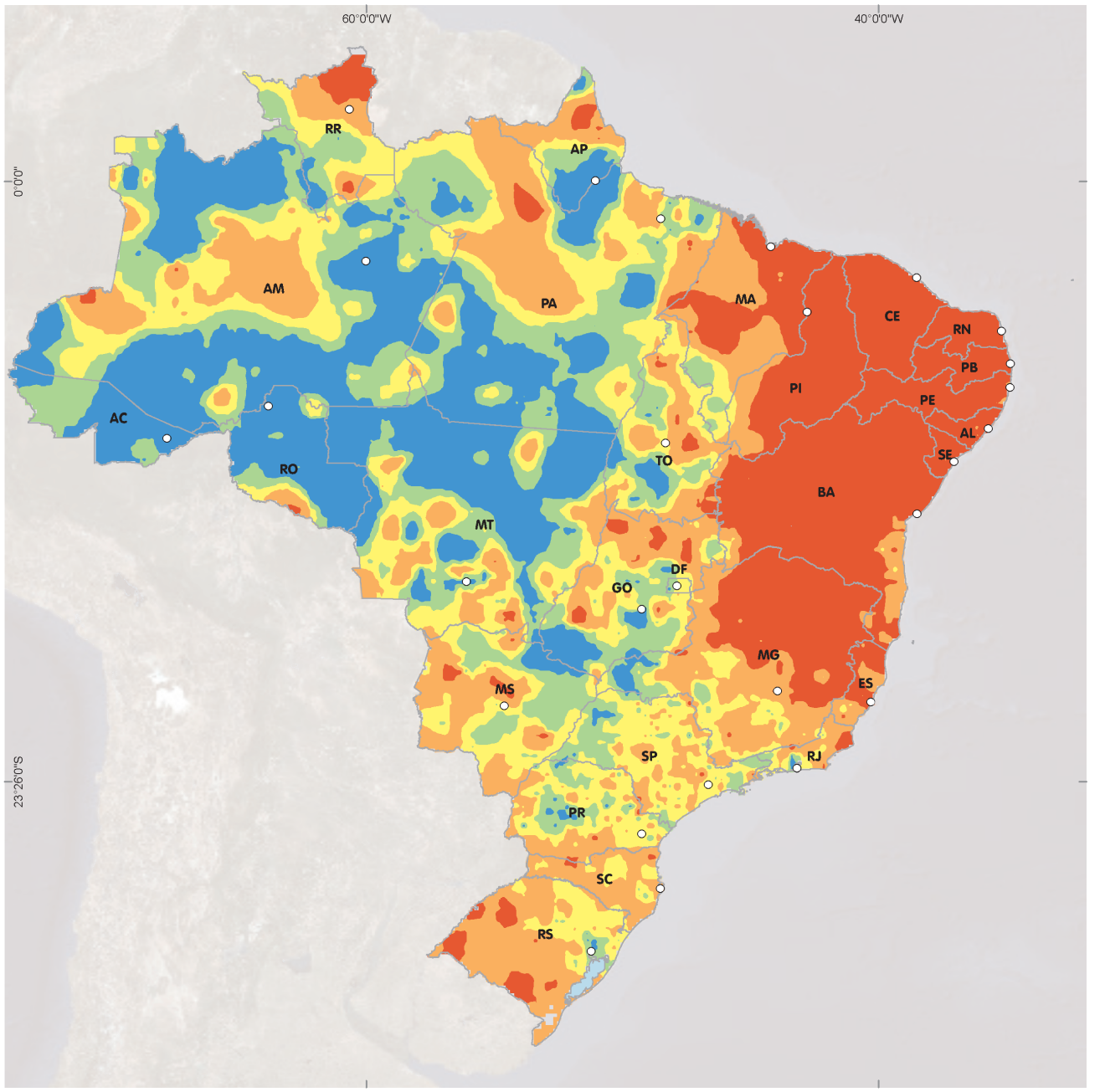
Mine tailing dams' location



Data from hydrometeorological stations were processed and resulted in a mapping of the country's rainfall variability used in one of the resilience dimension's indicators.

These data are derived from the National Hydrometeorological Network (RHN) and gathers river water level, flow, rainfall, climatology, water quality and sediment measurements. They can be accessed at the Hydrological Information System (HidroWeb), which is linked to the SNIRH.

Rainfall variability in Brazil



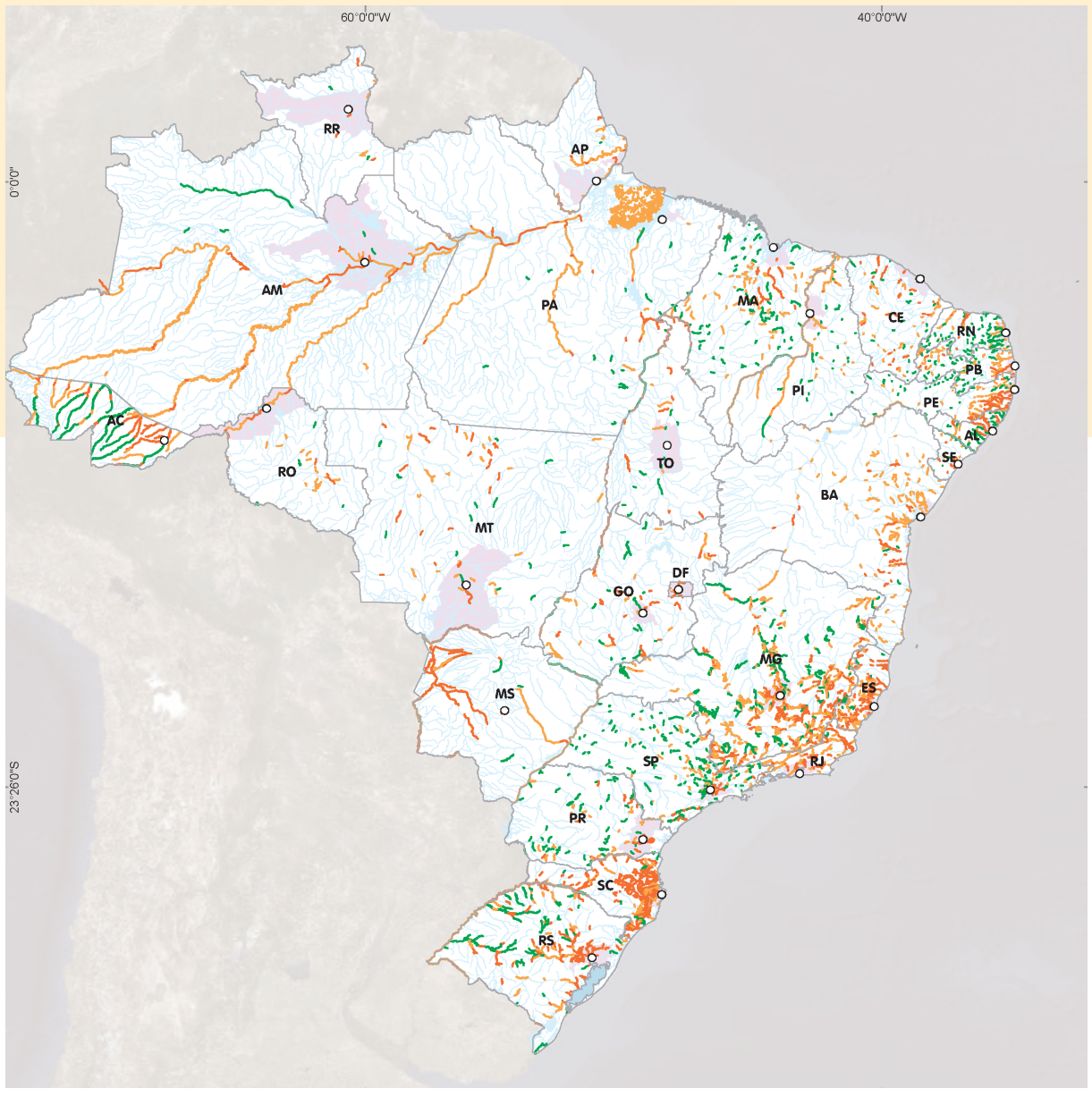
Flood Control in the PNSH

Floods play a significant role among the various types of natural disasters that occur in Brazil. According to the International Disaster Data Bank (EM-DAT), Brazil is among the ten countries most affected by floods in the world.

A total of 47.5% of the Brazilian municipalities (2,641) have decreed a state of emergency or public calamity due to floods at least once between 2003 and 2016. These municipalities are mostly located in the South and Southeast regions of the country. During that period 7.7 million people were affected by floods in Brazil, in contrast to the water scarcity experienced in several other regions.

Floods can happen and have impacts due to two distinct processes, which may occur separately or in combination: gradual floods, associated with the occurrence of heavy rainfall across the river basin, and flash floods, associated with the urbanization process. The potential for gradual flood occurrence in a river basin is the result of the joint action of a series of interdependent factors such as modelling, meteorological and geomorphological agents, but also due to vegetation coverage. The PNSH focuses on gradual floods, or river basin-related floods.

Watercourses' vulnerability to floods



It has been verified that gradual flood events depend on a number of river basin features. Therefore, flood control projects and interventions should take into account the basin as a complete system, avoiding one-off solutions and the simple transfer of impacts. They must also adhere to concepts that aim to reduce floods adverse impacts through better planning and management of the basin land use, and these plans should be constructed in harmony with the natural hydrological cycle processes.

The current trend in the prevention and mitigation of gradual flood risks is to implement a combination of structural and non-structural protection measures, aiming to balance water storage and drainage functions of the drainage system with the available space and sustainable human occupation.

Risk prevention and management regarding critical hydrological flood events in Brazil are supported and articulated by ANA with the State authorities – water resource managers and the Civil Defense – and other public and private organizations and entities related to the theme.

In 2014, ANA published the Flood Vulnerability Atlas, mapping prone to flood water courses throughout the national territory and classifying flood vulnerability the river flood vulnerability as a result of the combination of event frequency and degree of impact generated.

This document defined the water security level relative to the gradual flooding of water courses and river basins in Brazil. The Flood Vulnerability Atlas has identified 13,948 floodable river stretches in 2,780 water courses, of which 4,111 stretches (30%) were considered to be highly vulnerable, 6,051 (43%) fairly vulnerable and 3,786 (27%) of low vulnerability.

The inundation vulnerability diagnosis contained in the PNSH was based on the Flood Vulnerability Atlas. The following basins were identified as the most vulnerable: Acre river basin, in the state of Acre; Mundaú and Paraíba basins, in the states of Pernambuco and Alagoas; Coastal basins to the East of Pernambuco - Una, Sirinhaém and Ipojuca; Muriaé and Pomba river basins (tributaries of the Paraíba do Sul river) in the states of Minas Gerais and Rio de Janeiro; the Doce river basin, in the states of Minas Gerais and Espírito Santo; the Itajaí river bansin and the Tubarão and Araranguá river basins in Santa Catarina; and the Jacuí and Taquari-Antas river basins, in the state of Rio Grande do Sul.

Territorial Units for Analysis – UTAs

The Territorial Units for Analysis (UTAs) constitute the spatial reference both for the Integrated Analysis and the presentation of the PNSH's results. The risk values of the ISH human and economic dimensions were calculated to identify the units most sensitive to implantation of interventions of water supply.

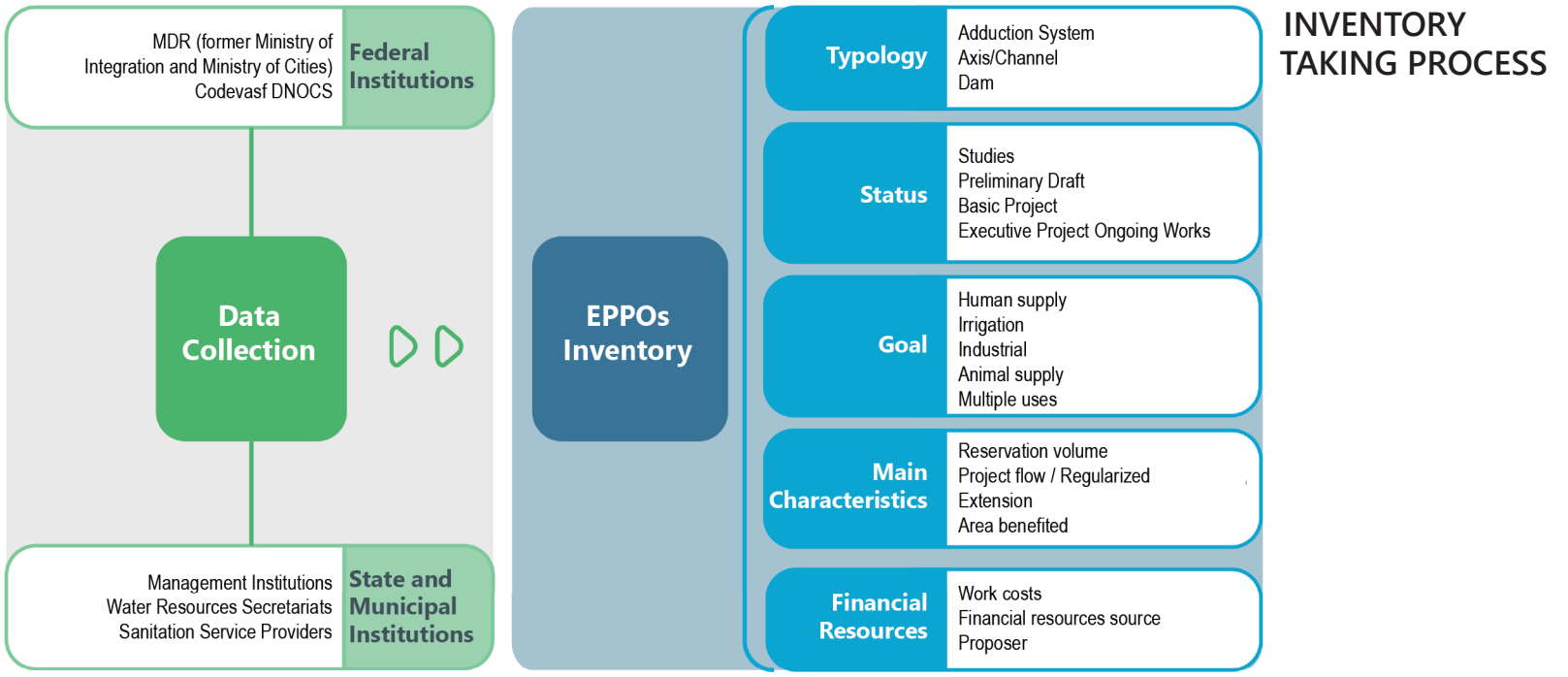
The UTAs considered critical are those in which the human and economic dimensions risk values (dimensions that respond to the implementing of infrastructure interventions) are expressive in relation to the total risk value of the state where they are located.

Studies, Plans, Projects and Works (EPPOs) Inventory

The inventory purpose was to pinpoint the EPPOs of dams, water conveying systems, integration canals and integrated water-conveyance system axes according to the PNSH's scope.

In addition to ANA and MDR technical collection, a survey was carried out within several state and federal organizations involved with Water Resources matters and/or with the water infrastructure theme, complemented by consultations to websites and interviews with experts.

The collected information was catalogued, georeferenced and organized according to the intervention typology, to the current implementation stage, to its dependence on other interventions, to supplied areas and demands, to the main main characteristics, etc.



Integrated Analysis

The Integrated Analysis comprised three approaches - qualitative, quantitative and complementary – to compare the location of the inventoried interventions (EPPOs) with the Water Security Diagnosis obtained from the ISH. The result of the integrated analysis is the forwarding of selected interventions to the Water Security Program (PSH).

The **Qualitative Analysis'** goal was to evaluate how the proposed infrastructures would behave in the face of the problem to be solved.

This analysis was developed based on the correspondence between the issues identified through the ISH and the solutions presented in the inventory, highlighting the dependence and complementarity between interventions and with the existing infrastructure, always focusing on the problem to be solved and in the effective demands to be met.

One of the most relevant aspects considered in this analysis was whether the source of the assessed intervention was dependent on the water supplied by another intervention not yet implemented/in operation. In the case of dams, it was verified whether there were interventions promoting capillarity within the territory to be benefited.

The current stage of the intervention was taken into account so that the complement or the interdependent interventions may be reprogrammed in time, avoiding the construction of disconnected infrastructure that may deteriorate over time waiting for additional works and not bringing the expected benefits.

The **Quantitative Analysis** aimed to define the contribution of one or more EPPOs to solve the water security problems identified for the year 2035. In this analysis the benefits of implementing each EPPO were dimensioned for supplying the total water deficit and for every water user sector through a water balance carried out by UTA.

The aggregation of the previously raised qualitative and quantitative aspects based the development of a **Supplementary Analysis** of the Territorial Units for Analysis (UTA) level covering additional benefits arising from the eventual implementation of the interventions considered, such as: the need for redundant infrastructures for urban supply, operational flexibility, convenience of an alternative source, the region's economic profile, and the evaluation of competing interventions.

Each intervention was classified into five types based on the Integrated Analysis' results. The types are compatible with the nature of the problem described and the suitability of the intervention to solve it, with the indication of how to forward, or not, the intervention to the Water Security Program (PNSH):

- **Intervention suited to the PSH (problem with an appropriate solution):** The intervention corresponds to the identified problem. No doubts (or only minor doubts) remain about its implementation. The proposal, in its current configuration, meets the technical requirements considered and is qualified for integrating the Water Security Program (PSH) as a recommended work.

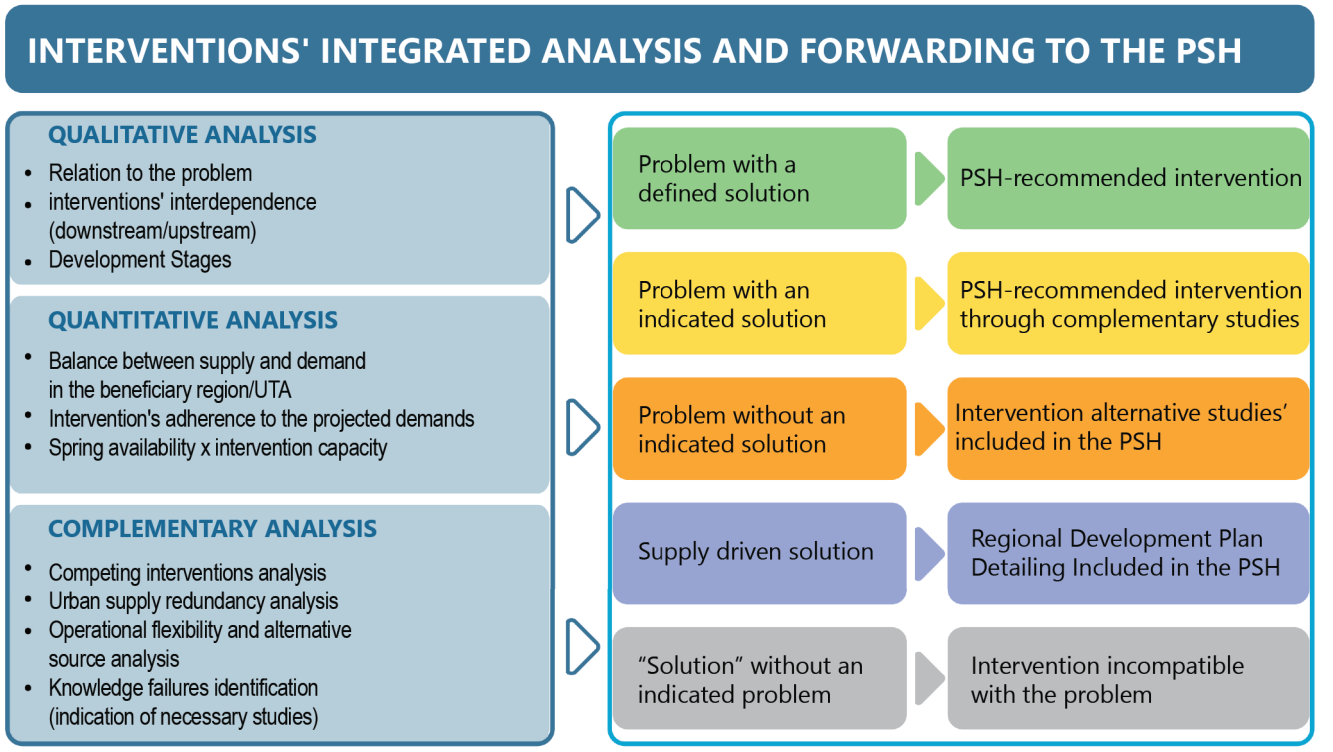
- **Intervention qualified for the PSH through complementary study (problem with an indication of solution):** An intervention that seems at first, to be adequate solution but is not yet consolidated either because not all possible alternatives (water source, pipeline path etc.) have been studied, or because the necessary decision-making elements are not present currently. It may be possible to incorporate this intervention to the PSH after complementary studies.

- **Non-identified Intervention (problem without indication of a solution):** Represents areas with water security problems without proposed solutions. Studies are required to identify the interventions necessary for future analysis and qualification for the PSH

A ***Supply Driven*** type project is primarily designed to induce development based on the supply of water and does not relate to existing supply deficits.

- **Intervention without effective demand (Supply Driven solution):** a Supply Driven project/ intervention type is an intervention that, because the demands are not effective, do not adhere to the methodology developed in the PNSH; in this cases it is necessary to detail regional development plans which promote joint analyses of demand feasibility associated with these interventions. Eventual effective demand confirmation allows for a new analysis to be carried out within the Plan's framework.

- **Intervention incompatible with the problem ("solution" without an identified problem):** an inventoried intervention that does not result in benefits for the area in which it is to be applied or that is located in a region without a water security problem (according to the ISH methodology).



Water Security Program - PSH

The Water Security Program brings together the strategic investments recommended by the PNSH to minimize risks associated with water scarcity and flood control and is subdivided into three major components:

- **Studies and Projects Component:** includes necessary investments for project development (Executive, Basic, and Draft Projects) for recommended works, and complementary studies necessary for confirming potential works, covering: Technical-Economic and Environmental Feasibility Studies – EVTEA; studies of alternatives for the use of water resources in complex areas (Metropolitan Regions and areas lacking water security); and detailed studies of Regional Development Plans.
- **Works Component:** covers investments relating to the physical execution of recommended works.
- **Institutional Component:** includes estimated investments for the recommended works' operation and maintenance (O&M), except for of electric energy.

The Studies and Projects Component and the Works Component investments are detailed in summary sheets for the proposed interventions. The PSH also includes executive planning for its implementation materialized in physical-financial schedules extending from the short term to the 2035 horizon.

The PSH totals 27.58 billion BRL in recommended interventions (works, projects and studies) and a 1.2 billion BRL/year average in operation and maintenance (O&M) investments.

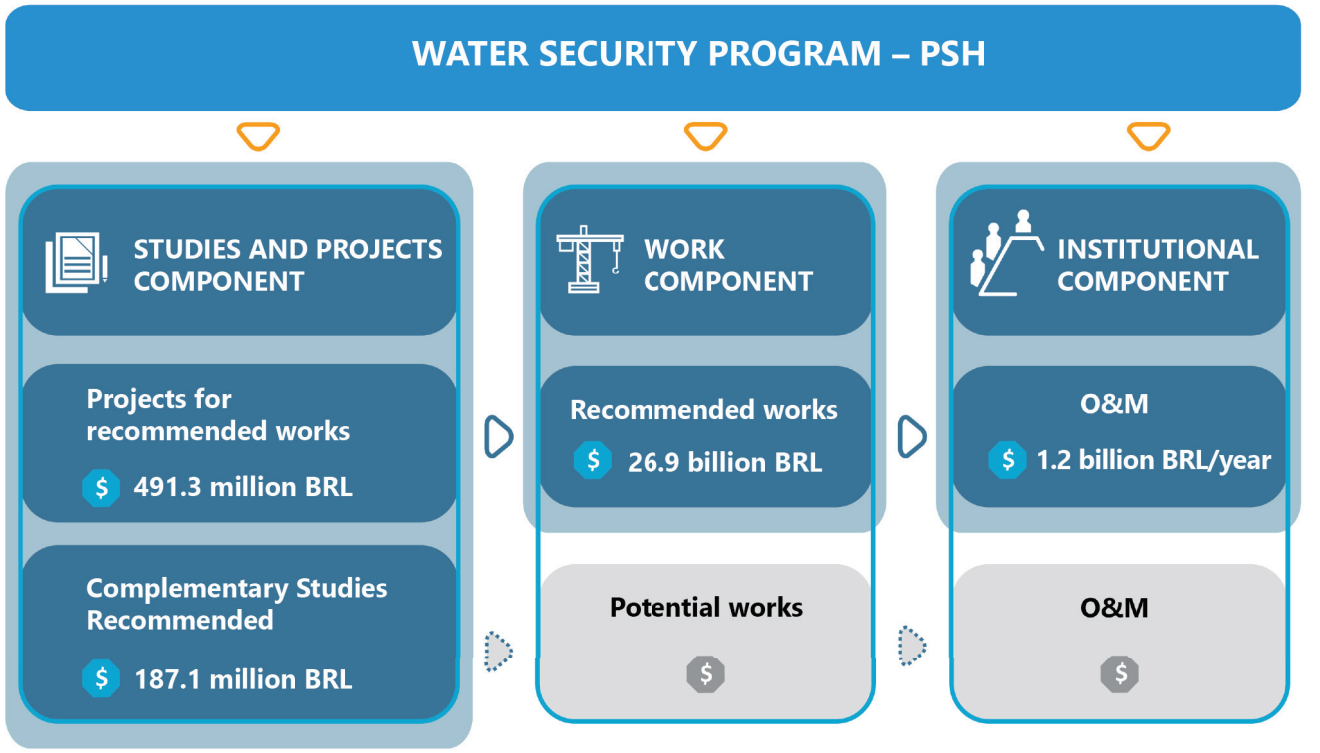
The PSH-recommended works amount to an investment of 27.4 billion BRL (including project costs) up to 2035, distributed into 99 water supply and flood control interventions. Four of the works pertain exclusively to flood control (0.5 billion BRL).

PSH-recommended interventions that require complementary studies account for 187.1 million BRL in investments directed to studies on water supply and flood control.

The largest part of the PSH-recommended investments for increasing water availability is intended for the Northeast region, with emphasis on the Semi-Arid region (15.7 billion BRL, corresponding to 58% of the total), followed by resources for the regions Southeast (8.7 billion BRL or 32%), South (1.2 billion BRL or 5%), Midwest (0.9 billion BRL or 3%) and the North (0.6 billion BRL or 2%) regions.

Investments in flood control recommended works are located in Pernambuco and Santa Catarina states and are related to the ongoing execution of dams in river basins vulnerable to floods. The dams planned in the Paraíba do Sul river basin in Minas Gerais and Rio de Janeiro states require additional studies, as well as the Acre (AC), Mundaú and Paraíba (PE/AL), Doce (MG/ES), Itajaí (SC), Tubarão and Araranguá (SC), Jacuí and Taquari-Antas (RS) river basins, in which studies, identification and analyses of alternatives were recommended. These studies total 23.5 million BRL.

WATER SECURITY PROGRAM (PSH) COMPONENTS



Water Security in Brazil 2

PROÁGUA-Cariri-TAU-Conveyance/CE
Photo: Eraldo Peres/ANA Image Banks. 2006

2 Water Security in Brazil

Brazil is characterized by variations in climate, ecosystems, and land use, which results in challenges for establishing water security indicators that portray these differences and allow a straightforward understanding to apply public policies linked to water infrastructure and management.

The PNSH innovates by presenting a Water Security Index (ISH) that considers four dimensions (human, economic, ecosystemic, and resilience) of the concept of water security in an integrated manner to compose an overall index for Brazil that represents the diversity of the national territory.

WATER SECURITY INDEX OF BRAZIL

The ISH was calculated for the years 2017 and 2035, considering the need for establishing a baseline (diagnosis), and in view of the Plan's horizon. Both projections consider only the existing water infrastructure and differ only in the incorporation of sectoral demands for water use in the 2035 scenario.

The more vulnerable areas for the 2035 scenario are prevalent in the Northeast region, where the impact of the semi-arid climate reduces the water availability to zero, a considerable part of the time – causing the intermittent water courses - and high rainfall inter- and intra-annual variability, mainly reflected in the ecosystems and resilience indicators.

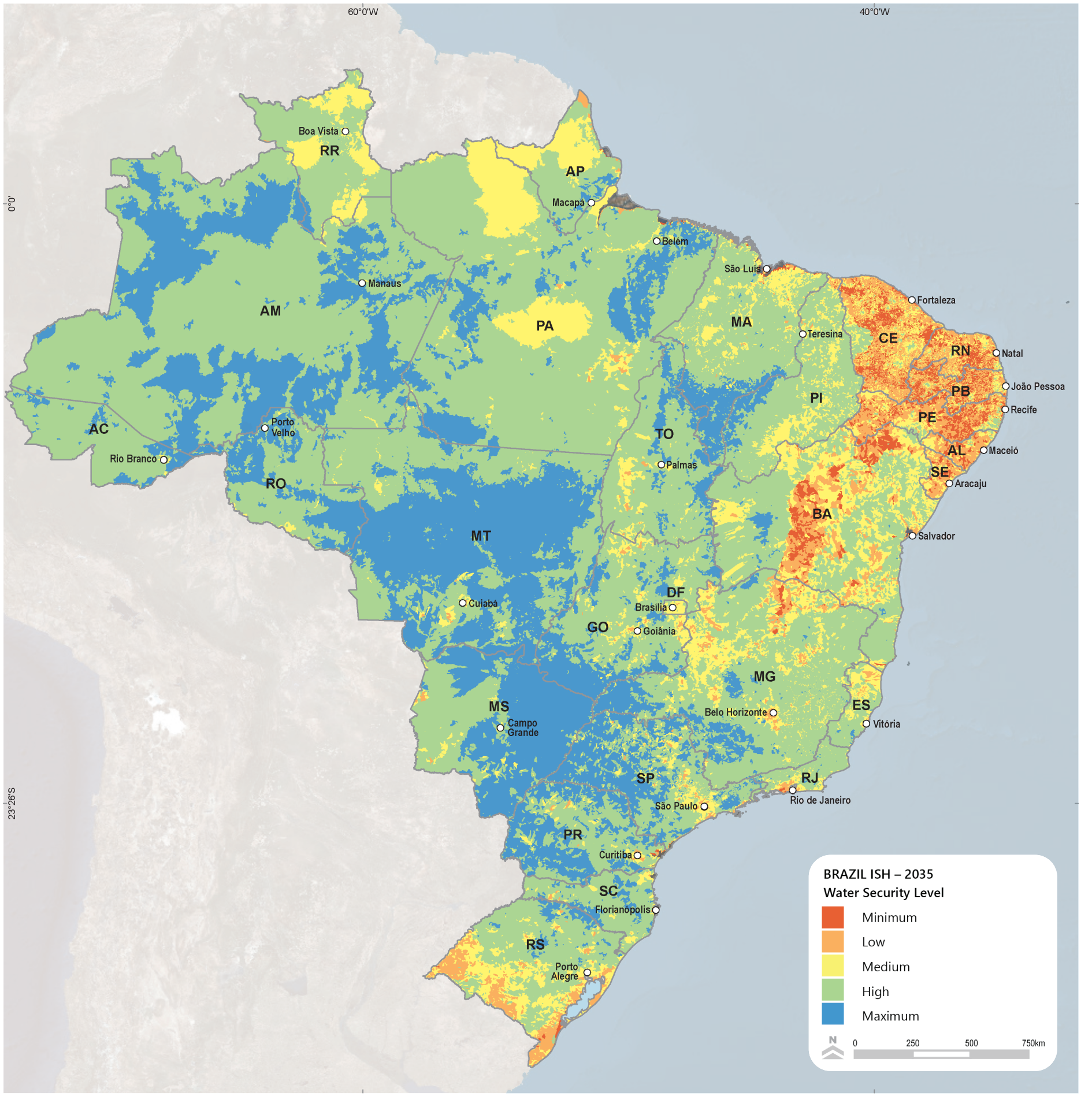
This is also the case for a great part of the São Francisco River Basin. However, in some portions of the São Francisco basin, low water security is the result of high irrigation demands reflected in the economic indicators.

In the Southern half of Rio Grande do Sul, state, the high pressure exercised on the available water resources and the low index of water security derive from a history of land use by flood irrigated rice crops, associated with high rainfall variability.

As for the Metropolitan Regions, low water security is the result of large urban agglomerations and their significant demands. Most MRs also suffer from poor water quality (mainly polluted by untreated domestic sewage). In these economically dynamic and productive regions, the water supply challenge is related to the frequent use of interdependent water sources, many of which are characterized by water transfers between basins, resulting in conflicts over water use. These water sources are mostly used by integrated systems that simultaneously supply several municipal centers in an interconnected manner, requiring complex water infrastructure. Integrated systems are also used to supply the population in the Semi-Arid region.

In regions with higher water security, higher natural water availability combined with low demand pressure are reflected in all dimensions. It is also important to highlight the relative importance of reservoirs for high water security. Reservoirs provide their areas of influence with greater resilience to extreme droughts, increasing the water security in these regions.

Brazil's Water Security Index - 2035



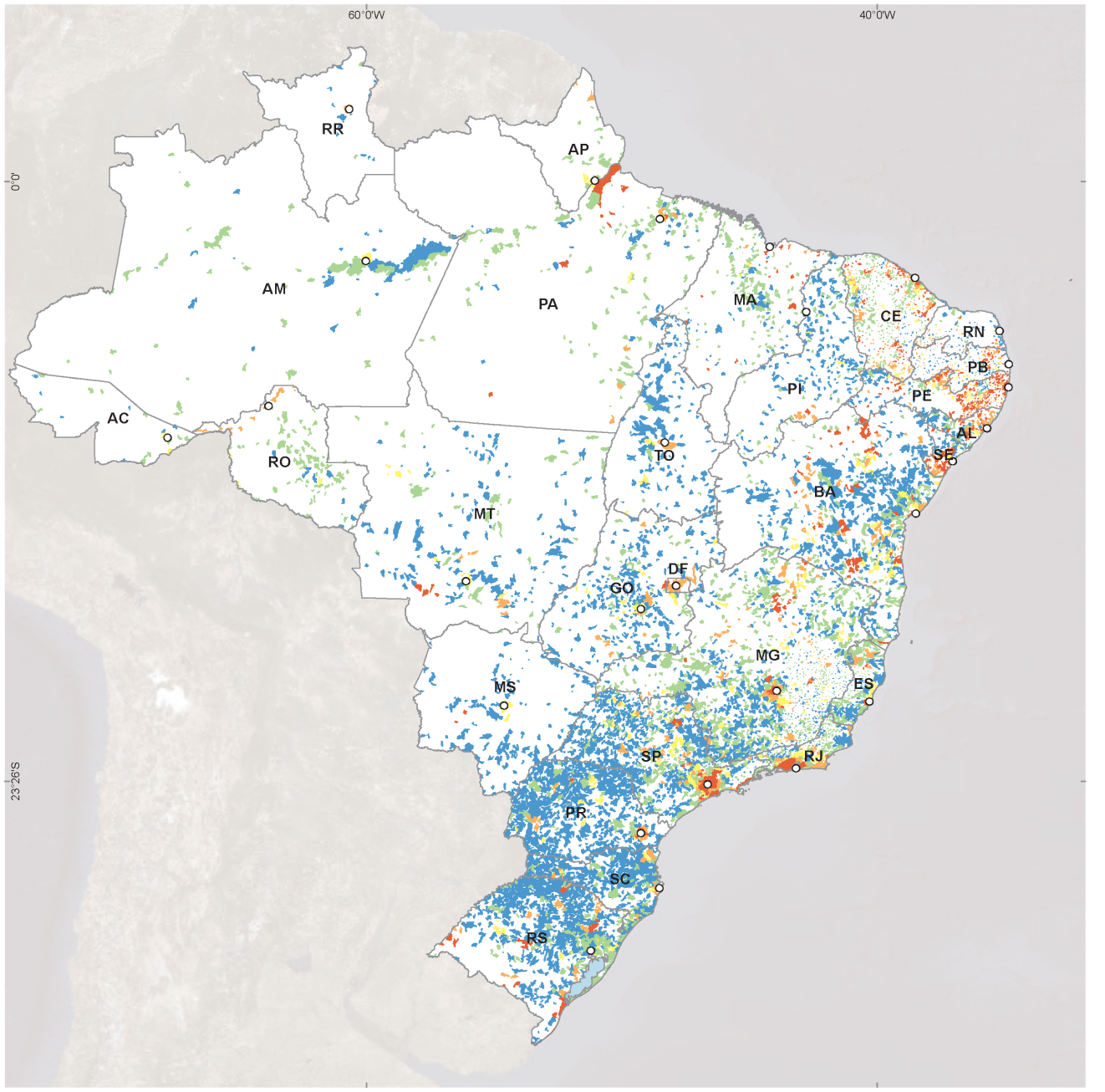
HUMAN DIMENSION

The human dimension of ISH assesses the water supply guarantee for all cities in the country. It aims to quantify the population exposed to greater water risks and to identify critical regions.

The water supply evaluation was carried out based on the availability of surface and groundwater used to supply the population of each municipal center and its capacity to meet the demands. The percentage of the population exposed to shortages was defined through the water balance at each intake point.

The urban distribution network coverage level for each municipality, representative of the population's water access, was used as a restrictive factor in the calculation of the Index.

Human Dimension of Brazil's Water Security Index - 2035



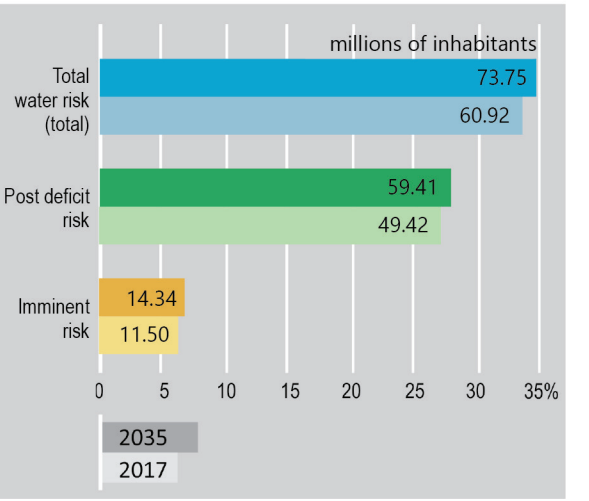
The ISH's calculation resulted in the identification of 60.9 million people (34% of the urban population in 2017) living in cities with low guarantee of water supply. By 2035, the total of the population at risk will reach 73.7 million people.

The majority (80%) of the population at risk is in a post-deficit risk situation, that is, when surface and groundwater sources do not possess sufficient water availability to meet the demands. A smaller portion is in imminent risk, when water demand comes close to the water availability.

These results reflect predominantly the pressure on water resources due to the demand of the large urban population centers' demand, the scarcity of water in some areas (such as the Semi-arid region) and the progressive increase in the urbanization rate of the country, which should approach 90% by 2020.

The human dimension analysis allowed the identification of areas where water conveyance systems and the use of other water sources (existing or requiring new infrastructure) are needed.

Population at Water Supply Risk in Brazil - 2017 and 2035



ECONOMIC DIMENSION

The agricultural and industrial sectors were used to represent the economic dimension of the ISH because these water uses account for the most expressive usage of water resources in the national territory.

This dimension aims to assess the risks to which these sectors are subject considering water supply variability; these risks were measured through the quantification of resulting economic losses, based on the following indicators:

- **Guarantee of water supply for irrigation and livestock:** value of agricultural production and animal breeding loss in the case of insufficient water supply. The indicator was obtained by using the municipal primary production Gross Value Added (agricultural GVA) and the water balance results for irrigation and livestock watering supplied per ottobasins.

- **Guarantee of water supply for industrial activities:** Similarly, the industrial production lost due to water scarcity was measured by the municipal secondary production Gross Value Added (industrial GVA) and the water balance for industrial supply provided per ottobasins.

As for the economic dimension, the total economic production at risk for these sectors due to severe water crises was 228.4 billion BRL in 2017, corresponding to about 13% of the GDP for the same sectors in that year. The post-deficit risk out of this total is estimated at 164 billion BRL and the imminent risk at 64.4 billion BRL. The total risk is forecast at 518.2 billion BRL for 2035, over twice the estimated value for 2017.

According to the criteria of PNSH, the productive activity that is most at risk in both time horizons is that of industrial production, due to its high aggregated values when compared to irrigation and livestock.

The economic dimension analysis allowed identification of the areas where water infrastructure is required for multiple uses (dams, canals and integrated water-conveyance systems).

The economy of a country can be divided into three productive sectors - primary, secondary and tertiary.

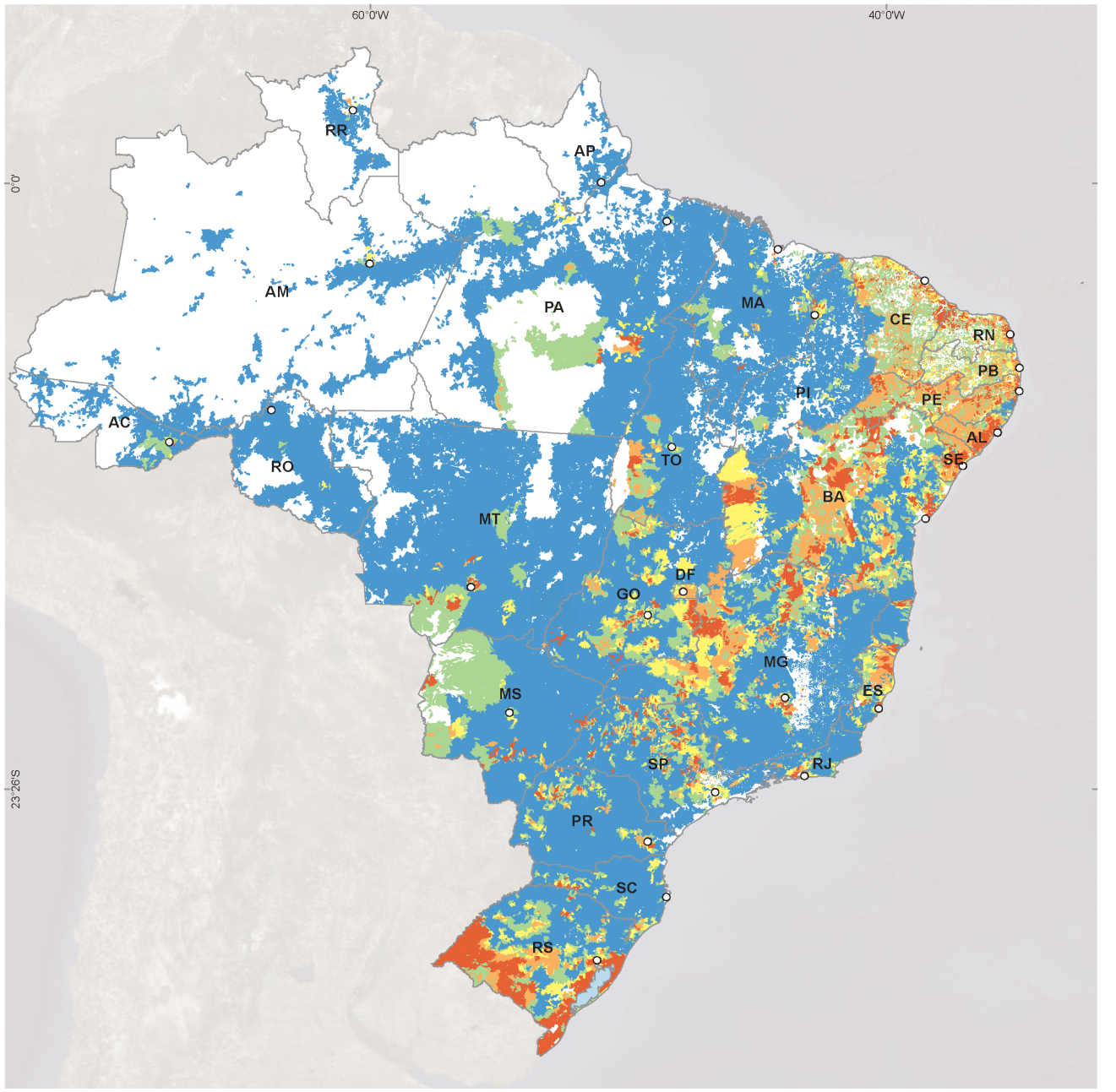
The primary sector is related to activities developed by using natural resources such as agriculture, mining, fishing, livestock, vegetation extraction and hunting.

The secondary sector uses the raw material generated by the primary sector, transforming it into different industrialized products.

The tertiary sector includes all remaining services, such as commerce, education, health, telecommunications, informatics, insurance, transport, banking and administrative services, among others.

Gross Value Added (GVA) is the value that the economic activity adds to the goods and services consumed in its productive process. GVA is the various economic activities contribution to the Gross Domestic Product (GDP) of a country, obtained by the difference between production value and intermediate consumption absorbed by these activities.

Economic Dimension of Brazil's Water Security Index - 2035

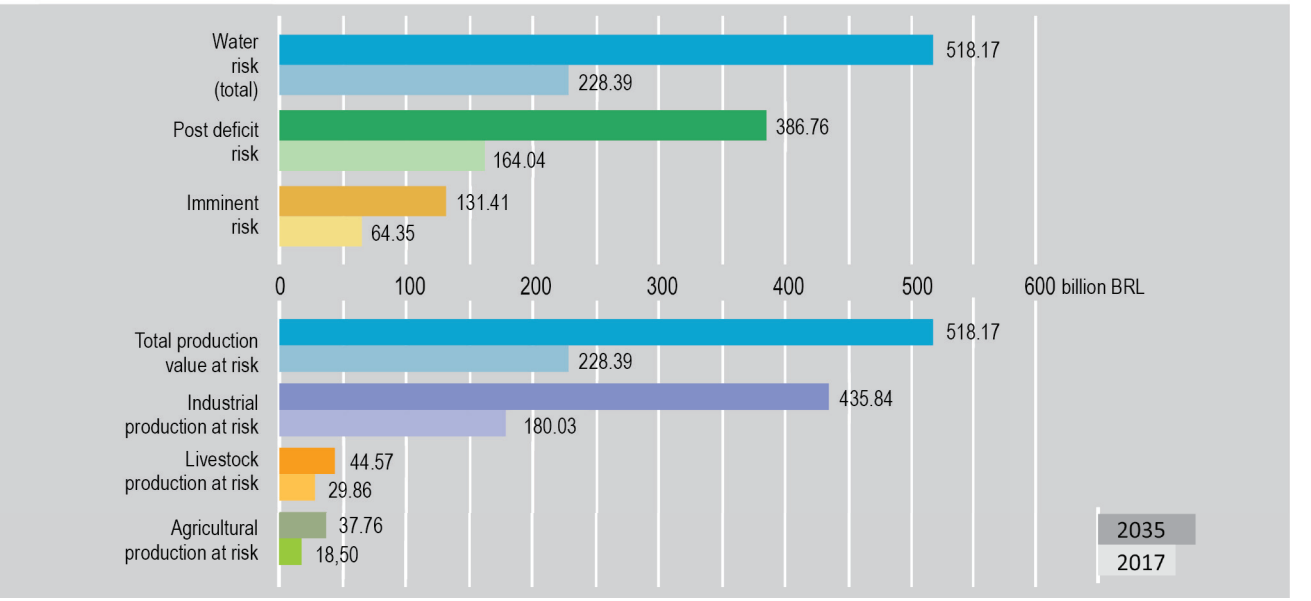


ISH - ECONOMIC DIMENSION
Water Security Level

- Minimum
- Low
- Medium
- High
- Maximum

N 0 250 500 750km

Economic Production at Water Availability Risk in Brazil – 2017 and 2035



ECOSYSTEMIC DIMENSION

Three indicators related to water quality and the environment to represent the ecosystemic dimension of PNSH were selected, in order to demonstrate the vulnerability of the water sources used to supply water for human and multiple uses. These indicators are the amount of water sufficient for ecosystemic uses; the adequate water quality for the maintenance of aquatic life; and the environmental risks resulting from the break of mine tailing dams.

These indicators were defined and calculated as follows:

- **Appropriate amount of water for natural uses:** covers the minimum amount of flow necessary to meet demands of natural uses (survival of the aquatic biota) in a stretch of a given water course, represented by the ratio between the remaining flow after withdrawals for consumptive uses and the natural flow, with 95% permanence in the stretch ($Q_{95\%}$).
- **Appropriate water quality for natural uses:** assessed through the analysis of $DBO_{5,20}$ concentrations in watercourses, considering standards defined by the National Environment Council (CONAMA) Resolution No. 357/2005. For this purpose, information from the Wastewater Atlas was used.
- **Safety of Mine Tailing Dam:** considers the existence of over 700 mining tailing dams in the country in 2017 and the potential damage (impacts) in the downstream stretches due to possible breaks, based on the evaluation of their safety conditions (break risk). In stretches with more than one dam located upstream the most critical value was adopted.

The **$Q_{95\%}$** is a low flow reference. This means that flows equal to or greater than this value will occur 95% of the time.

The **Biochemical Demand for Oxygen (DBO)** represents the amount of organic pollutants in the water, resulting from the release of effluents from various sources, such as domestic sewage, industrial effluents and others. CONAMA has set maximum BOD limits in the water for various purposes.

Mariana and Brumadinho Disasters

The Fundão dam break (Mariana, MG) on November 5th of 2015 released an estimated volume of 34 million cubic meters of mine tailing waste, causing 19 human deaths and various socio-economic and environmental impacts in the Doce river basin. The mud and flood waves produced by the break traveled over 650 km to the mouth of the Doce river on the coast of Espírito Santo.

The great load of sediments that reached the basin water bodies caused water supply interruption for the population supplied by the Doce river, in addition to the temporary suspension of other uses (power generation, industry, irrigation and livestock, fishing, and tourism), and biodiversity loss in the affected region.

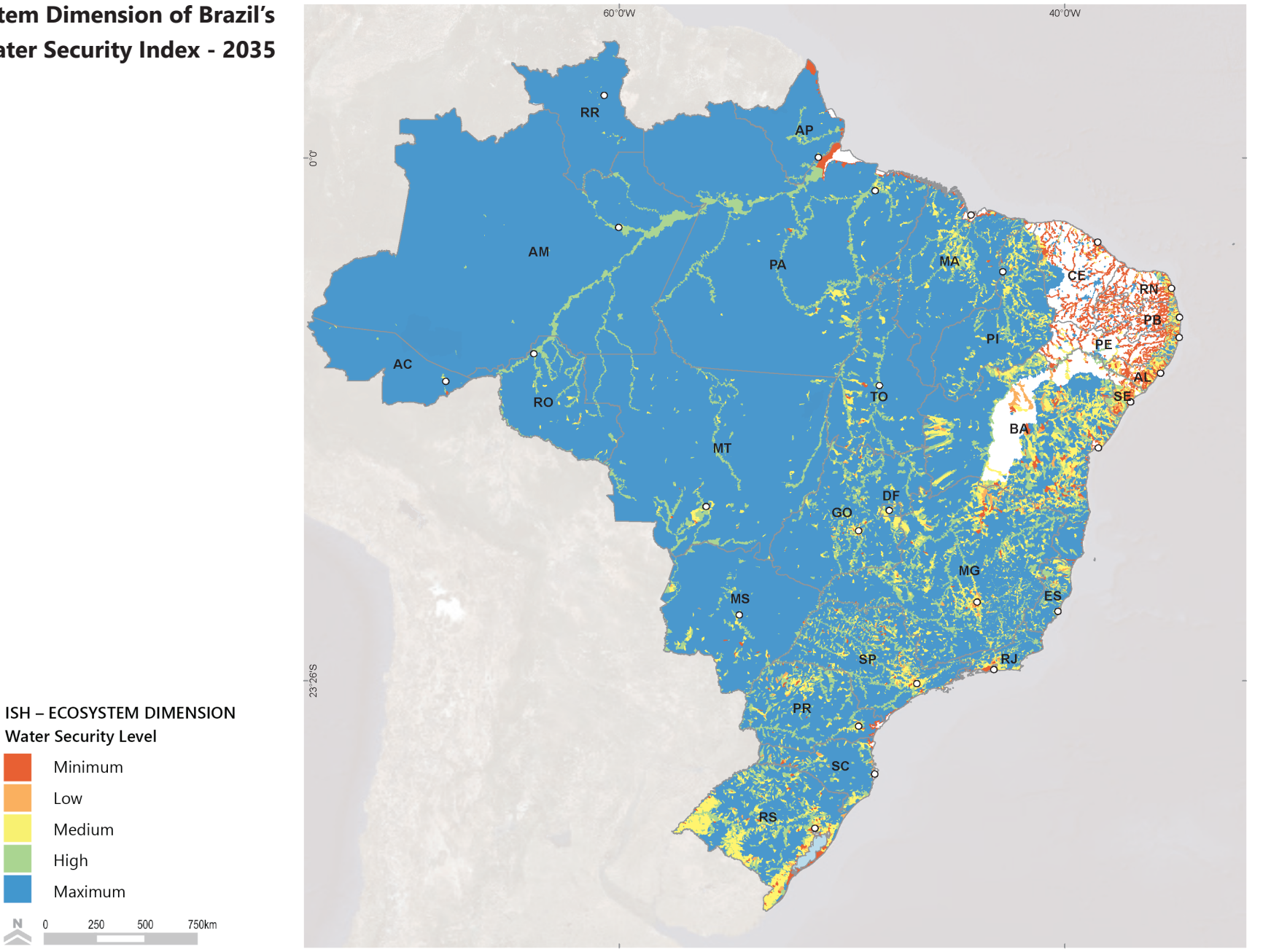
The population affected by water supply suspension was of about 477,000 people who lived in eight municipal centers that withdrew water directly from the Doce river; in addition, four other locations had their supply systems partially affected.

Emergency supply for the cities of Governador Valadares (MG) and Colatina (ES) was particularly difficult due to their population size (over 100,000 inhabitants) and their exclusive dependence on the Doce river. This challenging experience left remarkable water security lessons.

Another major disaster, this time causing the death of hundreds of people, occurred on January 25th of 2019, due to a dam break at the Córrego do Feijão mine, located in the municipality of Brumadinho, also in Minas Gerais state.

The mud resulting from the dam break reached the Paraopeba river, which supplies about 3 million people living in the Belo Horizonte Metropolitan Area. The water supply of the entire population could have been severely damaged had this happened during a water crisis. Economic activities (irrigated agriculture) and supply for riverside populations were also impacted.

Ecosystem Dimension of Brazil's Water Security Index - 2035



ISH – ECOSYSTEM DIMENSION
Water Security Level

- Minimum
- Low
- Medium
- High
- Maximum

N 0 250 500 750km

About 2% of the area of the country is at a minimum safety level according to the ecosystemic dimension of the ISH. This is mainly due to high DBO concentrations in watercourses predominantly polluted by untreated domestic sewage.

This dimension identifies critical areas that face water supply limitations in meeting demands due to low water quality and environmental issues.

RESILIENCE DIMENSION

The resilience dimension of ISH expresses the potential of Brazil's natural and artificial water stocks to supply demands for multiple uses in severe drought situations (events that may be aggravated by climate change).

Water resources are available in rivers, fed mainly by rainwater, in aquifers, which also contribute to basic watercourse flows, and in artificial reservoirs.

Thus, the sum of water volumes available in all these environments is useful to evaluate the resilience potential of a region. The following ISH indicators were considered for this dimension:

- **Artificial Reserve:** potential water supply provided by the country's 20,000 artificial reservoirs.
- **Natural Reserve:** Natural water supply in rivers, represented by the relationship between the average watercourse flow rate and the low flow rate.
- **Underground storage potential:** groundwater stock in the country's aquifers, estimated based on the infiltration coefficient (CI). This coefficient is represented in the present case by its average value for each aquifer type.
- **Rainfall variability:** represented by the variation coefficient (CV) of the 3,368 yearly rainfall series spatially located for the entire national territory.

Places where the river low flow is close to its average flow values generally correspond to regions with important recharge aquifers. Therefore, the ratio between the low flow and the average flow can indicate the percentage of the **natural water provision** of a river.

The **Infiltration Coefficient (IC)** measures an aquifer's ability to be recharged from surface by rainwater.

The **Variation Coefficient (CV**) measures the dispersion (or variability) of a series of data relative to its average. The total annual rainfall measured in each rainfall station correlated to its historical series was used for this characterization. The lower its value, the more homogeneous the data will be.

Climate Change in the PNSH

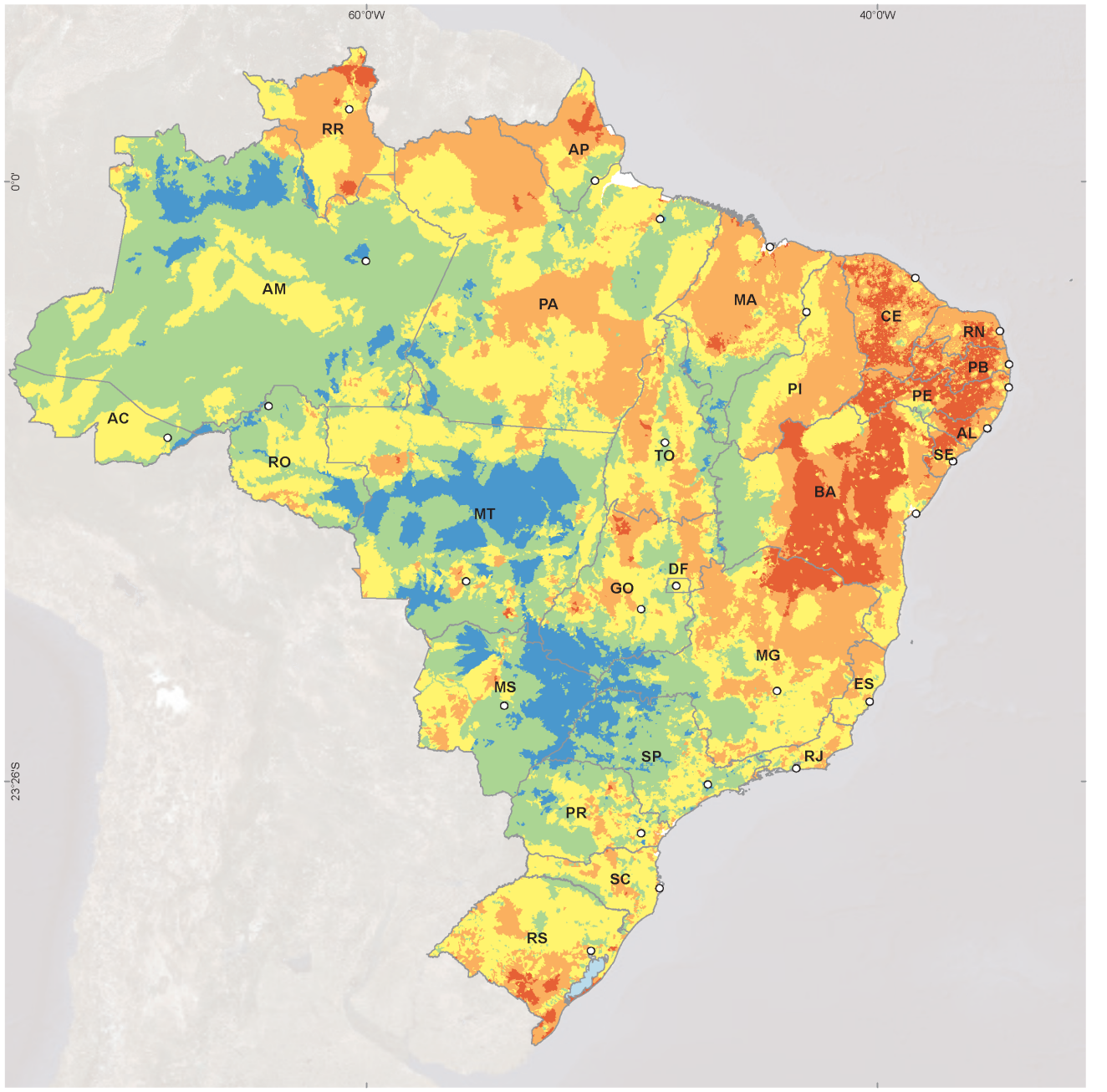
The hydrological cycle is directly linked to changes in the atmospheric temperature and in the radiation balance. According to the general circulation models (GCMs), it is expected that the warming of the atmosphere may cause, among other consequences, changes in rainfall patterns (increased intensity and variability), which may significantly affect the availability of river flows and their distribution in time. In short, studies show that critical hydrological events - droughts and floods – may become more frequent and more intense.

The impact of climate change on the hydrologic behavior of a certain region may be evaluated using two types of information: GCMs climate projections and possible changes identified in the hydroclimatologic historical variables, which are monitored. With regard to the first type: it is important to emphasize that the uncertainty level among different models in the early years of the projection (up to 2035, for example) is high. Therefore, it is difficult to identify climate change tendencies that may be internalized in the PNSH.

Thus, the second option is more feasible for this case, since it considers possible change behaviors that are already present in the time series. For planning horizons that are not very long this evolution is more likely not to vary significantly. In addition, possible variabilities and short and long-term persistence are better characterized in the observed time series than in the general circulation model results.

Therefore, the results of the water security indicators results using the time series and including recent data on results of hydroclimatological variables, such as the rainfall variation coefficient and the reference flows, with 95% permanence which were adopted in the ISH, implicitly consider possible climate changes.

Resilience Dimension of Brazil's Water Security Index - 2035



ISH - RESILIENCE DIMENSION
Water Security Level

- Minimum
- Low
- Medium
- High
- Maximum

N 0 250 500 750km

The ISH's resilience dimension for Brazil shows a heterogeneous spatial distribution compatible with the country's continental characteristics, and indicates the semi-arid region as the most vulnerable.

This dimension analysis allows identification of areas with lower resilience levels, where deficits in water balance are considered more critical due to the high rainfall variability added to the absence of reservoirs or groundwater storage. These areas require more complex and generally integrated water infrastructure and regional coverage.

3 Intervention Selection

PISF North Axe Channel - Cabrobó/PE
Photo: Ministry of National Integration. 2016

3 Interventions Selection

The selection of strategic interventions for supplying water (dams, water conveyance systems, canals and integrated water-conveyance systems) is based on the integrated analysis (qualitative, quantitative and complementary analyses) of the Studies, Plans, Projects and Works (EPPOs) inventoried for the Territorial Units for Analysis (UTAs) adopted as spatial reference for the most critical water security areas.

The results were aggregated for the country and detailed by region. The São Francisco river basin was considered the most critical. This basin received special attention in the PNSH due to its complex water balance and the large number of existing and planned projects to take advantage of its water (many of these projects cross basin borders, a fact which justifies its designation as a national integration river).

RESULTS FOR BRAZIL

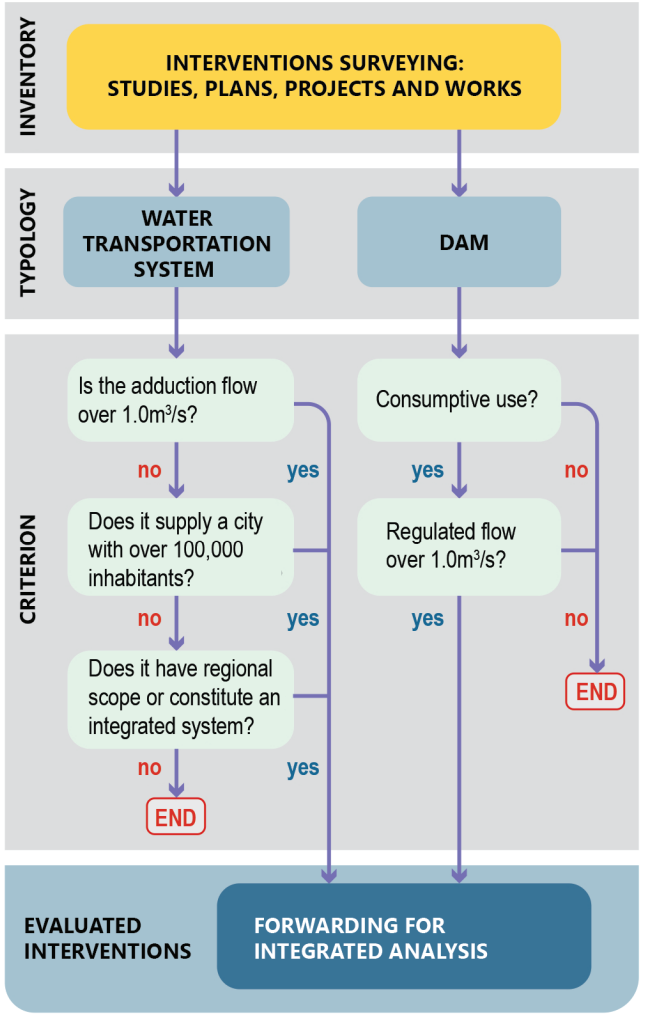
115 UTAs were identified based on the ISH. These Territorial Units for Analysis were evaluated based on values of the risk indicators of the human and economic dimensions compared to the risk value for the State in which these areas are located.

The inventory of EPPOs resulted in an expressive amount of interventions at different stages, with different sizes, scopes, objectives, and regional importance, totaling 624 interventions. Most of the interventions were conveyance systems (51%) and water storage dams (43%).

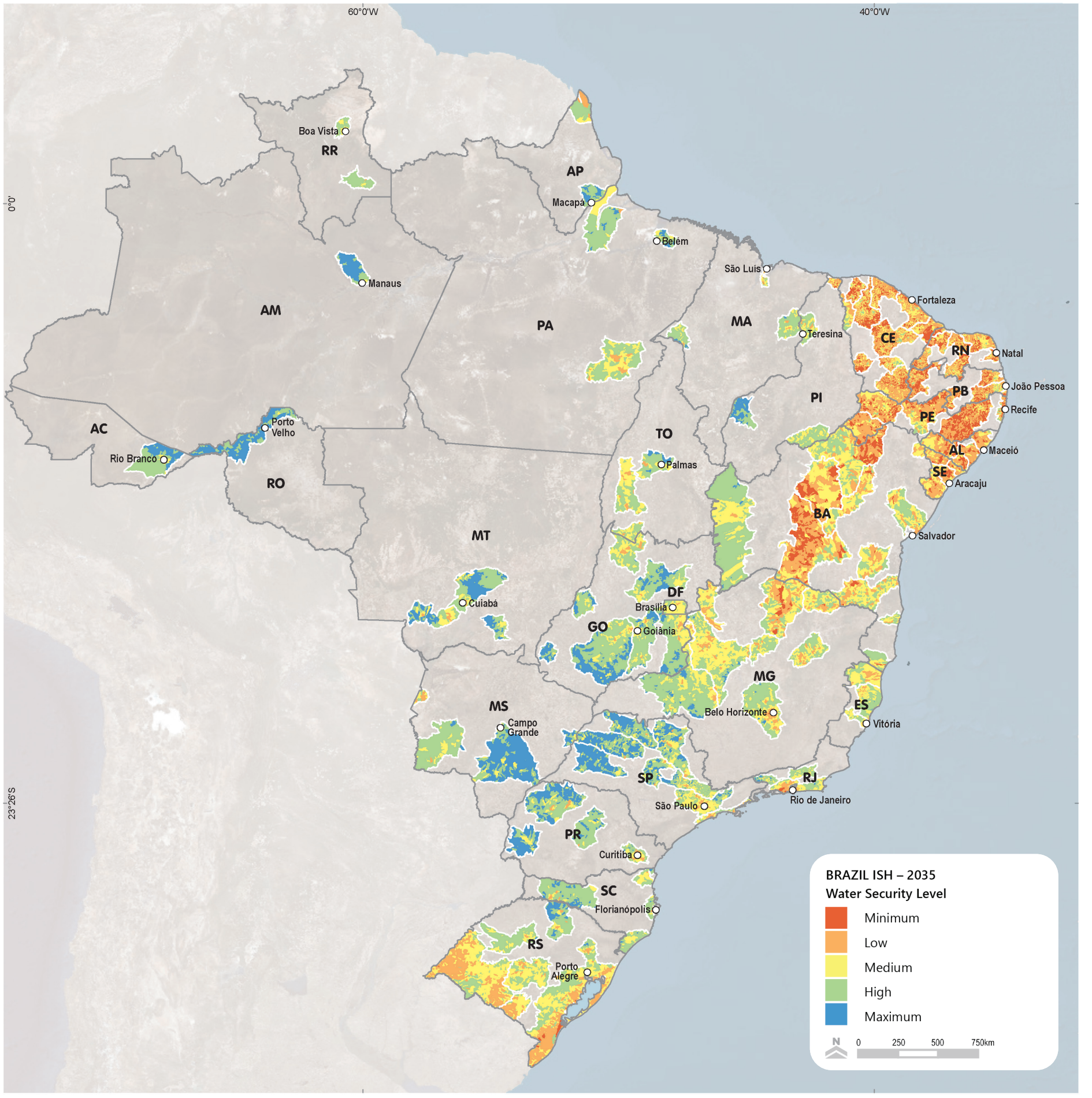
For the analysis of the interventions that contribute towards increasing water supply the initial criterion used for selecting the inventoried EPPOs, that would make up the Integrated Analysis step, was the intervention's size regarding the amount of transported flow (conveyance system works) or the flow regulated by the dams. The 1 m^3/s reference value was defined as the basis for the structuring character use for the inventoried solutions.

Regional coverage EPPOs (that do not necessarily reach particularly high values) were also considered eligible when proposing to benefit a population of over 100,000 inhabitants, an important socio-economic development pole, or an integrated supply system (a common source system that supplies more than one municipal center).

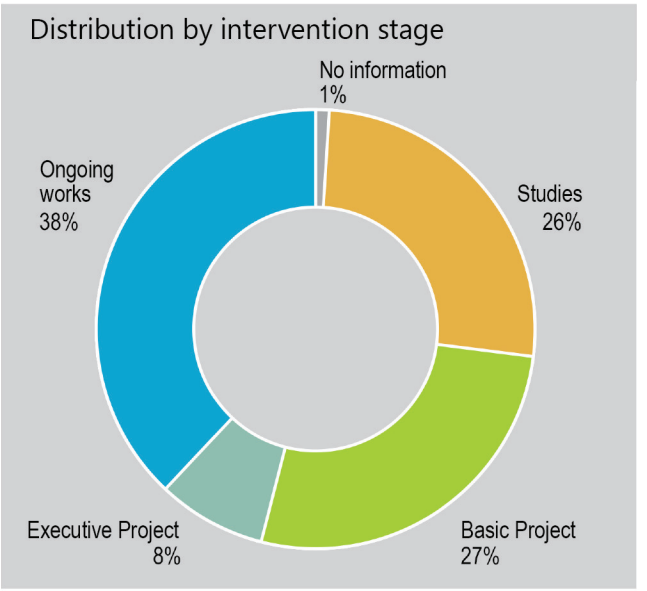
Step by step: From the EPPOs Inventory to the Integrated Analysis

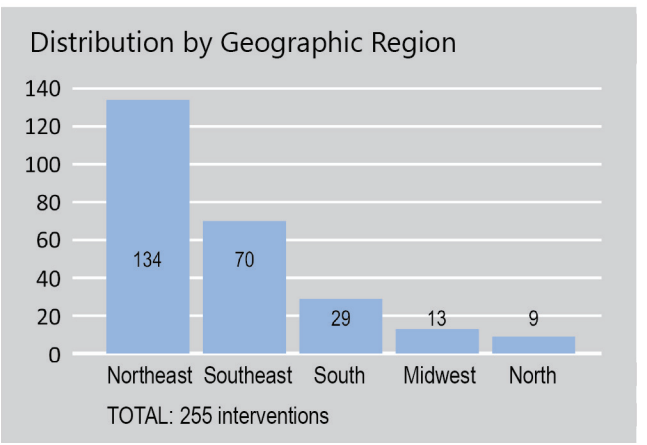


UTAs listed by the PNSH



Interventions selected for Integrated Analysis – Brazil



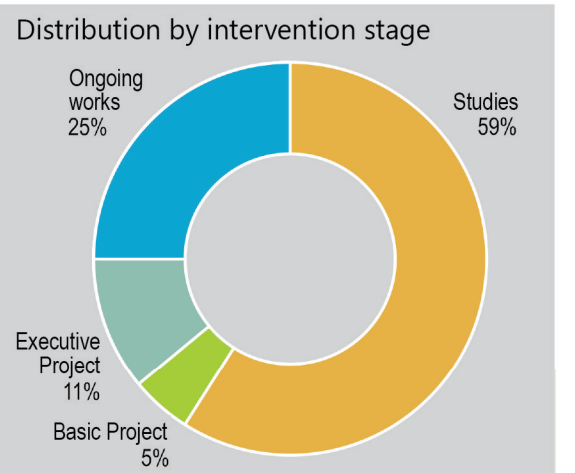


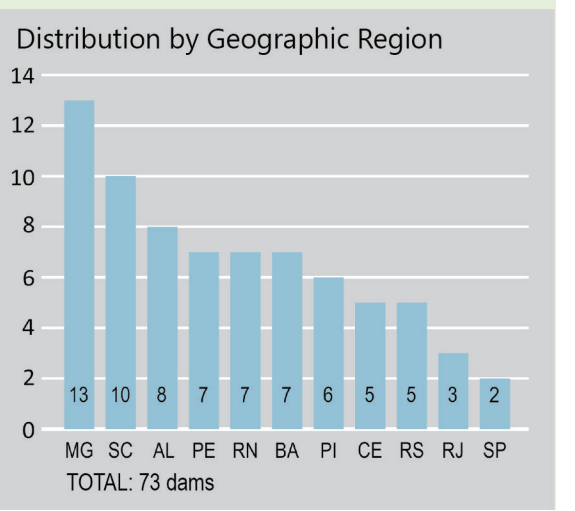
Considering the 624 EPPOs surveyed and analyzed according to the first criteria, 255 interventions were forwarded for Integrated Analysis in the 115 UTAs.

Most of these interventions consist of works in progress or ongoing bidding procedures (38%), 26% of studies, 27% of basic engineering projects, 8% of executive projects and 1% do not provide sufficient information about what stage they are in.

The Northeast and Southeast regions concentrate 80% of the interventions selected in the Inventory stage for evaluation in the PNSH Integrated Analysis stage.

Flood control dams included in the inventory





Flood Control - Inventory Results

The flood control inventory favored a broad and integrated look at each critical basin diagnosed in order to select specific dam solutions capable of minimizing flood vulnerability.

This inventory followed a similar methodology to that of the water supply interventions inventory and was based on the analysis of ANA's technical collection, on internet research, and on water resources plans and documents made available by several state and federal agencies. The chosen basins to be studied were the critical basins which were defined by the high frequency of floods and/or the severity of the impacts associated with the lack of logistic support.

73 dams were inventoried based on flood control studies, plans, projects or works. No dams have been identified for flood control in the following vulnerable river basins: Acre (AC), Doce (MG/ES), Tubarão and Araranguá (SC) and Jacuí and Taquari-Antas (RS). Dams may not be the best solution for flood control in these areas, alternative solutions must be sought.

Out of the 255 interventions surveyed by the Inventory, 95 (37%) fully met the Integrated Analysis criteria and were incorporated to the PSH and 62 (24%) required complementary studies still to be elaborated for decision-making concerning the forwarding process; these additional studies were also added to the PSH.

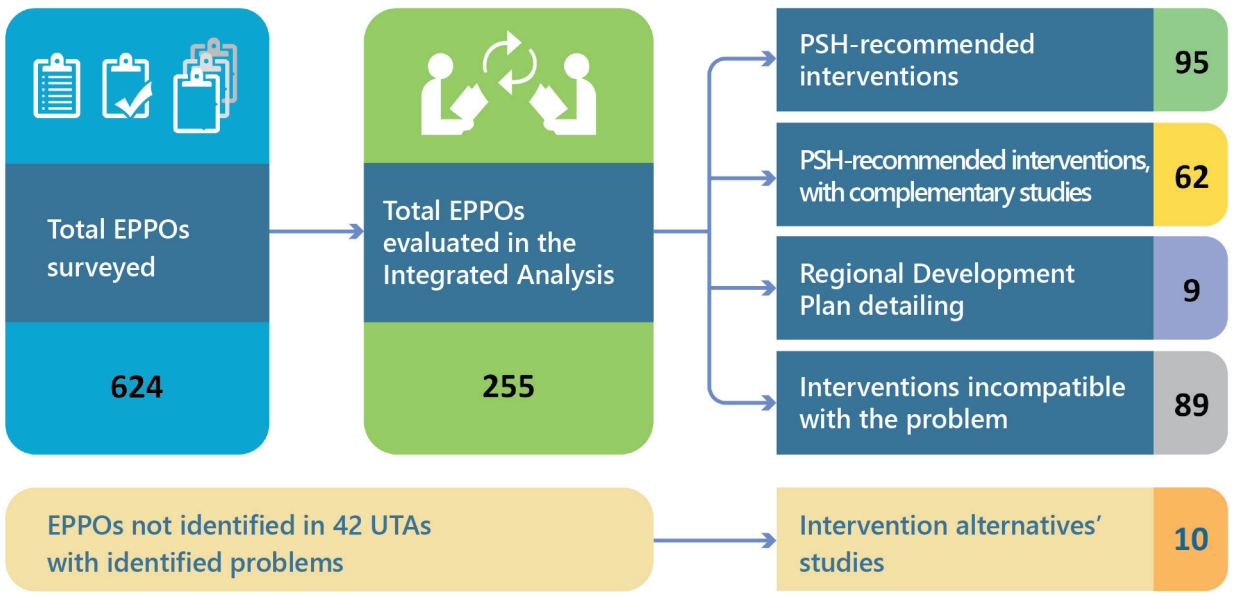
Nine inventoried interventions correspond to Supply Driven projects that require detailed regional development plan studies that promote integrated update and feasibility analysis of the demands associated with the interventions. The validation of effective demands should allow for a new analysis within the PNSH.

The other 89 interventions (35%) subject to integrated analysis are proposals incompatible with the water security problem identified by the PNSH.

Thus, 166 interventions (at different development or maturation stages) were selected to integrate the PSH including ones that fully meet the Plan's criteria, ones that require complementary studies, and nine projects that must be re-evaluated based on detailed regional development plan studies.

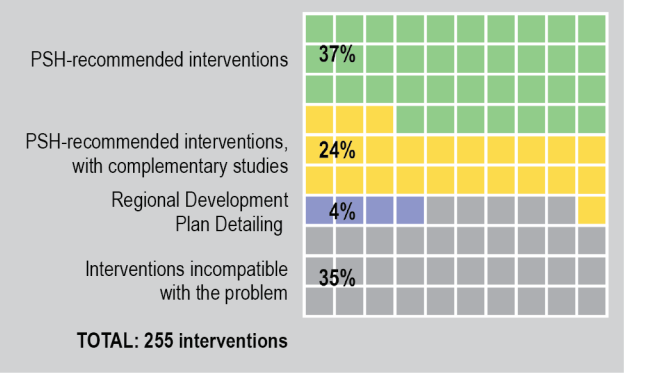
Supply Driven projects:

- Pernambuco Sertão Canal
- Xingó Canal
- Bahia Sertão Canal/South Axis
- Piauí Sertão Integration Canal/West Axis
- Alagoas Sertão Canal (stretches VI,VII and VIII)
- Entremontes Extension Line
- Ceará Water Belt (stretches II, III and extension lines)
- Acauã-Araçagi Canal/Coastal Branches (Stretch 3)
- Water Transfer from the Tocantins River Basin to the São Francisco River Basin



INVENTORY RESULTS AND INTEGRATED ANALYSIS - WATER SUPPLY

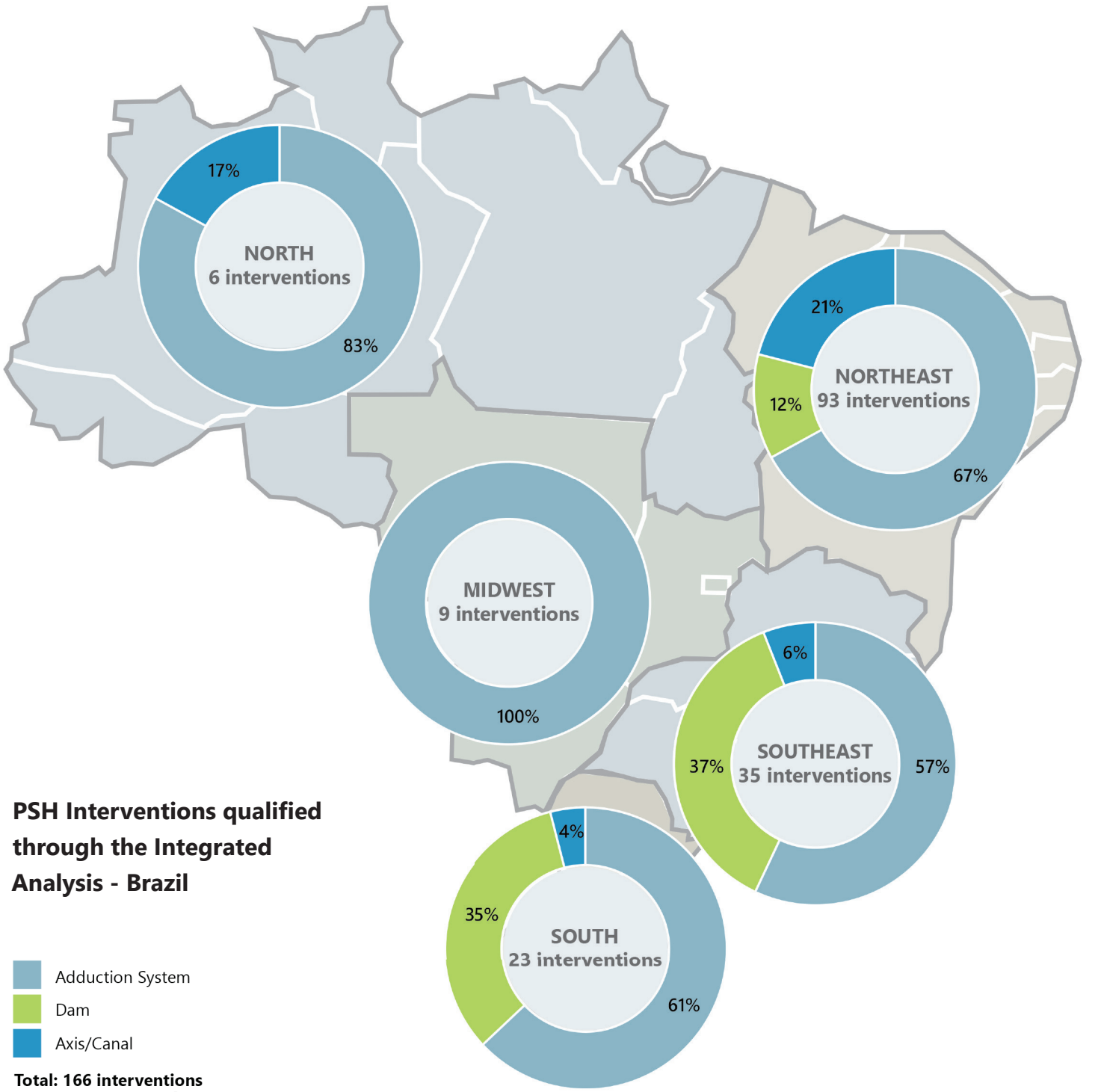
Classification of interventions evaluated by the Integrated Analysis - Brazil



The Integrated Analysis also mapped 42 UTAs with water security problems for which no intervention was identified in the inventory, characterizing problems without indicated solutions. Studies involving the ISH's refinement are proposed for these areas considering water deficits observed in the human and economic dimensions and water resources use studies in low water security areas.

As a reflection of the results of ISH and the mapping of water security risks in Brazil, the Northeast region is the one that presents the greatest amount of interventions added to the Water Security Program, followed by the Southeast, South, Midwest and North regions. The interventions mainly focus on water conveyance systems and dams.

Integrated water conveyance systems and canals are also significant in the Northeast Region mainly relating to water use proposals for the São Francisco River, namely the São Francisco River-Northern Northeast Region Integration Project (PISF).



ANALYSIS OF THE SÃO FRANCISCO RIVER USES

The São Francisco river is the third largest river in Brazil, with a basin that occupies 8% of the national territory and extends throughout the states of Alagoas, Bahia, Goiás, Minas Gerais, Pernambuco, Sergipe and the Federal District. The river has historical importance for the country and plays an important role in the occupation and development of the Northeast Region, especially in regards to the use of its waters for irrigated agriculture and generation of energy.

Agriculture is one of the main economic activities of the basin, with strong irrigation demands related to the public perimeters installed along the river. The Review of the São Francisco River Basin Water Resources Plan for 2016-2025 signals that 79% of the withdrawal flow in the basin is used for irrigation. When compared to the total granted amount of water for this type of use, the actual withdrawal value corresponds to only 52% of the granted flows, indicating a deficit in the full implementation of the irrigation projects, (at which much of the region's socio-economic development model is anchored).

The public irrigation projects in the São Francisco basin dates back to the second half of the 1960s and gained momentum with the creation of the São Francisco and Paraíba Valleys Development Company (CODEVASF). Forty-one of these undertakings are currently in operation and six are in the implementation phase. Considering the irrigation perimeters in operation that withdraw water from the mainstream of the São Francisco river from its direct tributaries, the flows amount to 206 m3/s. The total water infrastructure capacity associated with the projects in operation and in the implementation phase amounts to 296 m3/s, with a utilization rate of about 70% in terms of cultivated irrigable areas

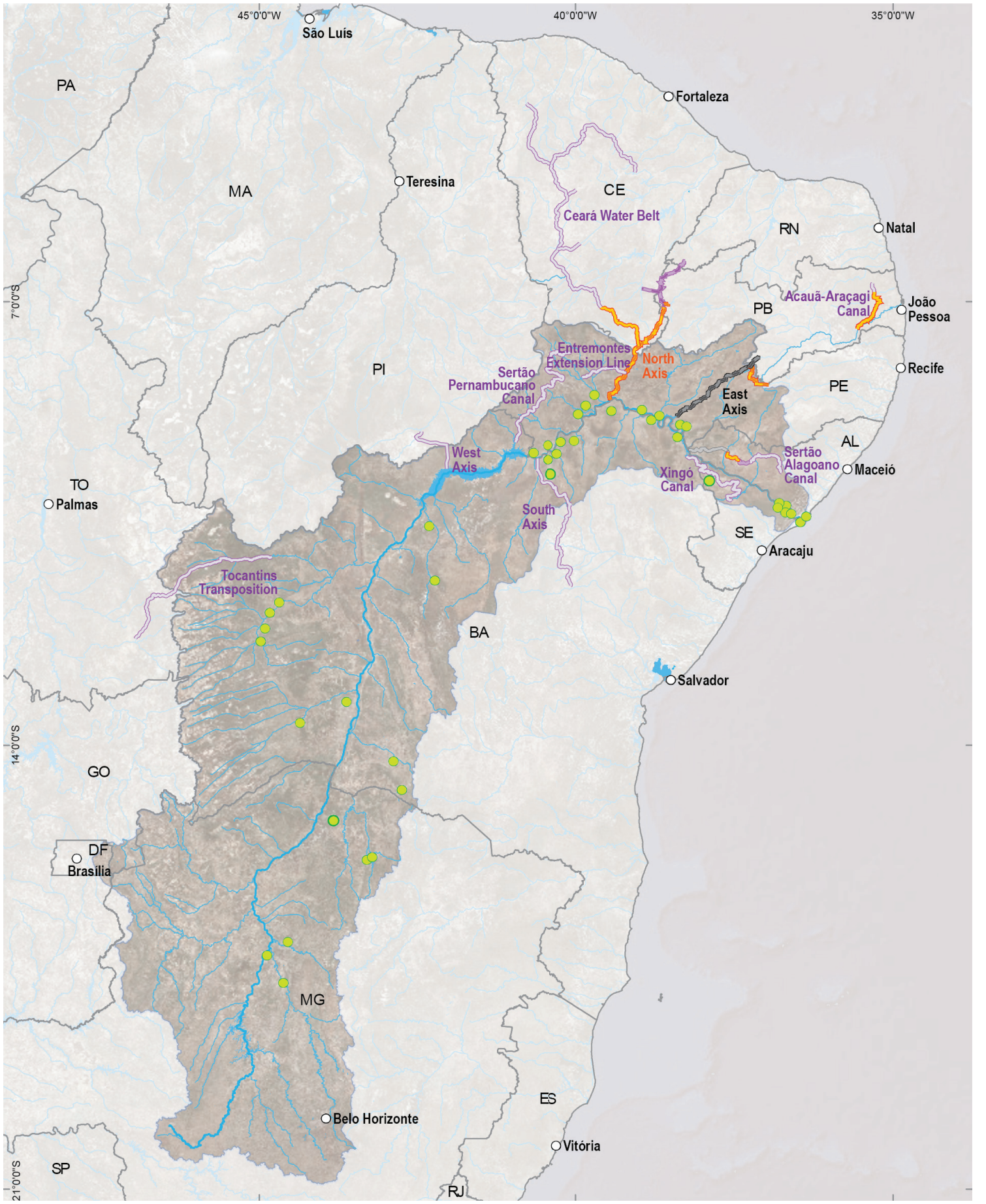
Therefore, there still is a long way to go in order to guarantee the effectiveness of the irrigation perimeters in the São Francisco basin, both in increasing utilization rates of those projects already in operation or in the conclusion of projects currently being implemented. Complementary public investments are necessary in both cases.

The same logic applies to the Integration Project of the São Francisco River with the Northeast Region (PISF) where the effective use of water also depends on investments in complementary works; notably the water-deriving branches of the PISF and new conveyance systems, as well as the execution of canal branches not yet started (Salgado and Apodi Branches). When considering only the East Axis of PISF (in pre-operation) and the works in the North Axis, about 57 municipalities can directly benefit from these investments. This number can be increased to 261 municipalities considering the PSH additional infrastructure, which will increase the PISF's waters capillarity in the territory.

Supply Driven projects using São Francisco river waters

Supply Driven Interventions	**Water source**	**Beneficiary state**	**Capacity** m^3/s	**Value Executed** (Billion BRL)	**Remaining Value Estimated** (Billion BRL)
Pernambuco Sertão Canal	São Francisco River	PE	71.5	-	1.80
Xingó Canal	São Francisco River	BA/SE	33.0	-	4.15
Bahia Sertão Canal/South Axis	São Francisco River	BA	32.0	-	4.99
Piauí Sertão Integration Canal/West Axis	São Francisco River	PI	30.0	-	ND
Alagoas Sertão Canal	São Francisco River	AL	32.0	1.80	2.50
Entremontes Extension Line	PISF North Axis	PE	25.0	-	1.61
Ceará - CAC Water Belt	PISF North Axis	CE	30.0	1.07	19.90
Acauã-Araçagi Canal/Coastal Branches	PISF North Axis	PB	10.0	0.54	0.56

São Francisco River Basin - Supply Driven Projects



Besides PISF, the PNSH identified other works and water use proposals for the São Francisco River. These projects are characterized as Supply Driven and have regional development as their main goal.

This set of development projects totals altogether a flow of 198.5 m^3/s, which, added to the PISF's total capacity (126.3 m^3/s), amounts to 324.8 m^3/s. This means that the scale of the new São Francisco water infrastructure if added to the PISF Axes is much larger than the total capacity (206 m^3/s) of all irrigation perimeters operating in the basin in the last 50 years.

It is worth highlighting among these projects those that have parts under construction and parts in operation, such as the Alagoas Sertão Canal (stretches I to IV), the Ceará Water Belt (stretch I) and the Acauã-Araçagi Canal, in the state of Paraíba (stretches I and II). The effective and widespread use of these stretches depends on additional investments that, from a water security standpoint (and according to the PNSH) should be prioritized before the implementation of new stretches. This concern is shared by the States involved, who have developed complementary actions to make the existing infrastructure more effective.

To make effective these stretches of the PISF and the public irrigation projects and perimeters in the São Francisco river basin represents an enormous challenge. Considering a hypothesis of using 80% of the capacity of this proposed additional infrastructure for irrigation only, would be necessary an area of approximately 1,400 thousand hectares, which is much bigger than the present public perimeters' irrigated area (110 thousand ha) and even the total irrigated area in the basin (779 thousand ha), including private enterprises.

In addition to this issue, the São Francisco river basin also requires special attention as to its water availability. As shown in Chapter 2, the ISH shows that the São Francisco basin has a large extent of its area under low and minimum water security, which reveals the complexity of its water balance. Ever since 2012, the basin has been facing a historical drought, with lower than average rainfall and flow rates and, as consequence, a significant loss of stored volume in reservoirs. From 2015 to 2017 the usable storage in the reservoirs was below 10% of the total usable storage capacity, and several water supply and demand management actions were executed to cope with this situation. By the end of 2018 the usable storage was at a safer level (25%). However, special attention and coordinated actions among stakeholders are still necessary in the basin, including the reduction of water volumes released by the reservoirs.

The problems related to the São Francisco river basin water balance have also led to a new debate about water transferring from the Tocantins river to the São Francisco River. The estimated capacity (30 m^3/s) does not seem to bring significant impact from a water supply standpoint if compared to the water availability of the basin (875 m^3/s) or even with the evaporated amount of water from the Sobradinho lake (110 m^3/s).

In this complex and fragmented context, and considering the Tocantins river transfer proposal and especially the magnitude of the São Francisco river's exploitation projects (especially those not yet started), a study to detail the regional development plans is recommended as a previous stage to decision-making regarding all these projects.

This study should evaluate all interventions in an integrated manner and focus on the effectiveness of the demands and on the vulnerabilities and capacities of the affected basins. Water infrastructure should be handled as only one of multiple variables, additionally to the public and private sectors investment capacity for implementing the demands, the consumer market, the energy supply, transportation logistics, environmental preservation, among others, all of which should be considered in the evaluation and qualification of water supply driven projects.

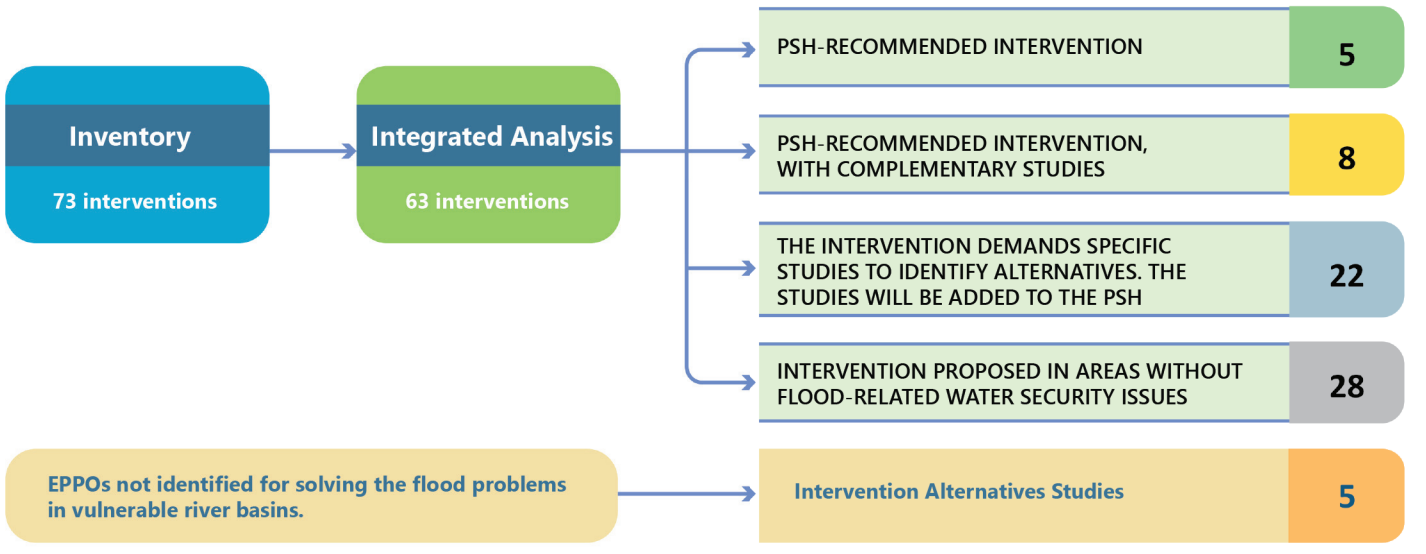
São Francisco River - Paulo Afonso/BA
Photo: Ministry of National Integration. 2016

Flood Control - Integrated Analysis Results

Out of the 73 flood control dams inventoried, 63 strategic and structuring interventions were forwarded for Integrated Analysis aiming at the identification of the ones that meet the PNSH's objectives and criteria. Out of these 63 interventions:

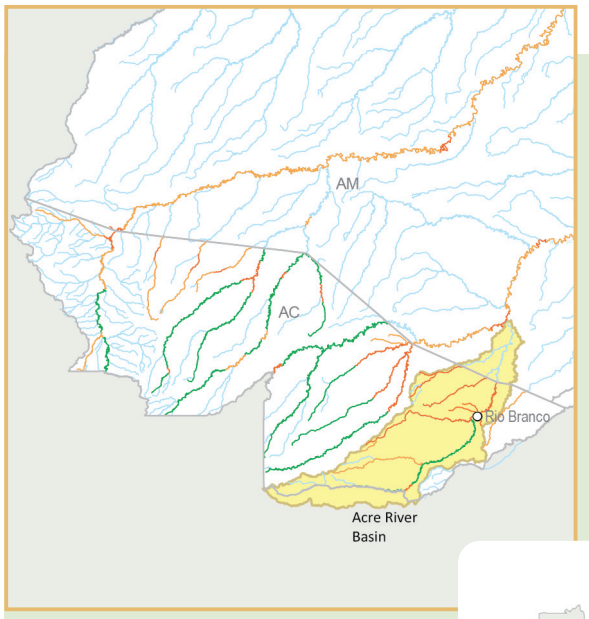
- five were **qualified to the PSH** because they represented defined solutions to effective problems and, there was no doubt that the proposed intervention will meet the problem demands.
- eight were **added to the PSH with complementary studies**, because they are compatible with the problem and indicate a solution that is not yet consolidated or that needs improvements in its studies and projects, for at the moment there is not enough information for appropriate decision-making.
- twenty-two require **specific studies** to identify alternatives to compose the PSH; and twenty-eight were not added to the PSH because they represent **interventions in areas without flood-related water security problems**. These are dams located in basins that are not highly vulnerable to flooding or dams for which there is no certainty about the benefit of mitigating the vulnerability of the basin or watercourse in which they are inserted.

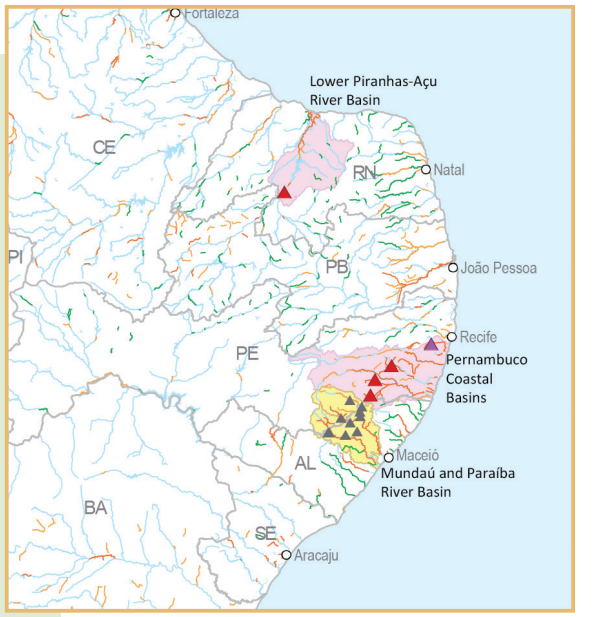
INTEGRATED ANALYSIS CRITERIA AND RESULTS

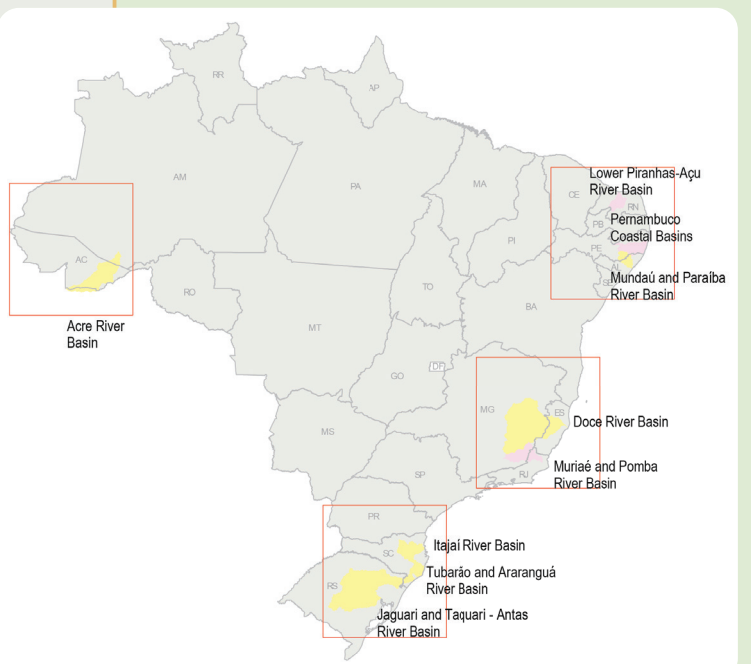


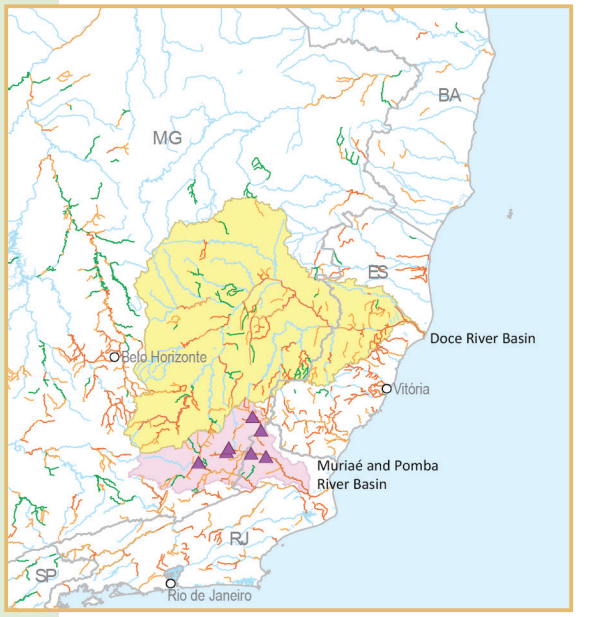
Works are already ongoing in the five PSH certified dams, three of which are located in the Coastal Pernambuco state basins (Igarapeba, Guabiraba and Panelas II-Gatos dams), one in the lower Piranhas-Açu river basin in Rio Grande do Norte state (Oiticica dam), and one in the Itajaí river basin, in Santa Catarina state (Botuverá dam).

The other eight selected require complementary study and are in the studies and projects phase. Seven of these dams are located in the Paraíba do Sul river basin (specially in its tributaries, Muriaé and Pomba) and in the Coastal Pernambuco basins, in the Recife Metropolitan Region.



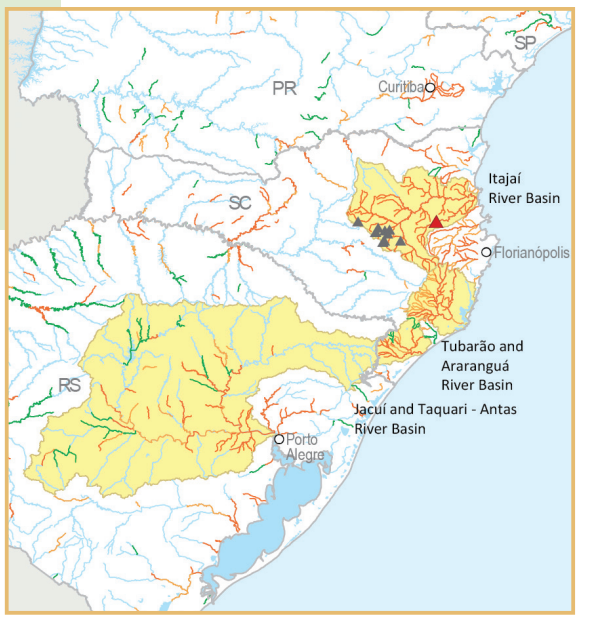






The flood control analyses also identified a requirement for studies in the the Mundaú and Paraíba (PE/AL), Itajaí (SC), Acre (AC), Doce (MG/ES), Tubarão and Araranguá (SC) and Jacuí and Taquari-Antas (RS) river basins. These studies should find appropriate intervention alternatives to flood problems in these critically vulnerable basins for which no intervention proposals that fully address the flood risks were identified.

The first two basins already have catalogued intervention proposals. However, their benefits and integrated action need to be further verified.



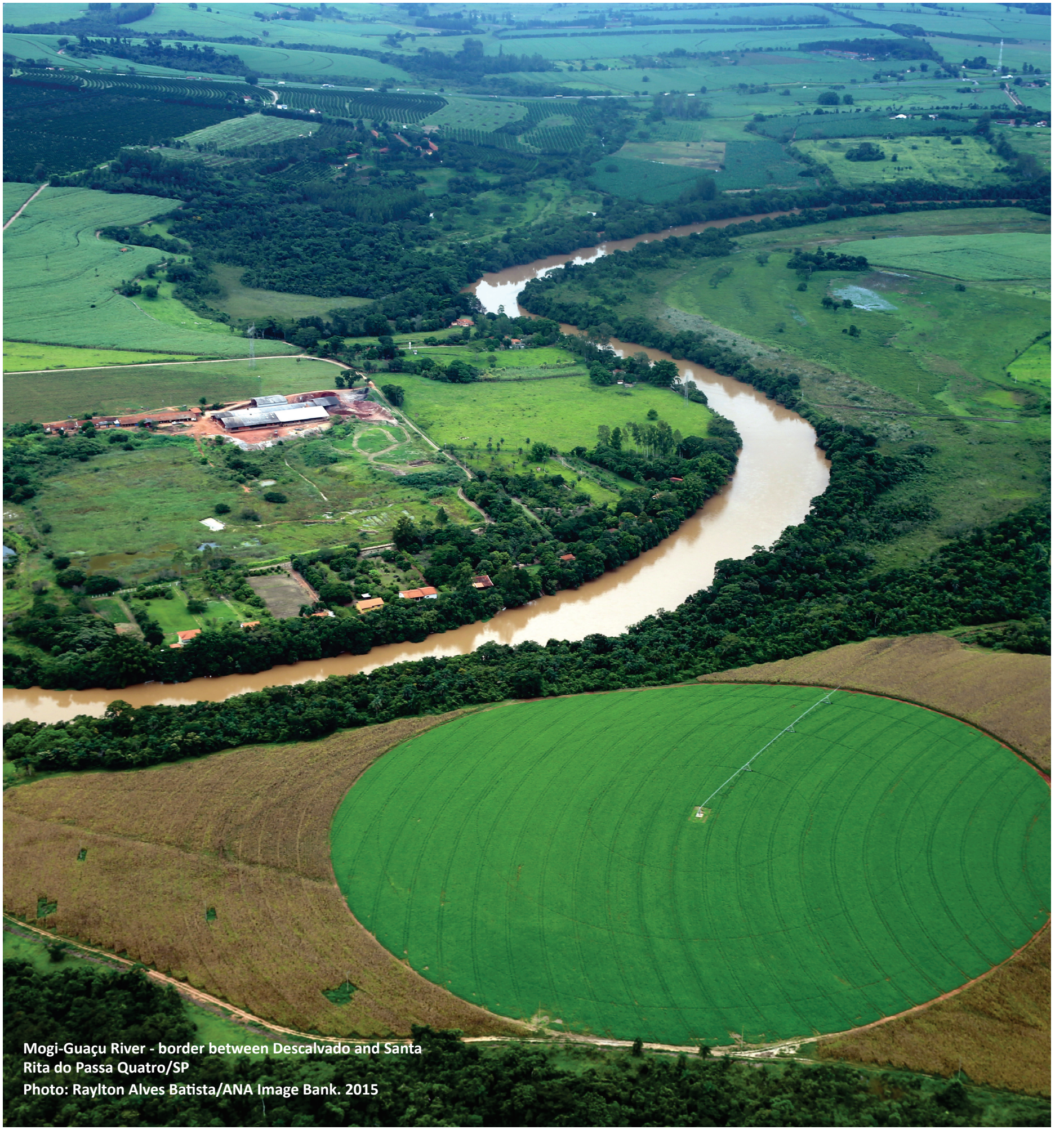
Extended Details

Vulnerability Class

- High
- Medium
- Low

N 0 150 300 450km

- Recommended dam
- Recommended dam with studies
- Inventory dam
- Water Resources Use Alternatives' Study
- Basin with PSH-recommended interventions



Mogi-Guaçu River - border between Descalvado and Santa Rita do Passa Quatro/SP
Photo: Raylton Alves Batista/ANA Image Bank. 2015

DETAILING BY REGION

In order to group States that present homogeneous characteristics regarding water supply and demand and the spatial distribution of selected interventions, five major regional groups were defined for presenting the PNSH results.

The states of Rondônia, Amapá, Amazonas, Pará, Acre, Mato Grosso, Mato Grosso do Sul, Tocantins, Maranhão and Piauí were grouped in the North, Midwest and Western Northeast region.

The Northern Northeast region is framed by the states of Ceará, Rio Grande do Norte, Paraíba and Pernambuco, which are the states benefiting from the PISF. The other Northeast states: Alagoas, Sergipe and Bahia frame the Southern Northeast region.

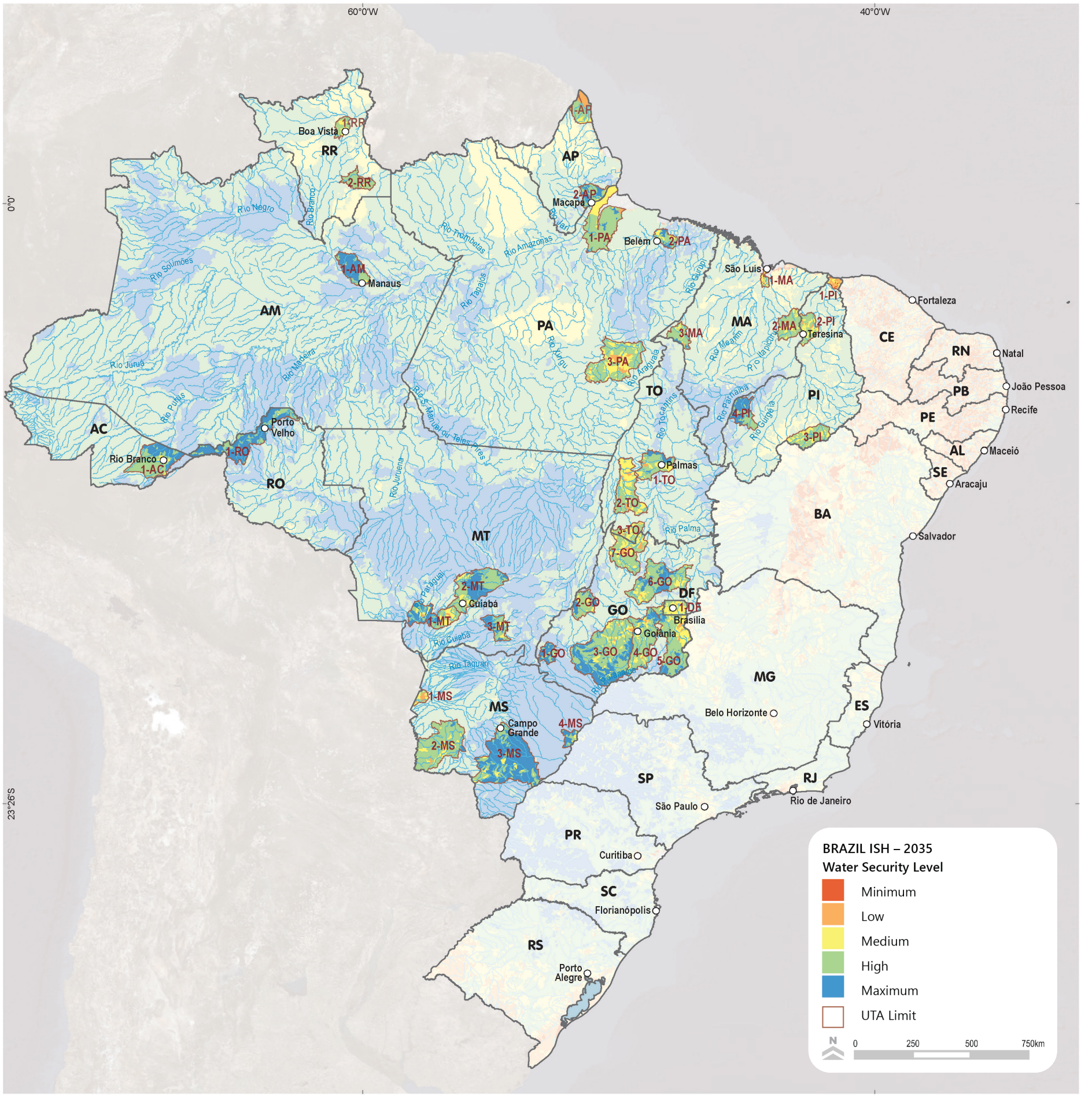
Minas Gerais, São Paulo, Espírito Santo and Rio de Janeiro compose the Southeast region, which coincides with the homonymous Geographic Region. Similarly, the Southern Region states are: Paraná, Santa Catarina and Rio Grande do Sul.

For each region, the critical UTAs were highlighted based on the ISH results, the populations and economic activities at risk were also defined. All interventions selected in the Integrated Analysis (EPPOs in several development stages) and added to the Water Security Program with or without the need for complementary studies were related and spatially located in these units.

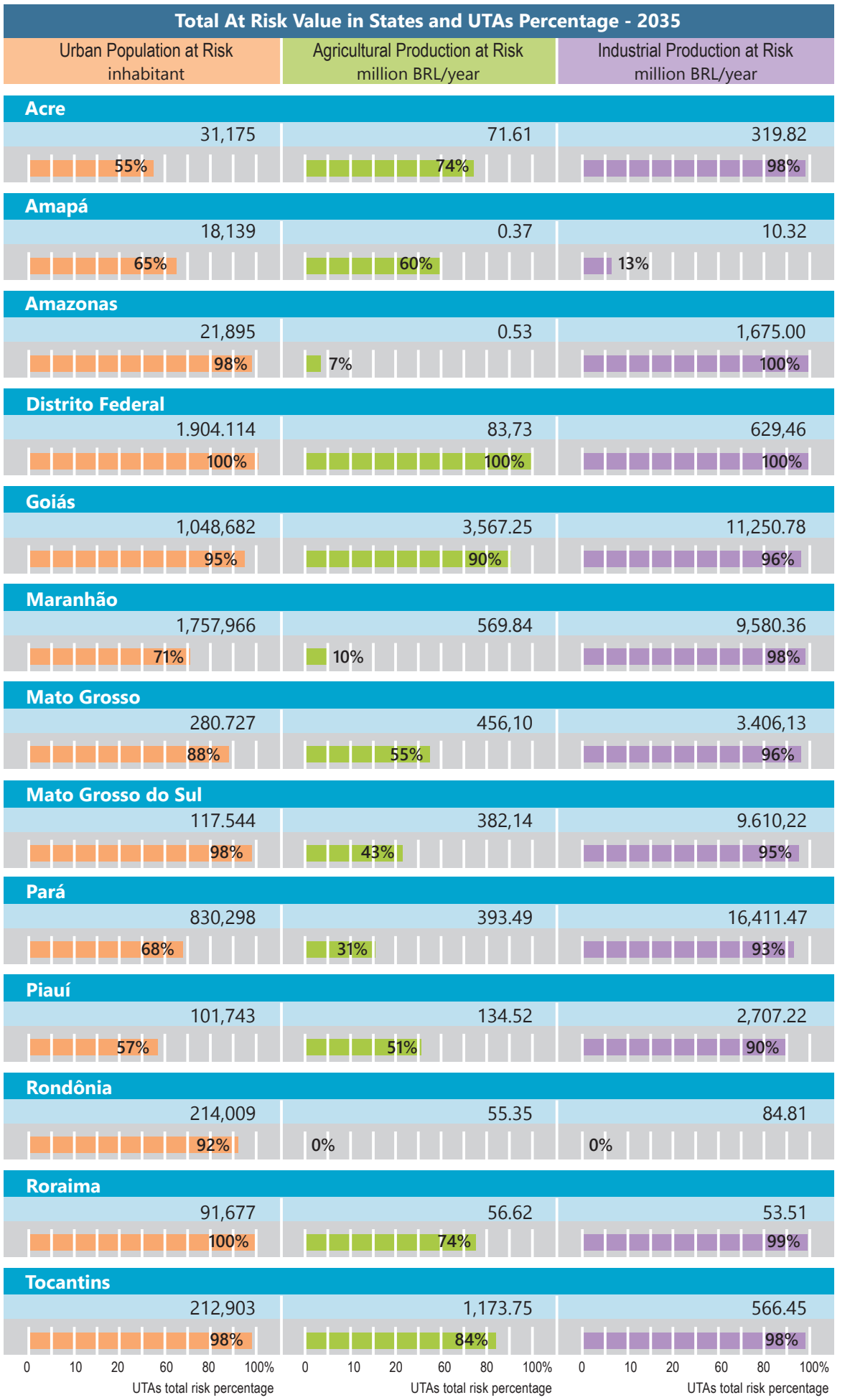
Bonito II Reservoir, with approximately 1% of its water reserve - São Miguel/ RN
Photo: Engecorps Engineering S.A. Library

ISH in the UTAs - 2035

North, Midwest and Western Northeast

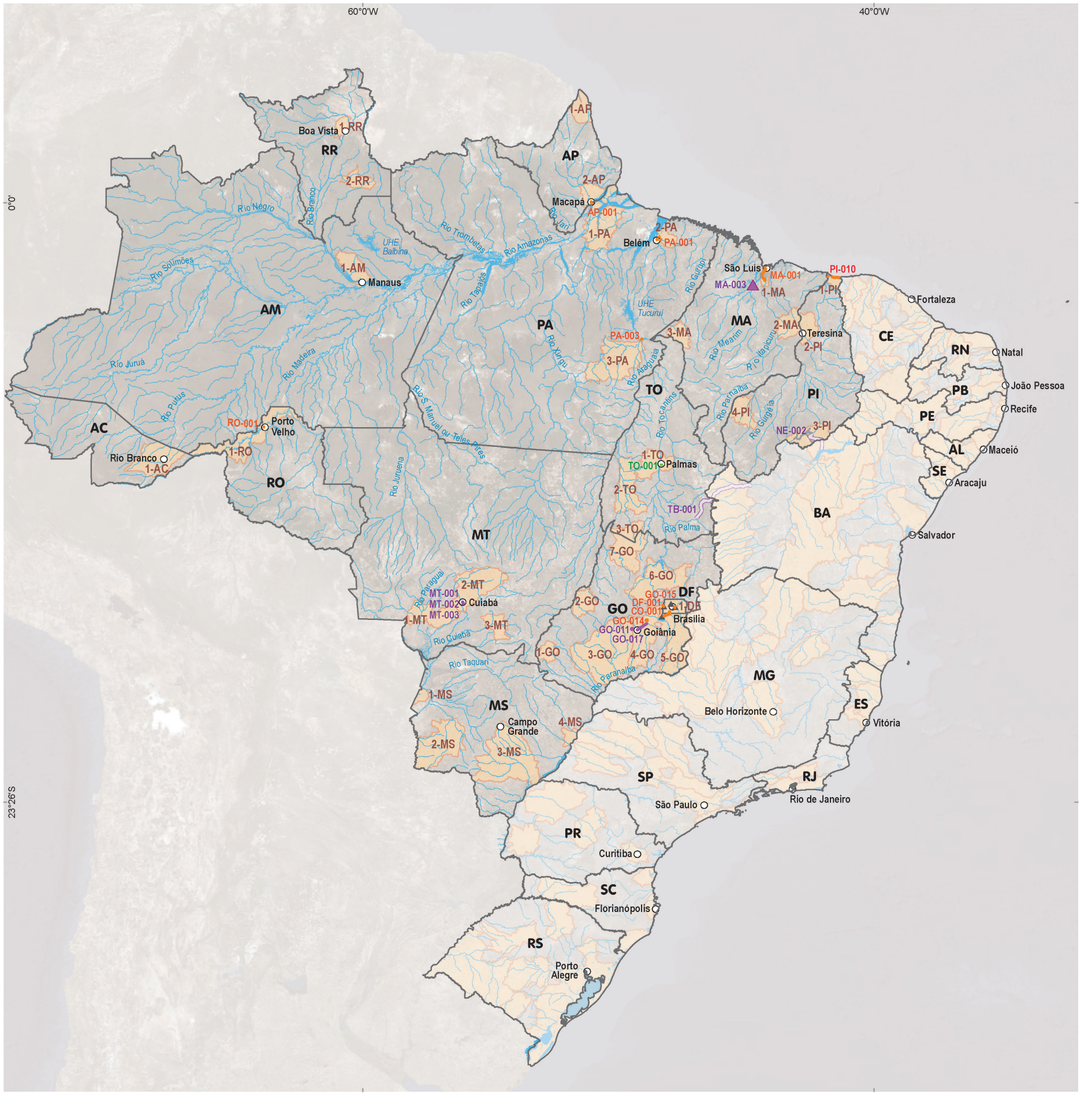


Code	Territorial Unit for Analysis - UTA
	Acre
1-AC	Acre-Iquiri Region
	Amapá
1-AP	Oiapoque and Uaçá River Basins
2-AP	Pedreira, Gurijuba and Macacoari River Basins
	Amazonas
1-AM	Amazonas River Basin
	Distrito Federal
1-DF	São Francisco River's Tributaries in the State of Goiás
	Goiás
1-GO	Lower Paranaíba Tributaries in the Goiás State
2-GO	Upper Araguaia and Vermelho River Tributaries in the Goiás State
3-GO	Bois River Basin
4-GO	Meia Ponte River Basin
5-GO	Corumbá, Veríssimo and Goiás State Portion of the São Marcos River
6-GO	Almas River Basin, Maranhão and Médio Tocantins Tributaries in the Goiás State
7-GO	Médio Araguaia Tributaries in the Goiás State
	Maranhão
1-MA	Mearim Basin
2-MA	Parnaíba and Itapecuru Basins
3-MA	Tocantins Basin
	Mato Grosso
1-MT	Paraguay-Pantanal Basin
2-MT	Cuiabá River Basin
3-MT	São Lourenço Basin
	Mato Grosso do Sul
1-MS	Taquari River Basin
2-MS	Nabileque, Miranda and APA River Basins
3-MS	Ivinhema and Pardo River Basins
4-MS	Verde and Sucuriú River Basins
	Pará
1-PA	Portel-Marajó Basin
2-PA	Northeast Atlantic Coast
3-PA	Tocantins-Araguaia Basin
	Piauí
1-PI	Diffuse Coastal Basins
2-PI	Lower Parnaíba and Longá Diffuse Basins
3-PI	Canindé and Piauí River Basins
4-PI	Upper Parnaíba and Uruçuí-Preto Diffuse Basins
	Rondônia
1-RO	Madeira River Basin
	Roraima
1-RR	Branco River Basin
2-RR	Anauá Basin
	Tocantins
1-TO	Palmas Lake's Surrounding Area
2-TO	Formoso do Araguaia River Basin
3-TO	South of the Formoso do Araguaia River Basin



Note: insignificant percentage values occur in states that present very low absolute at risk values

PSH Studies, Projects and Works
North, Midwest and Western Northeast



Code	Study/Project/Work
	AMAPÁ
AP-001	Macapá Conveyance System (expansion)
	DISTRITO FEDERAL
CO-001	Corumbá IV Conveyance System
DF-001	Paranoá Lake Conveyance System
	GOIÁS
CO-001	Corumbá IV Conveyance System
GO-011	Caldas Conveyance System
GO-014	Anápolis Conveyance System
GO-015	Águas Lindas Conveyance System
GO-017	Trindade Conveyance System
	MARANHÃO
MA-001	Italuís II Conveyance System (expansion)
MA-003	Maranhão Lowlands Level Dams/ Floodwall
	MATO GROSSO
MT-001	Cuiabá Park Conveyance System (expansion)
MT-002	Tijucal Conveyance System (expansion)
MT-003	Coophema Conveyance System (expansion)
	PARÁ
PA-001	Bologna Complex Conveyance System (extension)
PA-003	Marabá Conveyance System (expansion)
	PIAUÍ
NE-002	Piauí Sertão Canal (West Axis)
PI-010	Coastal Conveyance System
	RONDÔNIA
RO-001	Porto Velho Conveyance System
	TOCANTINS
TB-001	Tocantins-São Francisco Water Transfer
TO-001	Palmas Conveyance System (expansion)

Ongoing Works Planning Phase With Complementary Study

Note: the Acre, Amazonas, Mato Grosso do Sul and Roraima states do not have PSH-certified interventions for their TUAs. These states are included in the ISH detailing studies and the water resources uses studies.

PSH STUDIES, PROJECTS AND WORKS

UTA

EXISTING INFRASTRUCTURE

Dam

Conveyance System

RECOMMENDED INFRASTRUCTURE

Dam

With Complementary Study

Conveyance System

Ongoing works

Planning

With Complementary Study

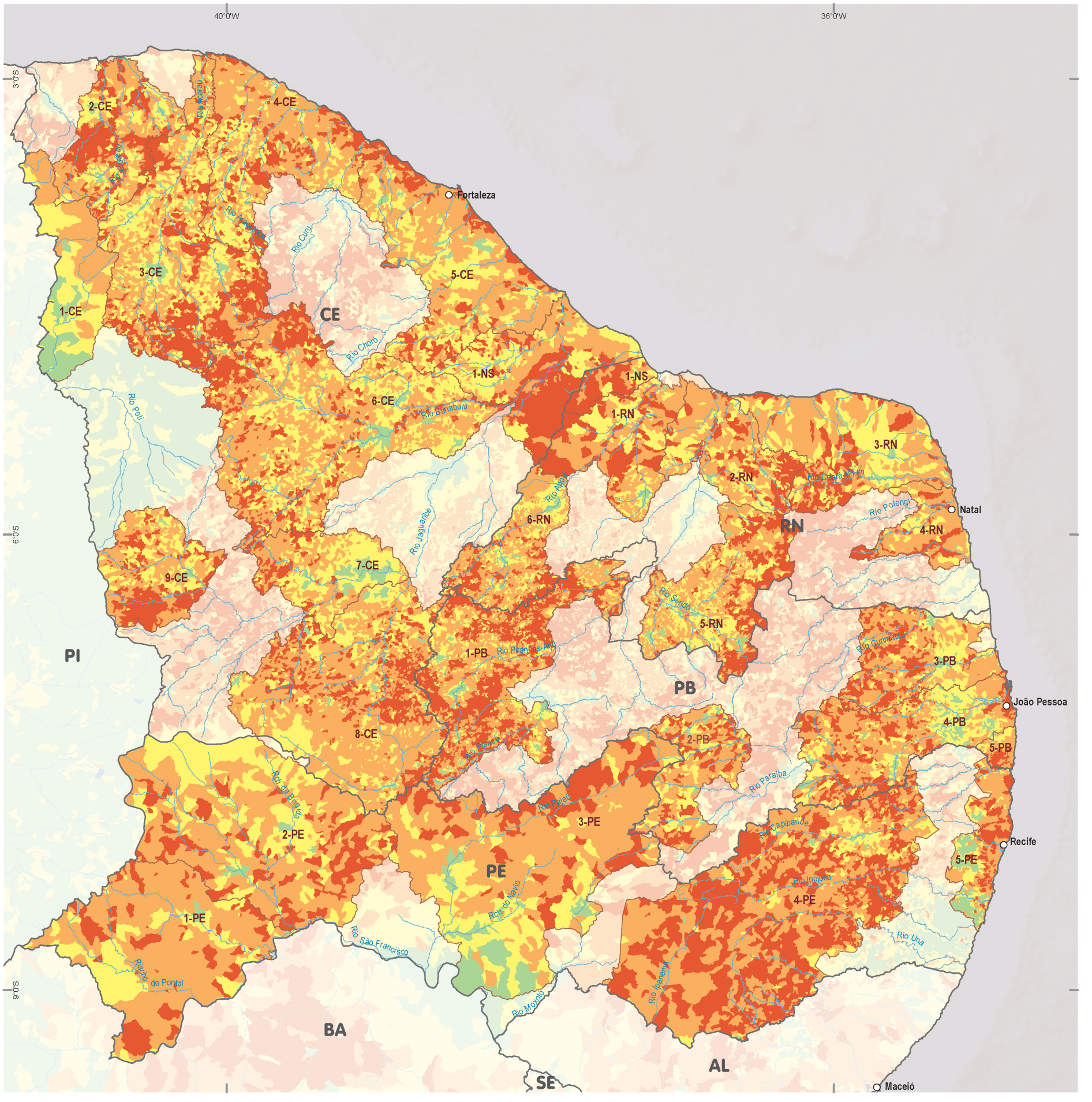
Canal

With Complementary Study – Supply driven

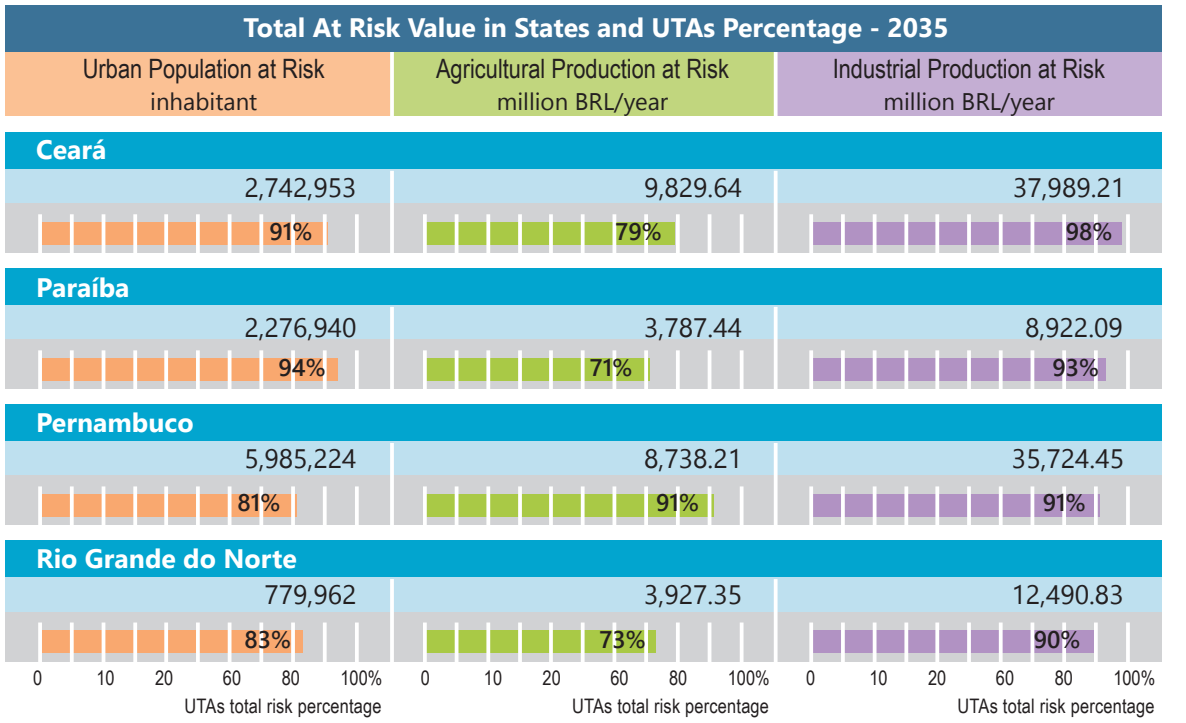
N 0 250 500 750km

ISH in the UTAs - 2035

Northern Northeast



Code	Territorial Unit for Analysis - UTA
	Ceará
1-CE	Ibiapaba Basin
2-CE	Coreaú Basin
3-CE	Acaraú Basin
4-CE	Coastal Basin
5-CE	Fortaleza Metropolitan Region
6-CE	Banabuiú Basin
7-CE	Orós
8-CE	Salgado Basin
9-CE	Upper Jaguaribe
1-NS	Lower Jaguaribe
	Paraíba
1-PB	Piancó/ Piranhas Basin
2-PB	Monteiro Region
3-PB	Curimataú
4-PB	Paraíba Basin
5-PB	Abiaí River Basin
	Pernambuco
1-PE	Pontal
2-PE	Brigida
3-PE	Pajeú
4-PE	Agreste Pernambucano
5-PE	Recife Metropolitan Region
	Rio Grande do Norte
1-RN	Lower Apodi
2-RN	Lower Piranhas-Açu
3-RN	North Coastal Region
4-RN	Natal Metropolitan Region
5-RN	Seridó Basin
6-RN	Upper Apodi
1-NS	Lower Jaguaribe



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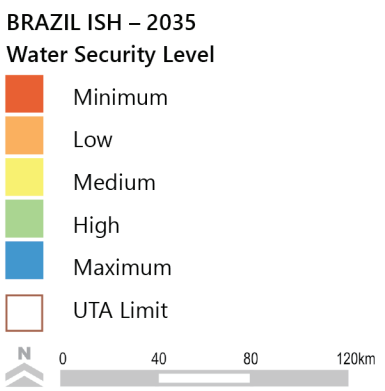
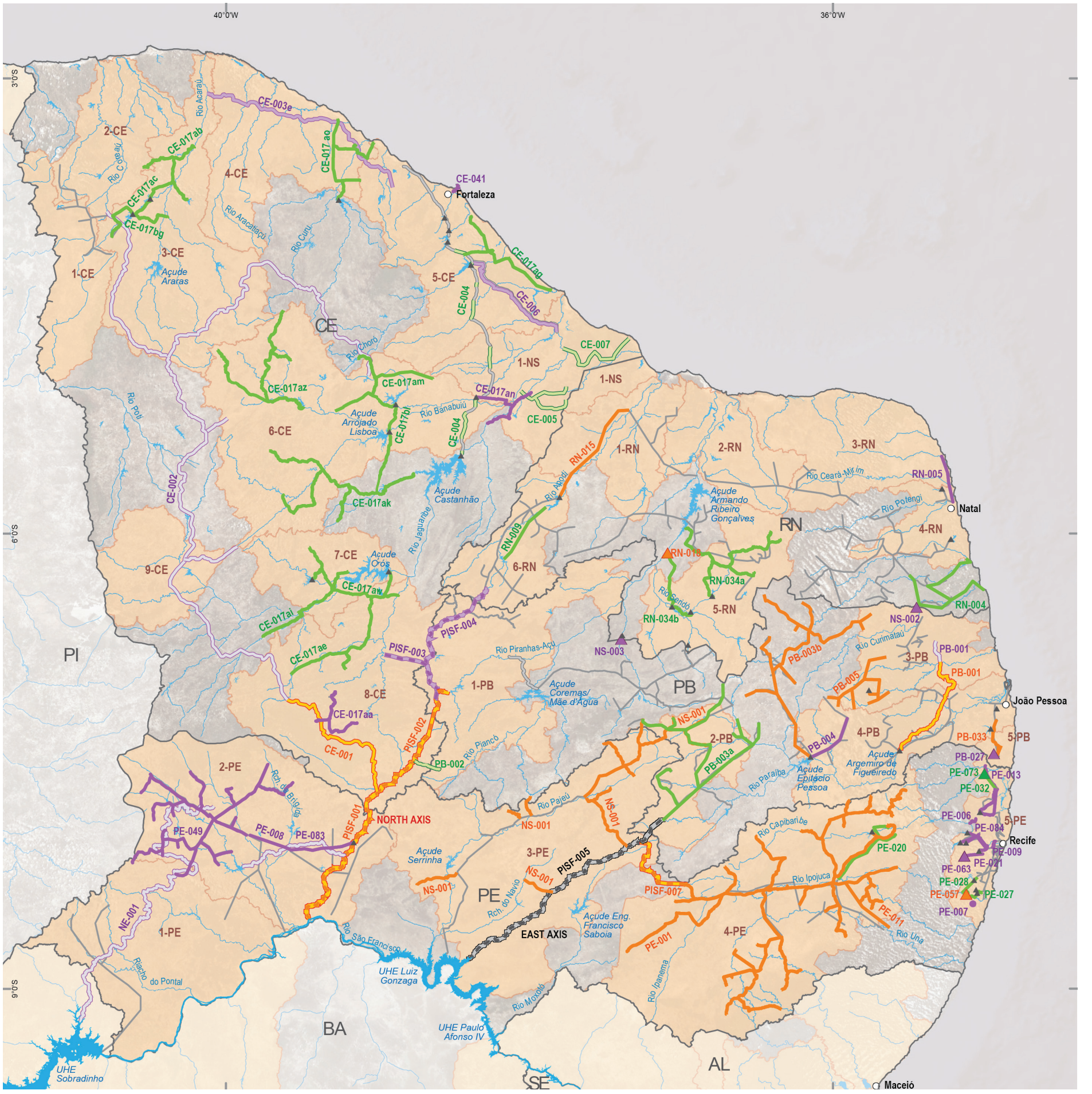


PSH Studies, Projects and Works
Northern Northeast



Code	Study/Project/Work
	CEARÁ
CE-001	CAC - Stretch I (Ceará Water Belt)
CE-002	CAC- Stretch II, Stretch III and Extension Lines 1, 2, East and West
CE-003e	CAC - Coastal Extension Line
CE-004	Eixão das Águas (duplication)
CE-005	Quixeré-Bom Sucesso Integration Axis
CE-006	Trabalhador Canal (recovery and extension)
CE-007	Jaguaribe-Icapuí Integration Axis
CE-017aa	Crajubar Conveyance System (Malha d'Água Project)
CE-017ab/ ac/bg	Taquara-Jaibaras Integration Axis and Jaibara-Sobral and Taquara-Sertão de Sobral Conveyance Systems (Malha d'Água)
CE-017ae/ ai/aw	Orós-Trussu Integration Axis and Orós-South Center and Trussu-Upper Jaguaribe Conveyance System (Malha d'Água Project)
CE-017ag	Metropolitan Eastern Coast Conveyance System (Malha d'Água)
CE-017ak/ am/bl	Banabuiú-Pedras Brancas Integration Axis and Banabuiú-Pedras Brancas Central Sertão and Pedras Brancas-Central Sertão Conveyance Systems (Malha d'Água Project)
CE-017an	Corral Velho-Jaguaribe Valley Conveyance System (Malha d'Água)
CE-017ao	Curu Valley-West Coast Conveyance System (Malha d'Água)
CE-017az	Upper Banabuiú-Fogareiro Conveyance System (Malha d'Água)
CE-041	Fortaleza MR Production System (Desalination ETA)
	PARAÍBA
NS-001	Pajeú Conveyance System - 2nd Phase
NS-002	Bujari Dam
PB-001	Acauã-Araçagi Canal/Coastal Branches
PB-002	Piancó Extension Line
PB-003a	Transparaíba Conveyance System (Cariri Extension Line)
PB-003b	Transparaíba Conveyance System (Curimataú Extension Line)
PB-004	Campina Grande (3rd) Conveyance System
PB-005	Nova Camará Conveyance System
PB-027	Cupissura Dam
PB-033	Abiaí-Papocas Conveyance System

Code	Study/Project/Work
	PERNAMBUCO
NS-001	Pajeú Conveyance System - 2nd Phase
NE-001	Pernambuco Sertão Canal
PE-001	Agreste Conveyance System
PE-006	Conveyance System Botafogo (expansion)
PE-007	Suape Conveyance System (expansion)
PE-008	Negreiros-Chapéu Conveyance System
PE-009	Tapacurá Conveyance System (expansion)
PE-011	Bitury Conveyance System (expansion)
PE-013	Itapirema-Goiana Conveyance System
PE-020	Tramo Sul Conveyance System (Jucazinho System Expansion)
PE-021	Engenho Pereira Conveyance System
PE-027	Engenho Maranhão-ETA Suape Conveyance System
PE-028	Engenho Maranhão-ETA Pirapama Conveyance System
PE-032	Tracunhaém-EE Arataca II Conveyance System (expansion)
PE-049	Western Conveyance System (expansion)
PE-057	Engenho Maranhão Dam
PE-063	Engenho Pereira Dam
PE-073	Tracunhaém Dam
PE-083	Entremontes Extension Line
PE-084	Recife MR Rings' Conveyance Systems and Connections
	RIO GRANDE DO NORTE
NS-002	Bujari Dam
NS-003	Serra Negra do Norte Dam (Nova Dinamarca)
RN-004	Monsenhor Expedito Conveyance System (expansion)
RN-005	Maxaranguape Conveyance System
RN-009	Santa Cruz-Pau dos Ferros Integration Axis (Express Adductor)
RN-015	Santa Cruz-Mossoró Conveyance System
RN-018	Oiticica Dam
RN-034a	Armando Ribeiro Gonçalves-Currais Novos Conveyance Systems (Projeto Seridó)
RN-034b	Oiticica-Caicó Conveyance System (Projeto Seridó)
	SÃO FRANCISCO RIVER INTEGRATION PROJECT
PISF-001	North Axis - Stretch I
PISF-002	North Axis - Stretch II
PISF-003	North Axis - Stretch III (Salgado Extension Line)
PISF-004	North Axis - Stretch IV (Apodi Extension Line)
PISF-005	East Axis - Stretch V
PISF-007	Agreste Extension Line

Ongoing Works | Planning Phase | With Complementary Study | Pre-Operating

PSH STUDIES, PROJECTS AND WORKS

EXISTING INFRASTRUCTURE
- Dam
- Conveyance System
- Canal

UTA

N 0 40 80 120km

RECOMMENDED INFRASTRUCTURE

Dam
- Ongoing works
- Planning
- With Complementary Study

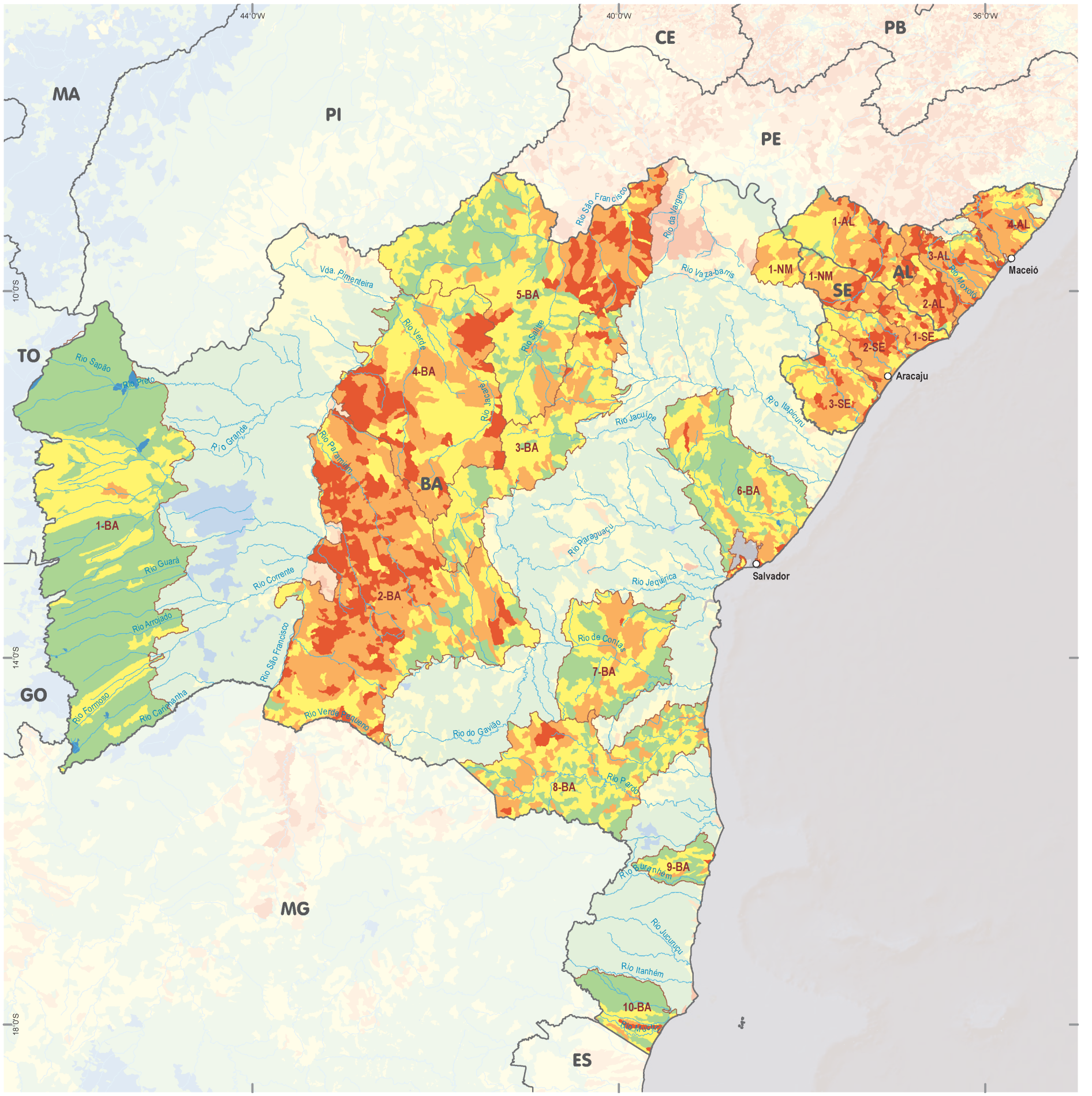
Conveyance System
- Ongoing works
- Planning
- With Complementary Study

Canal
- Ongoing works
- Planning
- With Complementary Study
- With Complementary Study – Supply Driven

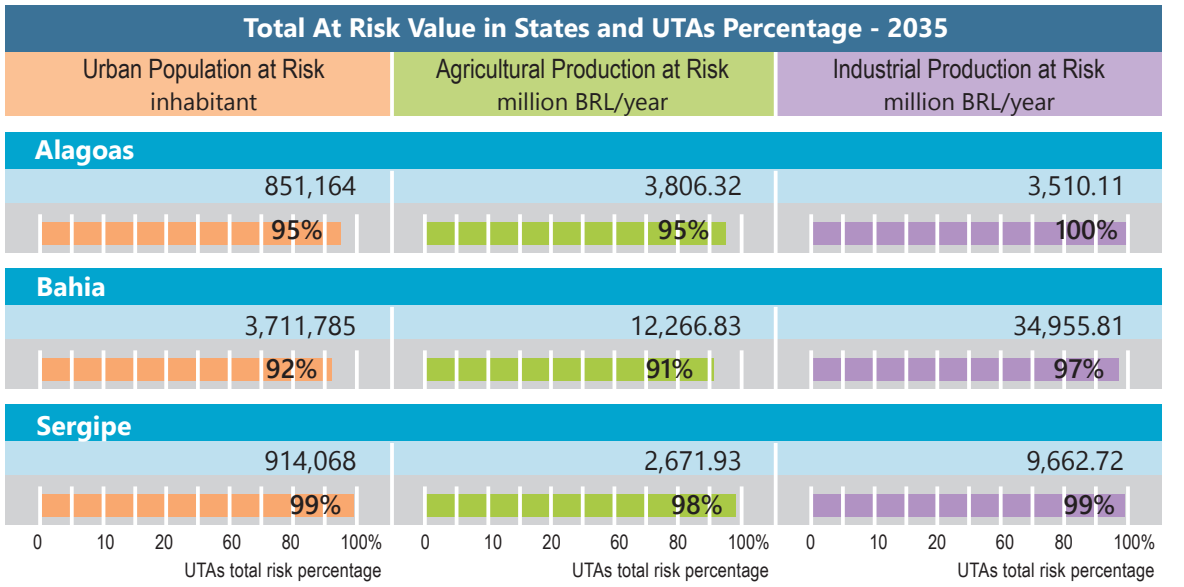
PISF
- Pre-operation
- Ongoing works
- Project

ISH in the UTAs - 2035

Southern Northeast



Code	Territorial Unit for Analysis - UTA
	Alagoas
1-AL	Talhada Basin
2-AL	Traipu and Piauí Basin
3-AL	Coruripe and Coastal Basins
4-AL	Camaragibe and Mundaú Basins
	Bahia
1-BA	São Francisco River Basin (Western Portion)
2-BA	São Francisco River Basin (Southeastern Portion)
3-BA	Itapicuru and Paraguaçu Rivers Basins
4-BA	São Francisco River Basin (Central-Eastern Portion)
5-BA	São Francisco River Basin (Northeastern Portion)
6-BA	Inhambupe and Recôncavo Norte River Basins
7-BA	Contas and Recôncavo Sul River Basins
8-BA	East and Pardo River Basins
9-BA	Jequitinhonha River Basin
10-BA	Extreme South Basin
1-NM	Sergipe Sertão
	Sergipe
1-SE	Lower São Francisco (East Bank)
2-SE	Sergipe and Aracaju MR River Basins
3-SE	Vaza-Barris River Basin
1-NM	Sergipe Sertão



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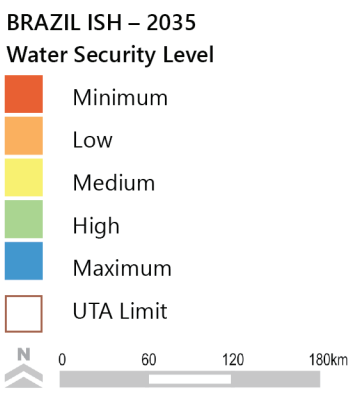
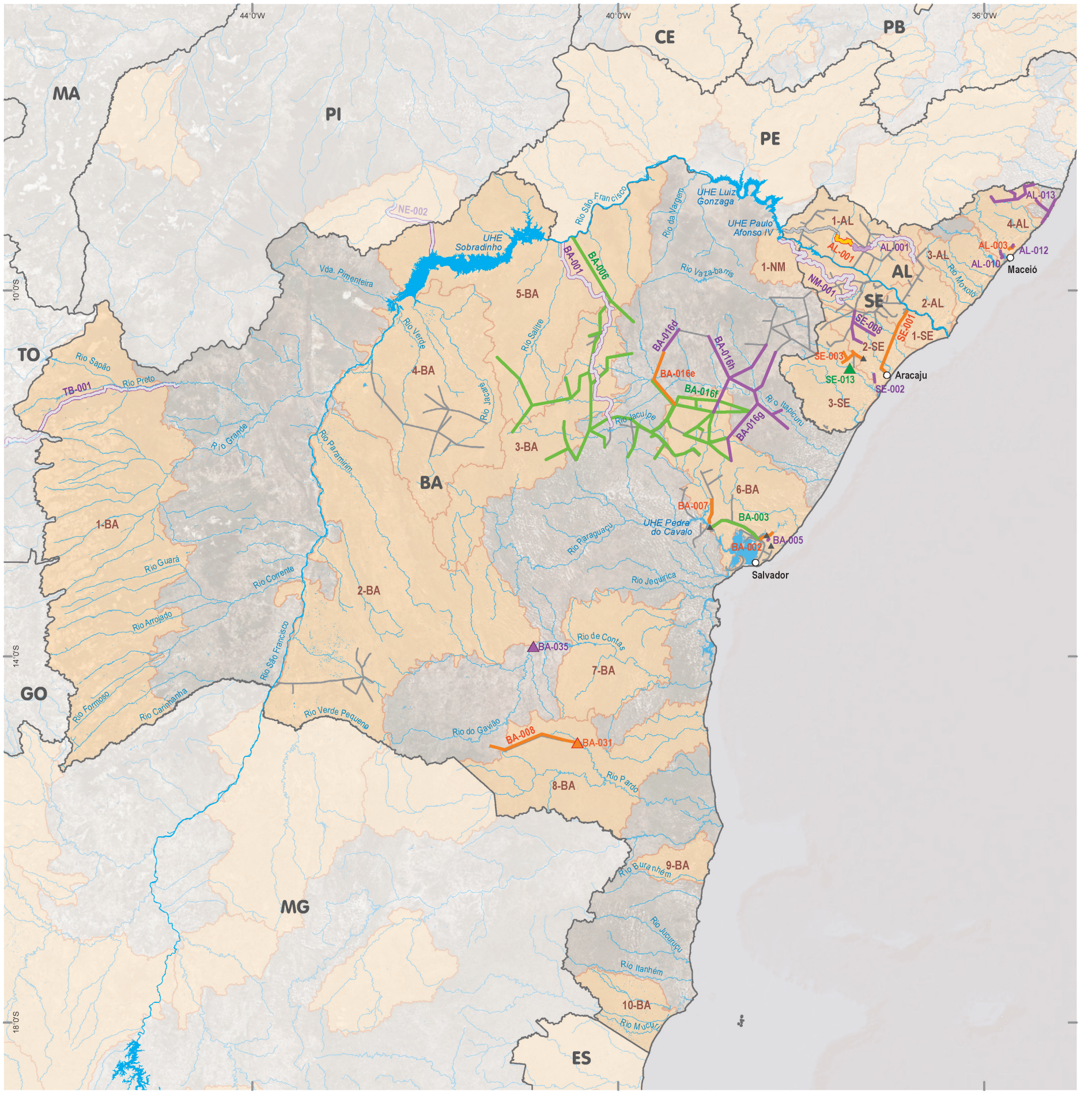


PSH Studies, Projects and Works
Southern Northeast



Code	Study/Project/Work
	ALAGOAS
AL-001	Alagoas Sertão Canal
AL-003	Meirim Conveyance System
AL-010	Coqueiro Seco Conveyance System (expansion)
AL-012	Messias-Meirim Integration Axis
AL-013	North Region Conveyance System
	BAHIA
TB-001	Tocantins-São Francisco Water Transfer Axis
BA-001	Bahia Sertão Canal (South Axis)
BA-002	Santa Helena-Joanes II Integration Axis
BA-003	Pedra do Cavalo Conveyance System (expansion - 3rd Phase)
BA-005	Joanes I-ETA Bolandeira Conveyance System
BA-006	Juazeiro-Senhor do Bonfim Conveyance System
BA-007	Feira de Santana Conveyance System (expansion)
BA-008	Vitória da Conquista Conveyance System (expansion)
BA-016d/g/h	Sertão Waters Conveyance System - Northwest, Southeast and Central Blocks
BA-016e/f	Sertão Waters Conveyance System -Southwest Block
BA-031	Catolé Dam
BA-035	Rio de Contas Dam
	SERGIPE
NM-001	Xingó Canal
SE-001	São Francisco Conveyance System (3rd Phase - expansion)
SE-002	Poxim Conveyance System
SE-003	Agreste Conveyance System (expansion)
SE-008	Upper Sertão Conveyance System (expansion)
SE-013	Vaza-Barris River Dam

Ongoing Works Planning Phase With Complementary Study

PSH STUDIES, PROJECTS AND WORKS

UTA

EXISTING INFRASTRUCTURE

- Dam
- Conveyance System
- Canal

RECOMMENDED INFRASTRUCTURE

Dam

- Ongoing works
- Planning
- With Complementary Study

Conveyance System

- Ongoing works
- Planning
- With Complementary Study

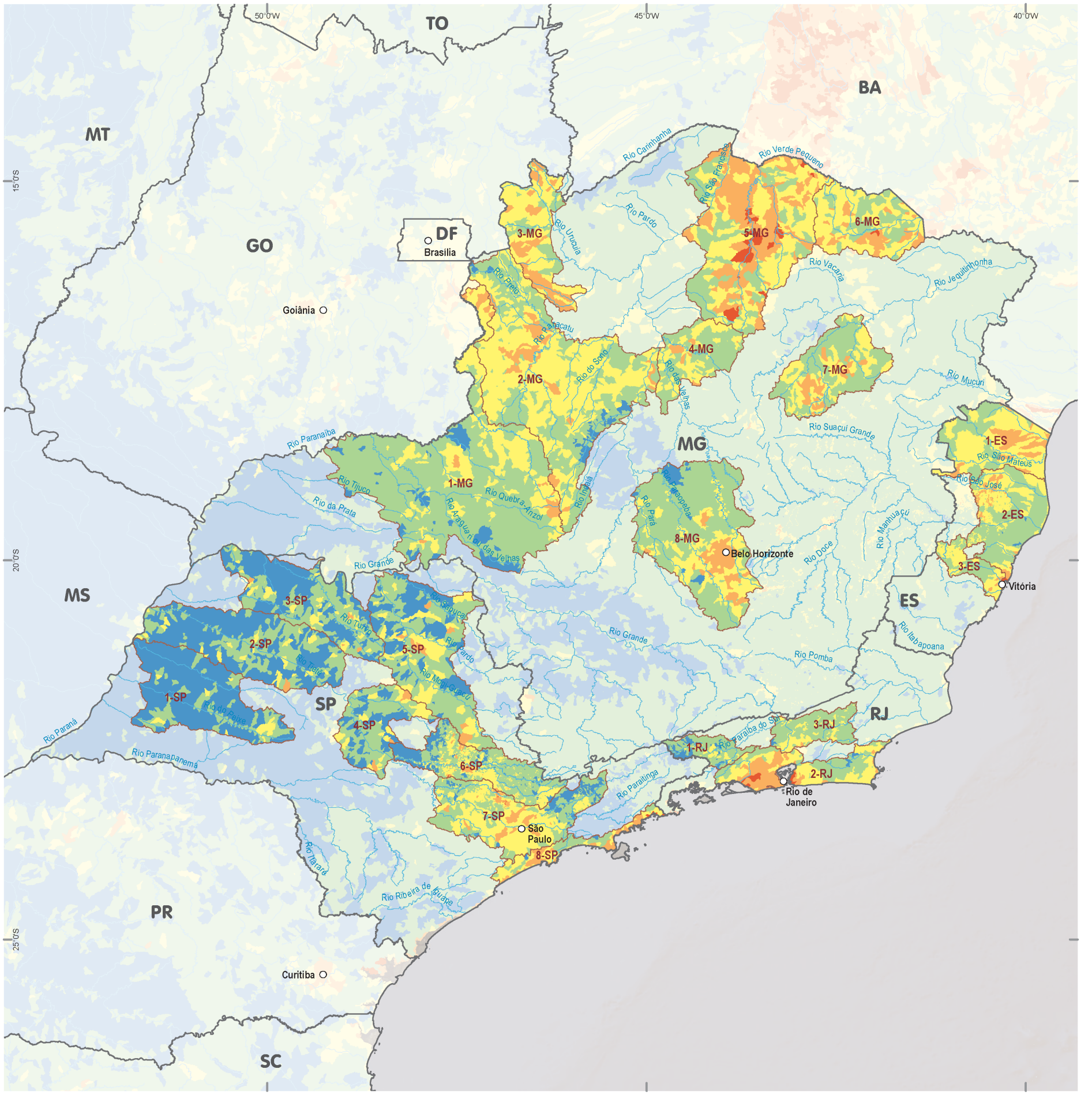
Canal

- Ongoing works
- Planning
- With Complementary Study
- With Complementary Study – Supply driven

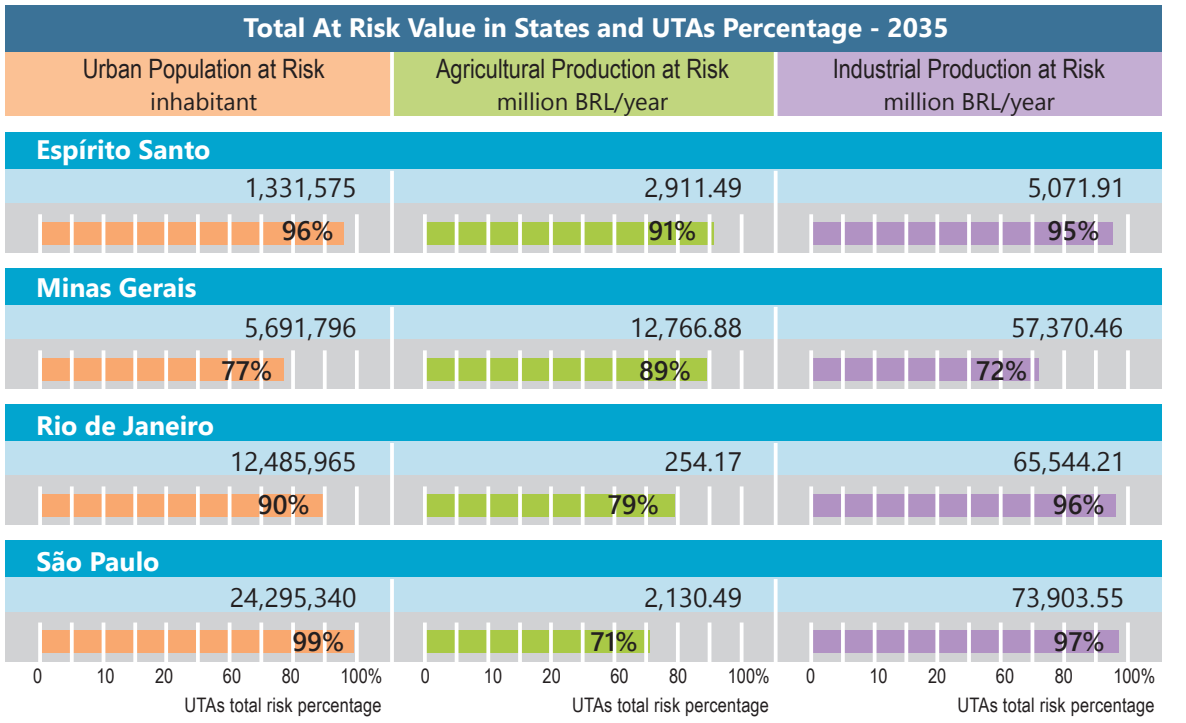
N 0 60 120 180km

ISH in the UTAs – 2035

Southeast



Code	Territorial Unit for Analysis - UTA
	Espírito Santo
1-ES	Itaunas and São Mateus River Basins
2-ES	Doce, Riacho and Reis Magos River Basins
3-ES	Doce, Santa Maria and Jucu River Basins
	Minas Gerais
1-MG	Paranaíba and Grande River Basins
2-MG	São Francisco River Basin (Paracatu River/ Três Marias Dam Surrounding Area)
3-MG	São Francisco River Basin (Urucuia River)
4-MG	São Francisco River Basin (Jequitaí and Pacuí Rivers)
5-MG	São Francisco River Basin (Verde Grande River)
6-MG	Pardo River Basin
7-MG	Jequitinhonha River Basin
8-MG	São Francisco River Basin (Paraopeba and Pará Rivers)
	Rio de Janeiro
1-RJ	Middle Paraíba do Sul Basin
2-RJ	Guandu, Guanabara Bay, Macaé and São João Lakes Basins
3-RJ	Piabanha Basin and Dois Rios River Basins
	São Paulo
1-SP	Aguapeí and Peixe Regions
2-SP	Tietê River Basin
3-SP	Turvo/Grande and São José dos Dourados Regions
4-SP	Tietê-Jacaré Basin
5-SP	Grande River São Paulo Branch
6-SP	Piracicaba, Capivari and Jundiaí Basins (PCJ)
7-SP	Paraíba do Sul Basin, Upper and Middle Tietê and Sorocaba
8-SP	Coastal Region



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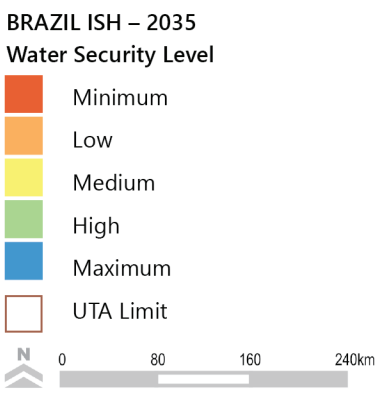
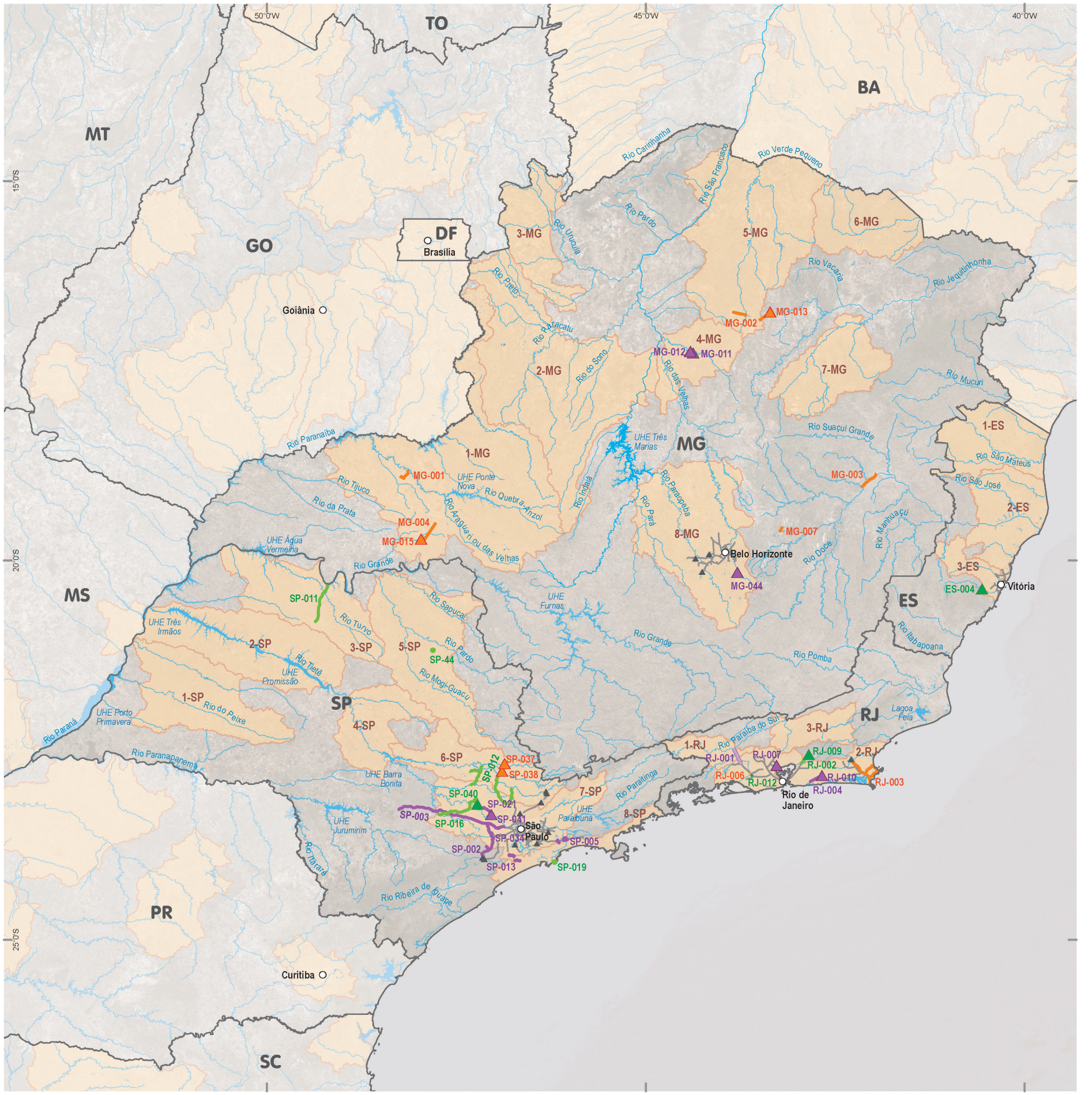


PSH Studies, Projects and Works
Southeast



Code	Study/Project/Work
	ESPÍRITO SANTO
ES-004	Pedra Bonita Dam
	MINAS GERAIS
MG-001	Capim Branco Conveyance System
MG-002	Congonhas-Montes Claros Conveyance System
MG-003	Governador Valadares Conveyance System (expansion)
MG-004	Uberaba Conveyance System (expansion)
MG-007	Itabira Conveyance System (expansion)
MG-011	Jequitaí I Dam
MG-012	Jequitaí II Dam
MG-013	Congonhas Dam
MG-015	Prainha Dam
MG-044	Rio das Velhas Dam
	RIO DE JANEIRO
RJ-001	Transposition Axis Paraíba do Sul -Guandu river (new scheme)
RJ-002	Imunana-Laranjal Conveyance System (expansion)
RJ-003	Prolagos Conveyance System (expansion)
RJ-004	Tangua-Maricá Conveyance System
RJ-006	Poços, Queimados and Ipiranga Diversion
RJ-007	Rio Preto Dam
RJ-009	Guapiaçu Dam
RJ-010	Rio Tanguá Dam
RJ-012	Guandu Production System (ETA New Guandu expansion)
	SÃO PAULO
SP-002	Alto Juquiá Conveyance System/Scheme
SP-003	Jurumirim-ETA Cotia Conveyance System/Scheme
SP-005	Itatinga-Itapanhaú Conveyance System/Scheme
SP-011	São José do Rio Preto Conveyance System
SP-012	Regional PCJ Conveyance System
SP-013	Capivari-Monos Conveyance System/Scheme
SP-016	Sarapuí-Sorocaba-Salto-Piraí Reservoir-Indaiatuba Conveyance System/Scheme
SP-019	Guarujá Conveyance System (expansion)
SP-021	Jundiuvira-Piraí Dam Conveyance System/Scheme
SP-034	Cabreúva-Barueri Conveyance System
SP-037	Duas Pontes Dam
SP-038	Pedreira Dam
SP-040	Ribeirão Piraí Dam
SP-041	Jundiuvira Dam
SP-044	Ribeirão Preto Conveyance System

Ongoing Works Planning Phase With Complementary Study

PSH STUDIES, PROJECTS AND WORKS

UTA

EXISTING INFRASTRUCTURE

- Dam
- Conveyance System

RECOMMENDED INFRASTRUCTURE

Dam

- Ongoing works
- Planning
- With Complementary Study

Conveyance System

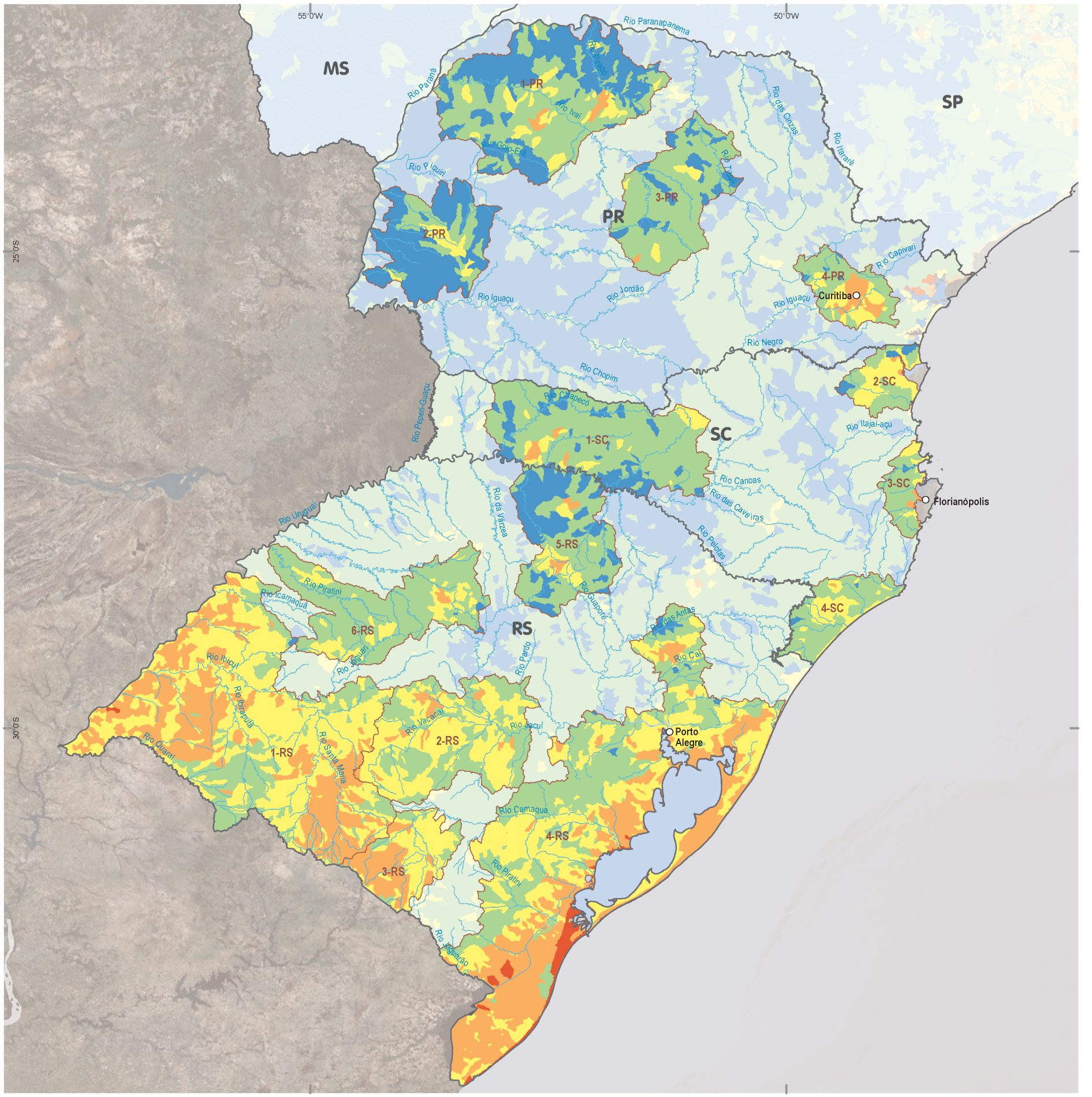
- Ongoing works
- Planning
- With Complementary Study

Canal

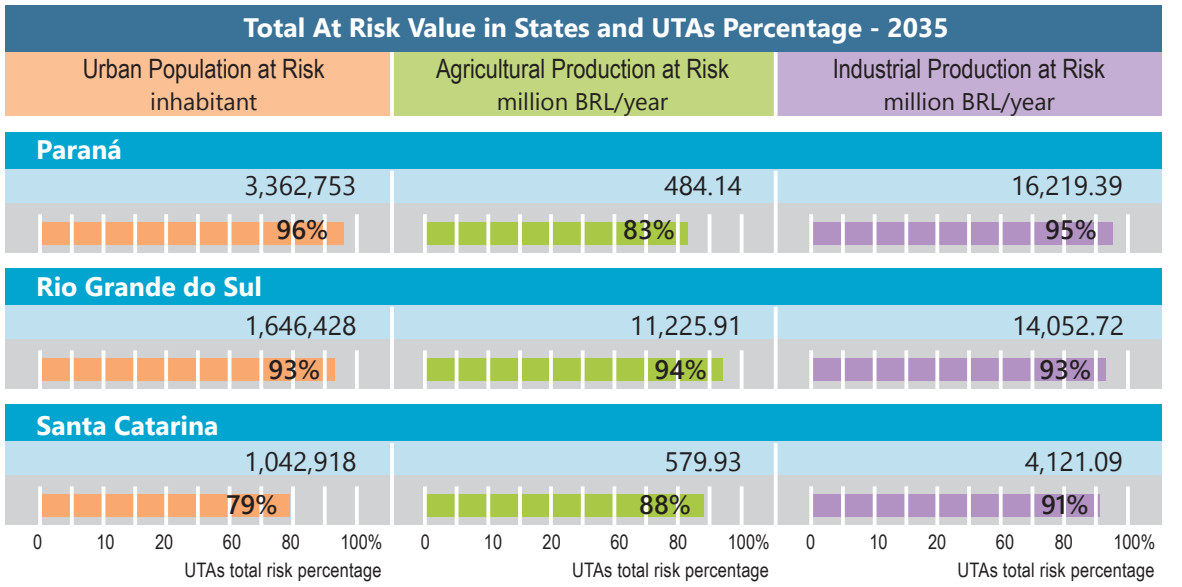
- Ongoing works
- With Complementary Study

N 0 80 160 240km

ISH in the UTAs – 2035
South



Code	Territorial Unit for Analysis - UTA
	Paraná
1-PR	Lower Ivaí and Lower Paranapanema Basins
2-PR	Piquiri, Paraná 2 and Tributaries of Middle e Lower Iguaçu Region
3-PR	Upper Ivaí Basin
4-PR	Upper Iguaçu Basin
	Rio Grande do Sul
1-RS	Ibicuí, Quaraí and Butuí-Icamaquã River Basins
2-RS	Vacacaí, Vacacaí-Mirim e Baixo Jacuí River Basins
3-RS	Camaquã and Negro River Basins, Mirim Lagoon and São Gonçalo Canal
4-RS	Coastal Region and Guaíba
5-RS	Apuaê-Indandava and Passo Fundo River Basins
6-RS	Ijuí, Upper Jacuí and Piratinim River Basins
	Santa Catarina
1-SC	Midwest Region and Peixe River Valley
2-SC	North Lowlands
3-SC	Central Coast
4-SC	Southern Santa Catarina



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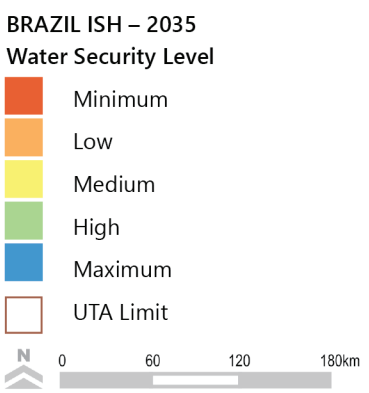
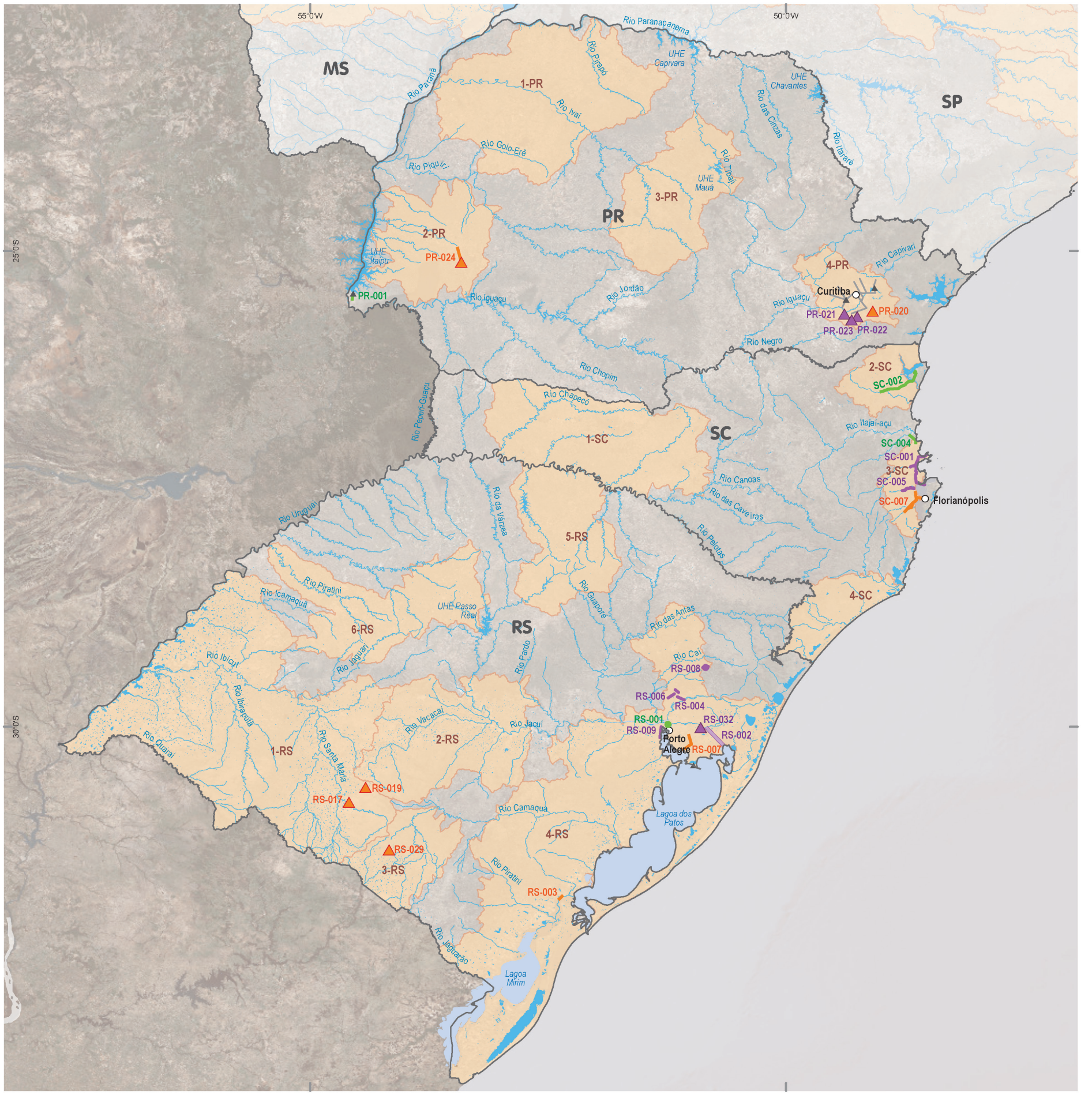


PSH Studies, Projects and Works
South



Code	Study/Project/Work
	PARANÁ
PR-001	Foz do Iguaçu Conveyance System (expansion)
PR-020	Miringuava Dam
PR-021	Faxinal Dam
PR-022	Despique Dam
PR-023	Maurício Dam
PR-024	Cascavel Conveyance System (expansion)
	RIO GRANDE DO SUL
RS-001	Porto Alegre Conveyance System (new water source)
RS-002	Casamento Lagoon-Gravataí River Integration Axis
RS-003	Pelotas Conveyance System (expansion)
RS-004	Novo Hamburgo Conveyance System (expansion)
RS-006	Campo Bom Conveyance System (expansion)
RS-007	Alvorada - Viamão Conveyance System (expansion)
RS-008	Canela-Gramado Conveyance System (expansion)
RS-009	Eldorado do Sul-Guaíba Conveyance System (expansion)
RS-017	Taquarembó Dam
RS-019	Jaguari Dam
RS-029	Arvorezinha Dam
RS-032	Anastácia Lagoon Dam
	SANTA CATARINA
SC-001	East Coast Conveyance System
SC-002	Araquari-Joinville Conveyance System
SC-004	Balneário Camboriú-Camboriú Conveyance System (expansion)
SC-005	Biguaçu River Conveyance System
SC-007	Cubatão-Pilão Conveyance System (expansion)

Ongoing Works Planning Phase With Complementary Study

PSH STUDIES, PROJECTS AND WORKS

UTA

EXISTING INFRASTRUCTURE

Dam

Conveyance System

RECOMMENDED INFRASTRUCTURE

Dam

Ongoing works

With Complementary Study

Conveyance System

Ongoing works

Planning

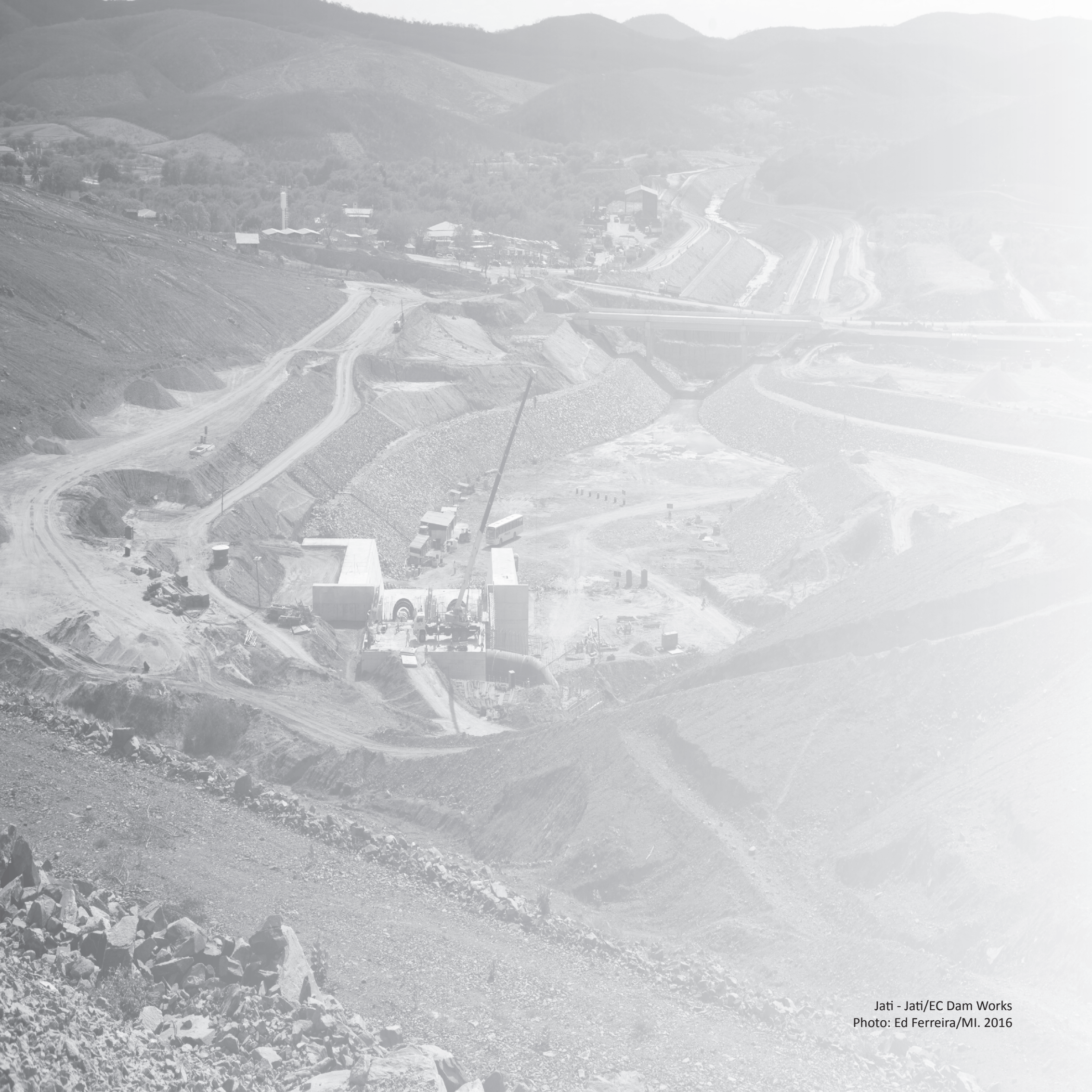
With Complementary Study

Canal

With Complementary Study

N 0 60 120 180km

Water Security Program 4



Jati - Jati/EC Dam Works
Photo: Ed Ferreira/MI. 2016

4 Water Security Program - PSH

The Water Security Program is the dynamic and executive planning instrument for the investments recommended by PNSH to minimize risks associated with water scarcity and flood control. The Program is organized in three Components.

1. **Studies and Projects Component:** includes investments for project development (Executive, Basic, and Draft Projects) for recommended works and complementary studies necessary for confirming potential works, covering: Technical-Economical and Environmental Feasibility Studies – EVTEA; Alternative Studies for Water Resources' Use in complex areas (as is the case of the Metropolitan Regions and areas with low water security levels); and Studies to Detail Regional Development Plans.

2. **Works Component:** covers investments relating to the physical execution of recommended works.

3. **Institutional Component:** includes estimated investments for operation and maintenance (O&M) of recommended works, with the exception of electric energy.

STUDIES AND PROJECTS COMPONENT AND WORKS COMPONENT

The investments for the Studies and Projects and the Works Components are presented together in physical-financial schedules, which extend from the short term up to the 2035 horizon, showing the interrelation between these two components.

The proposed studies are detailed in Terms of Reference (TRs) summary sheets, where the problems to be solved, goals and necessary efforts for conducting the study are outlined.

Similarly, the works are described in Works Identification Reports (RIOs), which present the general data, the development stage, the costs, and the deadlines and implementation stages of the proposed intervention.

In order to provide better understanding of the complementary works to be developed over significant areas (often located in multiple river basins), single-line diagrams were used to depict more complex water systems whose infrastructure operates in an associated and interdependent manner.

Prospective Lines were also drawn up for these cases projecting the collation between water demands and production evolution considering the PSH-certified interventions already in operation, over the PNSH's planning horizon.

These informational and illustrative elements constitute a PSH implementation roadmap, allowing the proper sizing of the materialization efforts for each intervention, considering its individual characteristics and their different development stages.

The complete TRs, RIOs, Single-Line Diagrams and Prospective Lines collection may be consulted at the ANA website.

NATIONAL WATER SECURITY PLAN

Term of Reference's Summary Sheet

Metropolitan Region Water Resources Use Plan

BACKGROUND / JUSTIFICATION

The Metropolitan Region – MR is made up of municipalities...

GOALS

The study to be developed has the main goal of planning the actions to be executed throughout the next years in the Metropolitan Region and its surrounding area focusing on meeting human supply demands to its population. Other specific goals are…

SCOPE

The study to be developed encompasses the springs supplying the Metropolitan Region, considering the river basins' limits...

ACTIVITIES TO BE DEVELOPED

a) Detailing of the work plan and study methodology:…

b) Caracterizing of the water production systems and urban supply demands for the MR

…

TERM

15 (fifteen) months.

ESTIMATED COSTS

3,000,000.00 BRL (three million BRL).

PRODUCTS AND DEADLINES

Stage	Product	Deadlines (calendar days)
1	Work plan detailing and studies' methodology	30
2	Caracterizing of the water production systems and urban supply demands for the MR	90
...		

PROPOSED TECHNICAL TEAM

Professional	Total Cost
Coordinator	2.400
Engineer, Water Infrastructure Planning Expert	1.320
...	

Term of Reference Structure Example - TR

All TRs detailing the recommended complementary studies are available at the ANA website.

Work Identification Report Structure Example - RIO

NATIONAL WATER SECURITY PLAN

Work Identification Report

Alemanha Dam/Alemanha Adduction System

GENERAL DATA

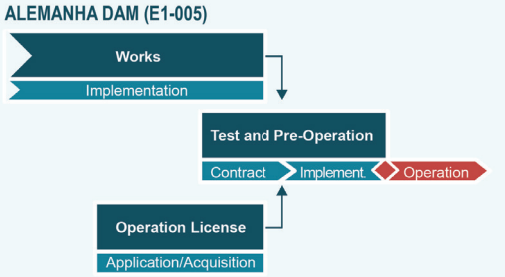
Code
Spring – Water Source
Basin
Location – Municipality/State
Description
Purposes

STAGE / DEADLINE / BUDGET

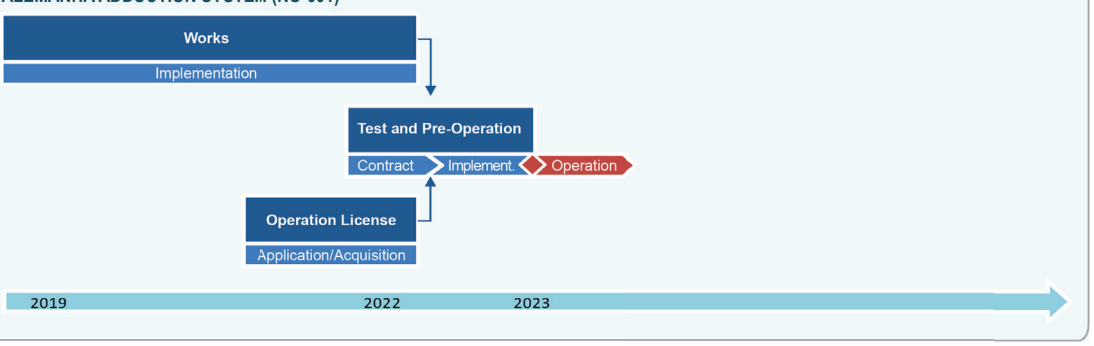
Phase/Status 2019
CERTOH
Estimated deadline for the conclusion of the works
Remaining estimated investments (ref. jul/18)
Financial Resources Source
Executors and Interventions

IMPLEMENTING ORGANIZATION CHART

ALEMANHA DAM (E1-005)



ALEMANHA ADDUCTION SYSTEM (NO-001)

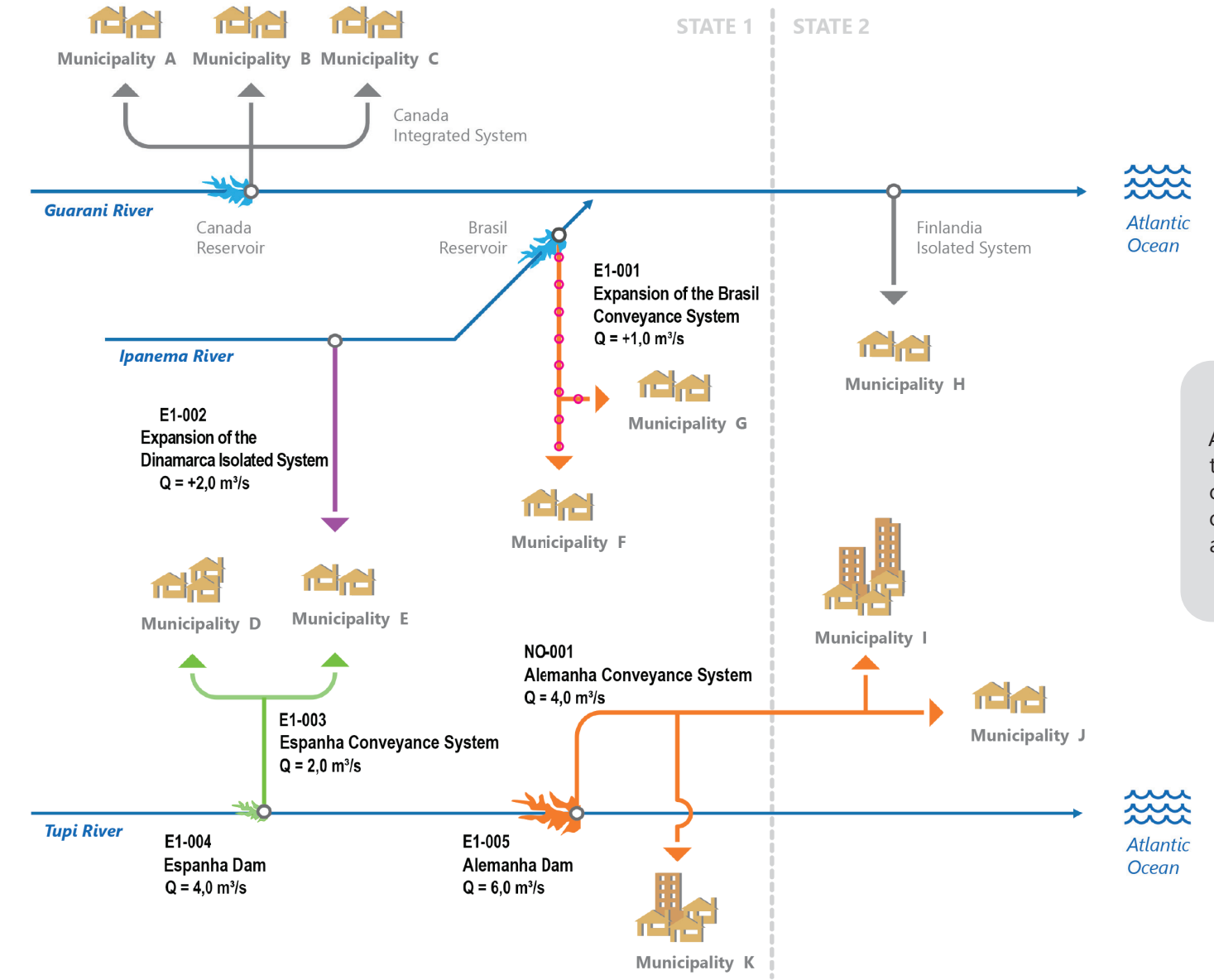


AVAILABLE DOCUMENTATION

Studios/Projects
Hiring Institution
Author/Date

All RIOs detailing the recommended interventions are available at the ANA website.

Water Systems' Diagram



All diagrams detailing the recommended works' complementarity in the case of complex systems, are available at the ANA website.

Existing reservoir
Ongoing works reservoir
Planning phase reservoir
Reservoir with complementary study
River rail
Connection/Intake point

Existing conveyance system
Ongoing works conveyance system
Planning phase conveyance system
Conveyance system with complementary study
Canal, axis or conveyance system expansion

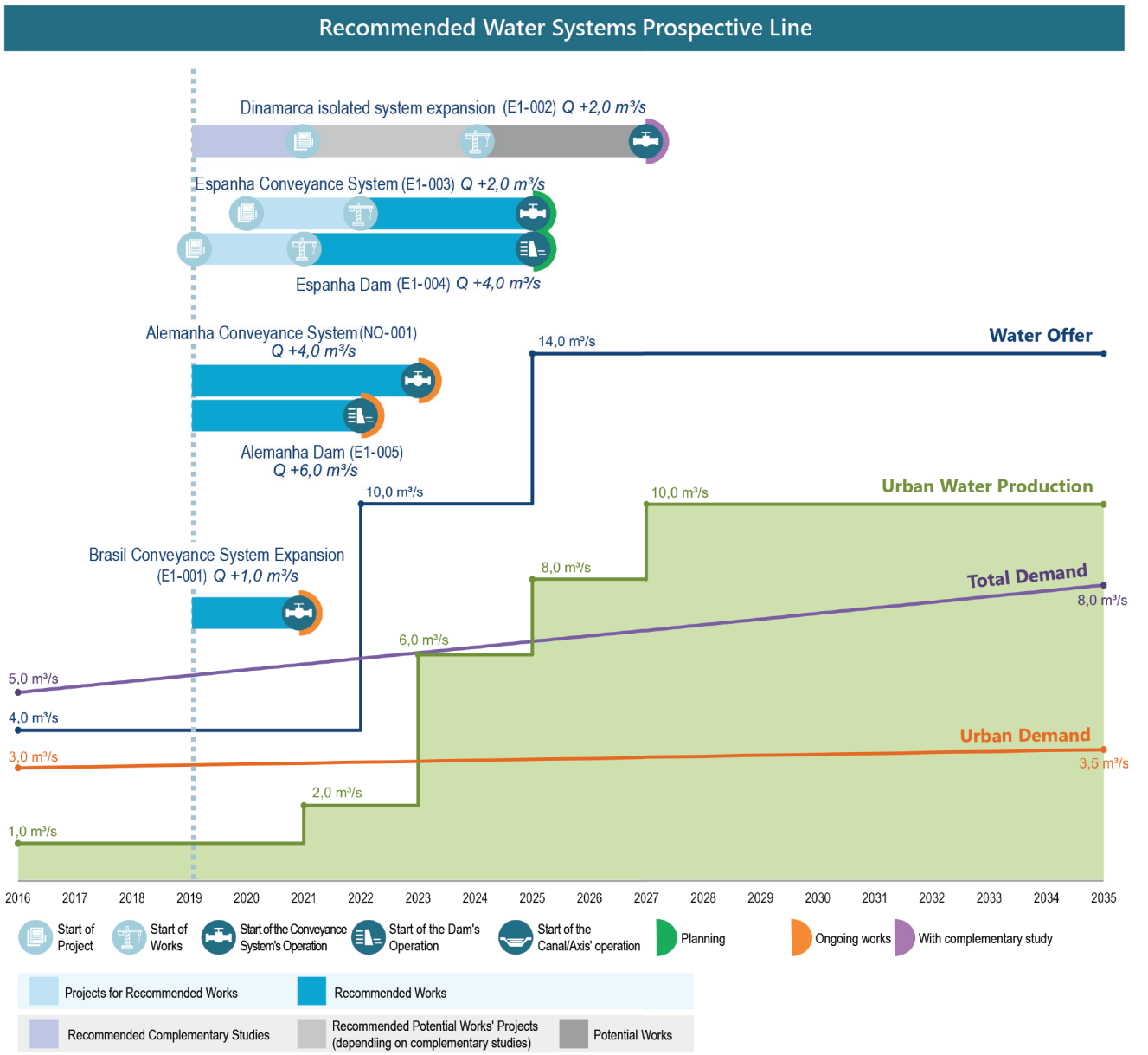
Reservoir size

> 1000 hm³
100 - 1000 hm³
10 - 100 hm³

Population size (inhabitants)

< 5.000
5.000 a 50.000
50.000 a 250.000
250.000 a 1.000.000
> 1.000.000

All Prospective Lines detailing water demand and production evolutions considering the recommended interventions' operation are available at the ANA website.



Physical-Financial Schedules of the Interventions by State

All Interventions provided for in the Studies and Projects and Works Components are presented in schedules organized by State.

The costs were obtained from studies and projects used as reference and updated for July of 2018. In the absence of a reference value, costs were estimated from parametric curves for similar infrastructure.

In the case of the complementary studies, detailed in the summary sheets of the terms of reference, values were based on the execution timeline and the profile of the technical team necessary for conducting the study.

PHYSICAL-FINANCIAL SCHEDULE BY STATE

Code	Studies/Projects/Works	Total Resources Million BRL	Short-term Investments					Medium to Long-term Investments						
			2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030...2035
	ACRE													
	Water Security Index Detailing in the Territorial Units for Analysis[1]	0.80	0.80											
	Water Resources Use Alternatives in High Flood Vulnerability Areas - Acre River Basin	3.80	3.80											
	ALAGOAS													
	Alagoas Sertão Canal (Stretch IV)	150.00	150.00											
AL-001	Alagoas Sertão Canal (Stretch V)	624.18	3.00		12.18			609.00						
	Alagoas Sertão Canal (Stretches VI, VII and VIII - km150 to 250)[1,2]	18.50	18.50											
AL-003	Meirim Conveyance System	118.07	118.07											
AL-013	North Region Conveyance System*	64.74	0.58		3.18			60.98						
	Maceió MR Water Resources Use Study: AL-010- Coqueiro Seco Conveyance System (expansion) AL-012 - Messias-Meirim Integration Axis	3.00	3.00		**			**						
	Water Resources Use Alternatives in High Flood Vulnerability Areas - Mundaú and Paraíba River Basins[3]	1.50	1.50											
	AMAPÁ													
AP-001	Macapá Conveyance System (expansion)	151.13	151.13											
	Water Security Index Detailing in the Territorial Units for Analysis[1]	0.80	0.80											
	AMAZONAS													
	Manaus Metropolitan Region Water Resources Use Study	3,00	3,00		*			*						

* PNSH Estimated Costs

** The potential works and projects values are not indicated due to the uncertainty in the interventions' selection and horizons.

[1] Supply Driven Interventions require complementary actions for their greater effectiveness in ensuring regional water security. The Upper Sertão Conveyance System Interconnections and irrigation perimeters' executive projects are framed to this context.

[2] The value corresponding to the study is presented for all beneficiary states.

[3] The value corresponding to the study is also presented for the Pernambuco state, which shares the Mundaú River Basin with the state of Alagoas.

[1] The value corresponding to the study is presented for all beneficiary states.

* The potential works and projects values are not indicated due to the uncertainty in the interventions' selection and horizons.

Recommended Works Projects

Recommended Works

Recommended Complementary Studies

Potential Works Projects (pending on Complementary Studies)

Potential Works

Regional Development Plan Detailed Study (Integrated Analysis on the effectiveness of the demands associated with potential Supply Driven Works)

PHYSICAL-FINANCIAL SCHEDULE BY STATE

Code	Studies/Projects/Works	Total Resources Million BRL	Short-term Investments 2019	2020	2021	2022	2023	Medium to Long-term Investments 2024	2025	2026	2027	2028	2029	2030...2035
	BAHIA													
TB-001	Tocantins-São Francisco Water Transfer Axis[1,2]	18.50	18.50											
BA-001	Bahia Sertão Canal (South Axis)[2]	18.50	18.50											
BA-002	Santa Helena-Joanes II Integration Axis	330.97	330.97											
BA-003	Pedra do Cavalo Conveyance System (expansion - 3rd Phase)*	201.84	3.76		198.09									
BA-006	Juazeiro-Senhor do Bonfim Conveyance System	678.21	12.62		665.59									
BA-007	Feira de Santana Conveyance System (expansion)	361.47	361.47											
BA-008	Vitória da Conquista Conveyance System (expansion)[3]	109.14	109.14											
BA-016d/g/h	Sertão Waters Conveyance System-Northwest-Southeast Blocks and Center	79.75	0.74		1.21			77.81						
BA-016e/f	Sertão Waters Conveyance System - Southwest Block	331.25	15.36			315.89								
BA-031	Catolé Dam[3]	172.81	172.81											
BA-035	Contas River Dam*	168.00	1.50		8.25			158.25						
	Water Resources Use Study for the Salvador MR: BA-005- Joanes I-ETA Bolandeira Conveyance System	3.00	3.00		**			**						
	Water Resources Use Alternatives in Low Water Security Areas - São Francisco River Left Bank[4]	1.80	1.80											
	Water Resources Use Alternatives in Low Water Security Areas - Contas River Basin	1.80	1.80											
	Water Resources Use Alternatives in Low Water Security Areas - Pardo and Jequitinhonha River Basins[4]	1.80	1.80											
	Water Resources Use Alternatives in Low Water Security Areas - Southern Bahia Coast and Espírito Santo River Basins[5]	1.80	1.80											

* PNSH Estimated Costs

** The potential works and projects values are not indicated due to the uncertainty in the interventions' selection and horizons.

[1] The Tocantins-São Francisco Transposition Axis (TB-001) benefits BA and TO. The value corresponding to the study is also shown in the Tocantins schedule.

[2] The value corresponding to the study is presented for all beneficiary states.

[3] The Vitória da Conquista Conveyance System (BA-008) has an intake point at the Catolé Dam (BA-031).

[4] The value corresponding to the study is also presented for the state of Minas Gerais, which shares these basins with the state of Bahia.

[5] The value corresponding to the study is also shown in the state of Espírito Santo.

Recommended Works Projects

Recommended Works

Recommended Complementary Studies

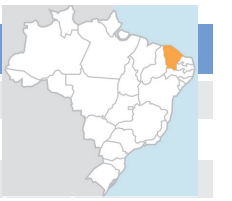
Potential Works Projects (pending on Complementary Studies)

Potential Works

Regional Development Plan Detailed Study (Integrated Analysis on the effectiveness of the demands associated with potential Supply Driven Works)

PHYSICAL-FINANCIAL SCHEDULE BY STATE

Code	Studies/Projects/Works	Total Resources Million BRL	Short-term Investments					Medium to Long-term Investments						
			2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030...2035
	CEARÁ													
CE-001	CAC-Stretch I (Ceará Water Belt)	1,117.76	1,117.76											
CE-002	CAC- Stretch II, Stretch III and Extension Lines 1, 2, East and West[1,2]	18.50	18.50											
CE-004	Eixão das Águas (duplication)	878.94	878.94											
CE-005	Quixeré-Bom Sucesso Integration Axis	912.51	45.21				867.29							
CE-007	Jaguaribe-Icapuí Integration Axis	130.54	5.34				125.20							
CE-017aa	Crajubar Conveyance System (Malha d'Água Project)[3]	162.04	1.46		6.57		154.01							
CE-017ab/ ac/bg	Taquara-Jaibaras Integration Axis and Jaibara-Sobral and Taquara-Sertão de Sobral Conveyance Systems (Malha d'Água Project)	372.31	15.23		357.08									
CE-017ae/ ai/aw	Orós-Trussu Integration Axis and Orós-South Center and Trussu-Upper Jaguaribe Conveyance System (Malha d'Água Project)	552.32	2259		529.73									
CE-017ag	Metropolitan Eastern Coast Conveyance System (Malha d'Água Project)	227.03	9.29		217.74									
CE-017ak/ am/bl	Banabuiú-Pedras Brancas Integration Axis and Banabuiú-Pedras Brancas Central Sertão and Pedras Brancas-Central Sertão Conveyance Systems	657.53	26.90		630.63									
CE-017an	Curral Velho-Jaguaribe Valley Conveyance System (Malha d'Água Project)[4]	155.01	1.40		6.28		147.33							
CE-017ao	Curu Valley-West Coast Conveyance System (Malha d'Água Project)	203.36	8.32		195.04									
CE-017az	Upper Banabuiú-Fogareiro Conveyance System (Malha d'Água project)	241.82	9.89		231.93									
CE-041	Fortaleza MR Production System (Desalination ETA)	527.79	4.75		21.40			501.64						
PISF-001	North Axis - Stretches I and II[5]	244.89	244.89											
PISF-003	North Axis - Stretch III (Salgado Extension Line)[6]	997.59	8.99		40.44			948.16						
	Fortaleza MR Water Resources Use Study: CE-003e -CAC-Coastal Extension Line CE-006 -Trabalhador Canal (recovery and extension)	3.00	3.00		*			*						
	Water Security Index Detailing in the Territorial Units for Analysis[2]	0.80	0.80											



* The potential works and projects values are not indicated due to the uncertainty in the interventions' selection and horizons.
[1] Supply Driven Interventions require complementary actions for their greater effectiveness in ensuring regional water security. The CAC-Stretch I directioning for supplying Fortaleza MR and the Malha d'Água Project are framed in this context.
[2] The value corresponding to the study is presented for all beneficiary states.
[3] The Crajubar Conveyance System (EC-017aa) has an intake point at CAC-Stretch I (EC-001).
[4] The Curral Velho-Jaguaribe Valley Conveyance System (CE-017an) has intake points at the Eixão das Águas (CE-004).
[5] The PISF North Axis benefits the states of CE, PB, PE and RN; the value corresponding to the North Axis also appears in the PB, PE and RN schedules.
[6] The Salgado Extension Line should be evaluated with a view to the directioning of CAC-Stretch t I, for supply of the Middle and Lower Jaguaribe and the Fortaleza MR.

	DISTRITO FEDERAL													
CO-001	Corumbá IV Conveyance System[1]	150.93	150.93											
DF-001	Paranoá Lake Conveyance System	523.25	523.25											
	Federal District Integrated Development Region Water Resources Use Study	4.80	4.80		*			*						
	Water Resources Use Alternatives in Low Water Security Areas - Paranaíba, Grande and Paranapanema River Basins[2]	1.80	1.80											

* The potential works and projects values are not indicated due to the uncertainty in the interventions' selection and horizons.
[1] The Corumbá IV Conveyance system benefits DF and GO; the corresponding value is also shown in the Goiás schedule.
[2] The corresponding value for the study is also shown in the states of Goiás, Minas Gerais, Paraná and São Paulo.

Recommended Works Projects
Recommended Works
Recommended Complementary Studies
Potential Works Projects (pending on Complementary Studies)
Potential Works
Regional Development Plan Detailed Study (Integrated Analysis on the effectiveness of the demands associated with potential Supply Driven Works)

PHYSICAL-FINANCIAL SCHEDULE BY STATE

Code	Studies/Projects/Works	Total Resources Million BRL	Short-term Investments 2019	2020	2021	2022	2023	Medium to Long-term Investments 2024	2025	2026	2027	2028	2029	2030...2035
	ESPÍRITO SANTO													
ES-004	Pedra Bonita Dam	106.15	4.34		101.81									
	Water Resources Use Alternatives in Low Water Security Areas - Southern Bahia Coast and Espírito Santo River Basins[1]	1.80	1.80											
	GOIÁS													
CO-001	Corumbá IV Conveyance System[1]	150.93	150.93											
GO-014	Anápolis Conveyance System	123.19	123.19											
GO-015	Águas Lindas Conveyance System	141.42	141.42											
	Goiânia MR Water Resources Use Study: GO-011 - Caldas Conveyance System GO-017 - Trindade Conveyance System	3.00	3.00		*			*						
	Water Security Index Detailing in the Territorial Units for Analysis[2]	0.80	0.80											
	Water Resources Use Alternatives in Low Water Security Areas - Paranaíba, Grande and Paranapanema River Basins[3]	1.80	1.80											
	MARANHÃO													
MA-001	Italuís II Conveyance System (expansion)	668.80	668.80											
	São Luís MR Water Resources Use Study: MA-003- Maranhão Lowlands Level Dams/Floodwalls	3.00	3.00		*			*						
	Water Security Index Detailing in the Territorial Units for Analysis[1]	0.80	0.80											
	Water Resources Use Alternatives in Low Water Security Areas - Teresina RIDE[2]	1.80	1.80											
	MATO GROSSO													
	Cuiabá MR Water Resources Use Study: MT-001- Cuiabá Park Conveyance System (expansion) MT-002-Tijucal Conveyance System (expansion) MT-003 - Coophema Conveyance System (expansion)	3.00	3.00		*			*						
	Water Security Index Detailing in the Territorial Units for Analysis[1]	0.80	0.80											
	MATO GROSSO DO SUL													
	Water Security Index Detailing in the Territorial Units for Analysis[1]	0.80	0.80											

[1] The value corresponding to the study is also shown in the state of Bahia

* The potential works and projects values are not indicated due to the uncertainty in the interventions' selection and horizons.
[1] The Corumbá IV Conveyance system benefits DF and GO; the corresponding value is also shown in the Federal District schedule.
[2] The value corresponding to the study is presented for all beneficiary states.
[3] The corresponding value for the study is also shown in the Federal District and in the states of Minas Gerais, Paraná and São Paulo.

* The potential works and projects values are not indicated due to the uncertainty in the interventions' selection and horizons.
[1] The value corresponding to the study is presented for all beneficiary states.
[2] The value corresponding to the study is also shown in the state of Piauí.

* The potential works and projects values are not indicated due to the uncertainty in the interventions' selection and horizons.
[1] The value corresponding to the study is presented for all beneficiary states.

[1] The value corresponding to the study is presented for all beneficiary states.

PHYSICAL-FINANCIAL SCHEDULE BY STATE

Code	Studies/Projects/Works	Total Resources Million BRL	Short-term Investments					Medium to Long-term Investments						
			2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030...2035
	MINAS GERAIS													
MG-001	Capim Branco Conveyance System	88.61	88.61											
MG-002	Congonhas-Montes Claros Conveyance System[1]	111.14	111.14											
MG-003	Governador Valadares Conveyance System (expansion)	163.53	163.53											
MG-004	Uberaba Conveyance System (expansion)	18.82	18.82											
MG-007	Itabira Conveyance System (expansion)	7.77	7.77											
MG-011	Jequitaí I Dam[2]	341.05	3.14		6.29		331.62							
MG-012	Jequitaí II Dam[2]	176.47	1.58			8.67				166.23				
MG-013	Congonhas Dam[1]	225.27	225.27											
MG-015	Prainha Dam	27.48	27.48											
CC-MG-008	Xopotó Dam[3]	145.87	7.95			6.83				131.08				
CC-MG-009	Muriaé and Preto Rivers Flood Control System[3]	279.31	7.95		5.05		266.31							
CC-MG-010	Muriaé Dam[3]	81.42	7.95			3.64				69.83				
CC-MG-011	Carangola Dam[3]	72.87	7.95			3.22				61.71				
CC-MG-012	Tombos Dam[3]	95.08	7.95			3.56				83.57				
	Belo Horizonte MR Water Resources Use Study: MG-044 - Velhas River Dam	4.80	4.80			*				*				
	Water Security Index Detailing in the Territorial Units for Analysis[4]	0.80	0.80											
	Water Resources Use Alternatives in Low Water Security Areas - Paranaíba, Grande and Paranapanema River Basins[5]	1.80	1.80											
	Water Resources Use Alternatives in Low Water Security Areas - Verde Grande River Basin	1.80	1.80											
	Water Resources Use Alternatives in Low Water Security Areas - São Francisco River Left Bank [6]	1.80	1.80											
	Water Resources Use Alternatives in Low Water Security Areas - Pardo and Jequitinhonha River Basins[6]	1.80	1.80											
	PARÁ													
PA-001	Bolonha Complex Conveyance System (expansion)	158.66	158.66											
PA-003	Marabá Conveyance System (expansion)	54.58	54.58											
	Water Security Index Detailing in the Territorial Units for Analysis[1]	0.80	0.80											

* The potential works and projects values are not indicated due to the uncertainty in the interventions' selection and horizons.
[1] The Congonhas Dam (MG-013) is a water source for the Congonhas-Montes Claros Conveyance System (MG-002).
[2] Jequitaí I (MG-011) and Jequitaí II (MG-012) dams are complementary and aim at flood control.
[3] The study's value considers the dams in the states of Minas Gerais and Rio de Janeiro (CC-MG-008, CC-MG-009, and CC-MG-010, CC-MG-011, CC-MG-012, CC-RJ-001 and CC-RJ-002).
[4] The value corresponding to the study is presented for all beneficiary states.
[5] The corresponding value for the study is also shown in the Federal District and in the states of Goiás, Paraná and São Paulo.
[6] The value corresponding to the study is also presented for the state of Bahia, which shares these basins with the state of MG.

[1] The value corresponding to the study is presented for all beneficiary states.

Recommended Works Projects
Recommended Works
Recommended Complementary Studies
Potential Works Projects (pending on Complementary Studies)
Potential Works
Regional Development Plan Detailed Study (Integrated Analysis on the effectiveness of the demands associated with potential Supply Driven Works)

PHYSICAL-FINANCIAL SCHEDULE BY STATE

Code	Studies/Projects/Works	Total Resources Million BRL	Short-term Investments 2019	2020	2021	2022	2023	Medium to Long-term Investments 2024	2025	2026	2027	2028	2029	2030...2035
	PARAÍBA													
NS-001	Pajeú Conveyance System - 2nd Phase[1]	24.57	24.57											
NS-002	Bujari Dam[2]	29.53	0.40		0.54			28.59						
PB-001	Acauã-Araçagi Canal/Coastal Branches - Stretches 1 and 2	426.32	426.32											
	Acauã-Araçagi Canal/Coastal Branches - Stretch 3[3,4]	18.50	18.50											
PB-002	Piancó Extension Line [5]	240.27	11.91			228.37								
PB-003a	Transparaíba Conveyance System (Cariri Extension Line)	330.00	13.50			316.50								
PB-003b	Transparaíba Conveyance System (Cariri Extension Line))	371.00	371.00											
PB-004	Campina Grande (3rd) Conveyance System	93.22	0.84		3.78			88.60						
PB-005	Nova Camará Conveyance System	96.49	96.49											
PB-033	Abiaí-Papocas Conveyance System	62.83	62.83											
PISF-001	North Axis - Stretches I and II[6]	244.89	244.89											
	João Pessoa MR Water Resources Use Study: PB-027 - Cupissura Dam	3.00	3.00		*			*						

* The potential works and projects values are not indicated due to the uncertainty in the interventions' selection and horizons.
[1] The Pajeu Conveyance System - 2nd Phase (NS-001) benefits PE and PB; the corresponding value is also presented in the Pernambuco schedule.
[2] The Bujari Dam (NS-002) benefits RN and PB; the corresponding value is also shown in the Rio Grande do Norte schedule.
[3] Supply Driven Interventions require complementary actions for their greater effectiveness in ensuring regional water security. The Gurinhém Dam and the interconnection between conveyance systems plan projects are framed in this context.
[4] The value corresponding to the study is presented for all beneficiary states.
[5] The Piancó Extension Line has an Intake Point in the North Axis - PISF Stretch II.
[6] The PISF North Axis benefits the states of CE, PB, PE and RN; the value corresponding to the North Axis also appears in the CE, PE and RN schedules.

	PARANÁ													
PR-001	Foz do Iguaçu Conveyance System (expansion)*	63.83	2.61			61.22								
PR-020	Miringuava Dam	157.81	157.81											
PR-024	Cascavel Conveyance System (expansion)	76.41	76.41											
	Curitiba MR Water Resources Use Study: PR-021 - Faxinal Dam PR-022 - Despique Dam PR-023 - Maurício Dam	4.80	4.80		**			**						
	Water Security Index Detailing in the Territorial Units for Analysis[1]	0.80	0.80											
	Water Resources use Alternatives in Low Water Security Areas - Paranaíba, Grande and Paranapanema River Basins[2]	1.80	1.80											

* PNSH Estimated Costs
** The potential works and projects values are not indicated due to the uncertainty in the interventions' selection and horizons.
[1] The value corresponding to the study is presented for all beneficiary states.
[2] The corresponding value for the study is also shown in the Federal District and in the states of Goiás, Minas Gerais, and São Paulo.

Recommended Works Projects
Recommended Works
Recommended Complementary Studies
Potential Works Projects (pending on Complementary Studies)
Potential Works
Regional Development Plan Detailed Study (Integrated Analysis on the effectiveness of the demands associated with potential Supply Driven Works)

PHYSICAL-FINANCIAL SCHEDULE BY STATE

Code	Studies/Projects/Works	Total Resources Million BRL	Short-term Investments					Medium to Long-term Investments						
			2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030...2035
	PERNAMBUCO													
NS-001	Pajeú Conveyance System - 2nd Phase[1]	24.57	24.57											
NE-001	Pernambuco Sertão Canal[2]	18.50	18.50											
PE-001	Agreste Conveyance System	735.64	735.64											
PE-008	Negreiros-Chapéu Conveyance System	77.62	0.69		3.81			73.11						
PE-011	Bitury Conveyance System (expansion)	213.53	213.53											
PE-020	Tramo Sul Conveyance System (Jucazinho Expansion System)	19.62	19.62											
PE-027	Engenho Maranhão Conveyance System - ETA Suape	232.27	9.50		222.76									
PE-028	Engenho Maranhão Conveyance System - ETA Pirapama	386.47	19.15			367.32								
PE-032	Tracunhaém-EE Arataca II Conveyance System (expansion)	427.86	21.20			406.66								
PE-049	Western Conveyance System (expansion)	147.54	1.36		2.72	143.46								
PE-057	Engenho Maranhão Dam	81.05	81.05											
PE-073	Tracunhaém Dam	323.62	16.04			307.59								
PE-083	Entremontes Extension Line[2]	18.50	18.50											
PISF-001	North Axis - Stretches I and II[3]	244.89	244.89											
PISF-007	Agreste Extension Line	1,466.71	1,466.71											
CC-PE-004	Igarapeba Dam	173.23	173.23											
CC-PE-006	Guabiraba Dam	78.73	78.73											
CC-PE-007	Panelas II-Gatos Dam	138.00	138.00											
	Recife ME Water Resources Use Study: PE-006- Botafogo Conveyance System (expansion) PE-007-Suape Conveyance System (expansion) PE-009 - Tapacurá Conveyance System (expansion) PE-013 - Itapirema-Goiana Conveyance System PE-021- Engenho Pereira Conveyance System PE-063- Engenho Pereira Dam4 PE-084- Recife MR Rings' Conveyance Systems and Connections	3.00	3.00		*			*						
	Water Resources Use Alternatives in Low Water Security Areas - the water catchment area of the Mundaú and Paraíba River Basins[5]	1.50	1.50											
	PIAUÍ													
NE-002	Piauí Sertão Canal (West Axis)[1,2]	18.50	18.50											
PI-010	Coastal Conveyance System	70.35	70.35											
	Water Resources Use Alternatives in Low Water Security Areas Teresina Integrated Development Region [3]	1.80	1.80											

* The potential works and projects values are not indicated due to the uncertainty in the interventions' selection and horizons.
[1] The Pajeu Conveyance System - 2nd Phase (NS-001) benefits PE and PB; the corresponding value is also presented in the Paraíba schedule.
[2] The value corresponding to the study is presented for all beneficiary states.
[3] The PISF North Axis benefits the states of CE, PB, PE and RN; the value corresponding to the North Axis also appears in the CE, PB and RN schedules.
[4] The Pereira Engenho dam (PE-063) also aims to control floods.
[5] the value corresponding to the study is also presented for the Alagoas state, which shares the Mundaú River Basin with the state of Pernambuco.

[1] The Piauí Sertão Canal (NE-002) has an intake point at the São Francisco River in the state of Bahia, but only benefits municipalities in the state of Piauí.
[2] The value corresponding to the study is presented for all beneficiary states.
[3] The value corresponding to the study is also shown in the state of Maranhão.

PHYSICAL-FINANCIAL SCHEDULE BY STATE

Code	Studies/Projects/Works	Total Resources Million BRL	Short-term Investments 2019	2020	2021	2022	2023	Medium to Long-term Investments 2024	2025	2026	2027	2028	2029	2030...2035
	RIO DE JANEIRO													
RJ-002	Imunana-Laranjal Conveyance System (expansion)* [1]	268.85	13.32	255.53										
RJ-003	Prolagos Conveyance System (expansion)	85.98	85.98											
RJ-006	Poços, Queimados and Ipiranga Diversion	56.83	56.83											
RJ-009	Guapiaçu Dam[1]	281.05	5.23	275.82										
RJ-012	Guandu Production System (Nova Guandu ETA expansion)	4,439.75	82.60	4,357.15										
CC-RJ-001	Itaperuna Dam[2]	278.85	7.95	5.04	265.86									
CC-RJ-002	Laje do Muriaé Dam[2]	145.14	7.95	2.55	134.64									
	Rio de Janeiro MR Water Resources Use Study: RJ-001 - Paraíba do Sul-Guandu Water Transfer Axis (new scheme) RJ-004 - Tangua-Maricá Conveyance System RJ-007 - Preto River Dam RJ-010 - Tanguá River Dam	4.80	4.80	**				**						
	Water Security Index Detailing in the Territorial Units for Analysis[3]	0.80	0.80											

* PNSH Estimated Costs
** The potential works and projects values are not indicated due to the uncertainty in the interventions' selection and horizons.
[1] The Guapiaçu Dam (RJ-009) is the expansion water source for the Imunana-Laranjal Conveyance System (RJ-002).
[2] The study's value considers the dams in the states of Minas Gerais and Rio de Janeiro (CC-MG-008, CC-MG-009, and CC-MG-010, CC-MG-011, CC-MG-012, CC-RJ-001 and CC-RJ-002).
[3] The value corresponding to the study is presented for all beneficiary states.

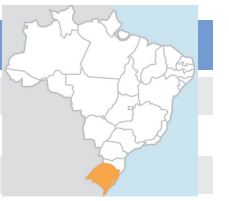
Code	Studies/Projects/Works	Total Resources Million BRL	Short-term Investments 2019	2020	2021	2022	2023	Medium to Long-term Investments 2024	2025	2026	2027	2028	2029	2030...2035
	RIO GRANDE DO NORTE													
NS-002	Bujari Dam[1]	29.53	0.40	0.54	28.59									
NS-003	Serra Negra do Norte Dam (Nova Dinamarca)[2]	472.31	4.26	19.15	448.90									
RN-004	Monsenhor Expedito Conveyance System (expansion)	114.41	5.67	108.74										
RN-009	Santa Cruz-Pau dos Ferros Integration Axis (express conveyance system)	113.05	4.62	108.42										
RN-015	Santa Cruz-Mossoró Conveyance System	139.72	139.72											
RN-018	Oiticica Dam[3,4]	261.11	261.11											
RN-034a	Armando Ribeiro Gonçalves-Currais Novos Conveyance System (Seridó Project)	107.22	5.31	101.91										
RN-034b	Oiticica-Caicó Conveyance System (Seridó Project)[4]	35.63	1.77	33.86										
PISF-001	North Axis - Stretches I and II[5]	244.89	244.89											
PISF-004	North Axis -Stretch IV (Apodi Extension Line)[6]	3,092.53	27.86	125.37	2,939.29									
	Natal MR Water Resources Use Study: RN-005 - Maxaranguape Conveyance system	3.00	3.00	*				*						

* The potential works and projects values are not indicated due to the uncertainty in the interventions' selection and horizons.
[1] The Bujari Dam (NS-002) benefits RN and PB and may be a possible water source for the Monsenhor Expedito Conveyance System (RN-004); the corresponding value is also presented in the Paraíba schedule.
[2] The Serra Negra do Norte Dam (NS-003) may also benefit Paraíba because it is located at the state-border.
[3] The Oiticica Dam (RN-018) also aims to control floods.
[4] The Oiticica Dam (RN-018) is a water source for the Oiticica-Caicó Conveyance System (RN-034b).
[5] The PISF North Axis benefits CE, PB, PE and RN; the North Axis corresponding value is also shown in the CE, PB and PE schedules.
[6] The Apodi Extension Line should be evaluated considering the PISF North Axis' new use configuration.

Recommended Works Projects
Recommended Works
Recommended Complementary Studies
Potential Works Projects (pending on Complementary Studies)
Potential Works
Regional Development Plan Detailed Study (Integrated Analysis on the effectiveness of the demands associated with potential Supply Driven Works)

PHYSICAL-FINANCIAL SCHEDULE BY STATE

Code	Studies/Projects/Works	Total Resources Million BRL	Short-term Investments					Medium to Long-term Investments						
			2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030...2035
	RIO GRANDE DO SUL													
RS-001	Porto Alegre Conveyance System (new water source)	171.69	171.69											
RS-003	Pelotas Conveyance System (expansion)	50.43	50.43											
RS-007	Alvorada-Viamão Conveyance System (expansion)	64.78	64.78											
RS-008	Canela-Gramado Conveyance System (expansion)	14.81	0.40		0.80	13.01								
RS-017	Taquarembó Dam[1]	25.30	25.30											
RS-019	Jaguari Dam[1]	154.43	154.43											
RS-029	Arvorezinha Dam	96.98	96.98											
	Porto Alegre MR Water Resources Use Study: RS-002 - Casamento Lagoon-Gravataí River Integration Axis RS-004 - Novo Hamburgo Conveyance System (expansion) RS-006 - Campo Bom Conveyance System (expansion) RS-009 - Eldorado do Sul-Guaíba Conveyance System (expansion) RS-032 - Anastácia Lagoon Dam	4.80	4.80		*			*						
	Water Resources Use Alternatives in Low Water Security Areas - Uruguay River Basin[2]	1.80	1.80											
	Water Resources Use Alternatives in High Flood Vulnerability Areas - Jacuí and Taquari-Antas River Basins	6.20	6.20											
	RONDÔNIA													
RO-001	Porto Velho Conveyance System	166.04	166.04											
	RORAIMA													
	Water Security Index Detailing in the Territorial Units for Analysis[1]	0.80	0.80											
	SANTA CATARINA													
SC-002	Araquari-Joinville Conveyance System	126.70	5.18		121.51									
SC-004	Balneário Camboriú-Camboriú Conveyance System (expansion)	76.49	3.13		73.36									
SC-007	Cubatão-Pilão Conveyance System (expansion)	141.51	141.51											
CC-SC-001	Itajaí Mirim River Dam (Botuverá Dam)	102.80	102.80											
	Florianópolis MR Water Resources Use Study: SC-001 - East Coast Conveyance System SC-005 - Biguaçu River Conveyance System	3.00	3.00		*			*						
	Water Security Index Detailing in the Territorial Units for Analysis[1]	0.80	0.80											
	Water Resources Use Alternatives in Low Water Security Areas - Uruguay River Basin[2]	1.80	1.80											
	Water Resources Use Alternatives in High Flood Vulnerability Areas - Tubarão and Aranguá River Basins	1.50	1.50											
	Water Resources Use Alternatives in High Flood Vulnerability Areas - Itajaí River Basin	2.50	2.50											



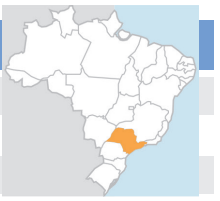
* The potential works and projects values are not indicated due to the uncertainty in the interventions' selection and horizons.
[1] The Tacharembó (RS-017) and Jaguari (RS-019) dams also aim at flood control.
[2] The value corresponding to the study is also presented for the Santa Catarina state, which shares the Uruguay River Basin with the state of Rio Grande do Sul.

[1] The value corresponding to the study is presented for all beneficiary states.

* The potential works and projects values are not indicated due to the uncertainty in the interventions' selection and horizons.
[1] The value corresponding to the study is presented for all beneficiary states.
[2] The value corresponding to the study is also presented for the Rio Grande do Sul state, which shares the Uruguay River Basin with the state of Santa Catarina.

PHYSICAL-FINANCIAL SCHEDULE BY STATE

Code	Studies/Projects/Works	Total Resources Million BRL	Short-term Investments 2019	2020	2021	2022	2023	Medium to Long-term Investments 2024	2025	2026	2027	2028	2029	2030...2035
	SÃO PAULO													
SP-011	São José do Rio Preto Conveyance System	361.18	6.72			354.46								
SP-012	PCJ Regional Conveyance System[1]	724.31	29.63			694.68								
SP-016	Sarapuí-Sorocaba-Salto-Piraí Reservoir-Indaiatuba Conveyance System/Scheme[2]	467.58	19.13			448.45								
SP-019	Guarujá Conveyance System (expansion)	125.19	6.20			118.98								
SP-037	Duas Pontes Dam[1]	206.87	206.87											
SP-038	Pedreira Dam[1]	243.60	243.87											
SP-040	Ribeirão Piraí Dam[2]	131.71	131.71											
SP-044	Ribeirão Preto Conveyance System	490.04	9.12			480.92								
	São Paulo MR Water Resources Use Study: SP-002 - Upper Juquiá Conveyance System/Scheme SP-003 - Jurumirim-ETA Cotia Conveyance System/Scheme SP-005 - Itatinga-Itapanhaú Conveyance System/Scheme SP-013 - Capivari-Monos Conveyance System/Scheme SP-021 - Jundiuvira-Piraí Dam Conveyance System/Scheme SP-034 - Cabreúva-Barueri Conveyance System SP-041 - Jundiuvira Dam	4.80	4.80			**			**					
	Water Security Index Datailing in the Territorial Units for Analysis[3]	0.80	0.80											
	Water Resources Use Alternatives in Low Water Security Areas - Paranaíba, Grande and Paranapanema River Basins[4]	1.80	1.80											



* The potential works and projects values are not indicated due to the uncertainty in the interventions' selection and horizons.
[1] The Duas Pontes (SP-037) and Pedreira (SP-038) Dams are water sources for the PCJ Regional Conveyance System (SP-012).
[2] The Ribeirão Piraí Dam (SP-040) is a water source for the Sarapuí-Sorocaba-Salto-Piraí Reservoir-Indaiatuba Conveyance System/Scheme (SP-016).
[3] The value corresponding to the study is presented for all beneficiary states.
[4] The corresponding value for the study is also shown in the Federal District and in the states of Goiás, Minas Gerais, and Paraná.

	SERGIPE													
NM-001	Xingó Canal[1]	18.50	18.50											
SE-001	São Francisco Conveyance System (3rd Phase - expansion)	160.34	160.34											
SE-003	Agreste Conveyance System (expansion)	44.15	44.15											
SE-008	Upper Sertão Conveyance System (expansion)	30.74	0.40		0.56	29.78								
SE-013	Vaza-Barris River Dam	406.00	20.12			385.89								
	Aracaju MR Water Resources Use Study: SE-002 - Poxim Conveyance System	3.00	3.00			*			*					

* The potential works and projects values are not indicated due to the uncertainty in the interventions' selection and horizons.
[1] The value corresponding to the study is presented for all beneficiary states.

	TOCANTINS													
TB-001	Tocantins-São Francisco Water Transfer Axis[1]	18.50	18.50											
TO-001	Palmas Conveyance System (expansion)	41.79	0.78		41.01									
	Water Resources Use Alternatives in Low Water Security Areas - Formoso River Basin	1.80	1.80											

[1] The value corresponding to the study is presented for all beneficiary states.

Recommended Works Projects
Recommended Works
Recommended Complementary Studies
Potential Works Projects (pending on Complementary Studies)
Potential Works
Regional Development Plan Detailed Study (Integrated Analysis on the effectiveness of the demands associated with potential Supply Driven Works)

INSTITUTIONAL COMPONENT

The completion of the water infrastructure planning and implementation phases will result in a set of continued activities to be carried out until the end of the useful life of the infrastructure. The efforts and investments in operation and maintenance (O&M) are therefore key elements for ensuring water security. For this reason, the PSH included the necessary investments for the recommended operation and maintenance of the works in the Institutional Component, in order to ensure that the expected benefits will be achieved.

The estimate of the O&M cost for the recommended interventions used as a reference the values calculated for the operation structuring engineering studies for the PISF (North and East Branches), without considering electric energy costs.

The estimate parameters took into account the manpower necessary for the operation, monitoring, and surveillance of the systems, and the service of small repairs, as well as material and equipment necessary for executing these services. The calculation also took into account the maintenance costs (civil works, electrical and mechanical equipments) to guarantee the good conditions of the infrastructure throughout its useful life.

Even though the operating costs may have an increasing trend, mainly in relation to maintenance and repairs, the PSH has adopted the annual average value of 2% of the implementation costs, even considering that maintenance costs tend to be lower at the beginning increasing throughout the life cycle of the infrastructure due to wear, need for replacement of parts, and other factors. This reference value was adopted for PSH canals and dams. In the case of conveyance systems, the value adopted was 3.5% of the total implementing costs.

The estimated O&M costs for the recommended interventions is 1,2 billion BRL annually, of which 234 million BRL refers to the average annual O&M costs for the PISF North and East Axes.

In addition to the very significant amount of financial resources, there is also the additional challenge of an efficient organizational arrangement that provides the necessary conditions for operation and maintenance actions. The strategy of the MDR of modelling the PISF's untreated water conveyance service, for example, aims at structuring the project's operation to meet water demands and to ensure synergy with local water sources.

The recommended integrated conveyance systems of PSH for the semi-arid and metropolitan regions tend to extrapolate the logic of exclusive business of the water utilities sector, requiring a differentiated institutional arrangement that considers the systems' large extensions, interconnections and interdependence of water sources. In the state of Ceará the arrangement separates the untreated water conveyance services, operated by the Water Resources Management Company (COGERH) from the treated water distribution services, operated by the water utility (Water and Sewage Company of the state of Ceará – CAGECE). This has proven to be an appropriate model for the general operation and maintenance of water infrastructure, as well as for complex integrated conveyance systems.

The structuring of the institutional arrangements regarding the O&M of conveyance systems, integration water-conveyance systems and canals is based on the provision of services to meet specific demands. As regards dams, the lack of revenue directly associated with the water reservation service (both for water supply and for flood control) further complicates the situation. In the case of water supply dams, DNOCS and CODEVASF are responsible for the vast majority of the public dams of Federal domain in the Semi-arid region. However, they depend on the allocation of budgetary resources that have historically been insufficient.

In the specific case of flood control, the extinction of the National Sanitation Works Department (DNOS), in 1990, negatively affected conservation and maintenance actions in the existing infrastructure.

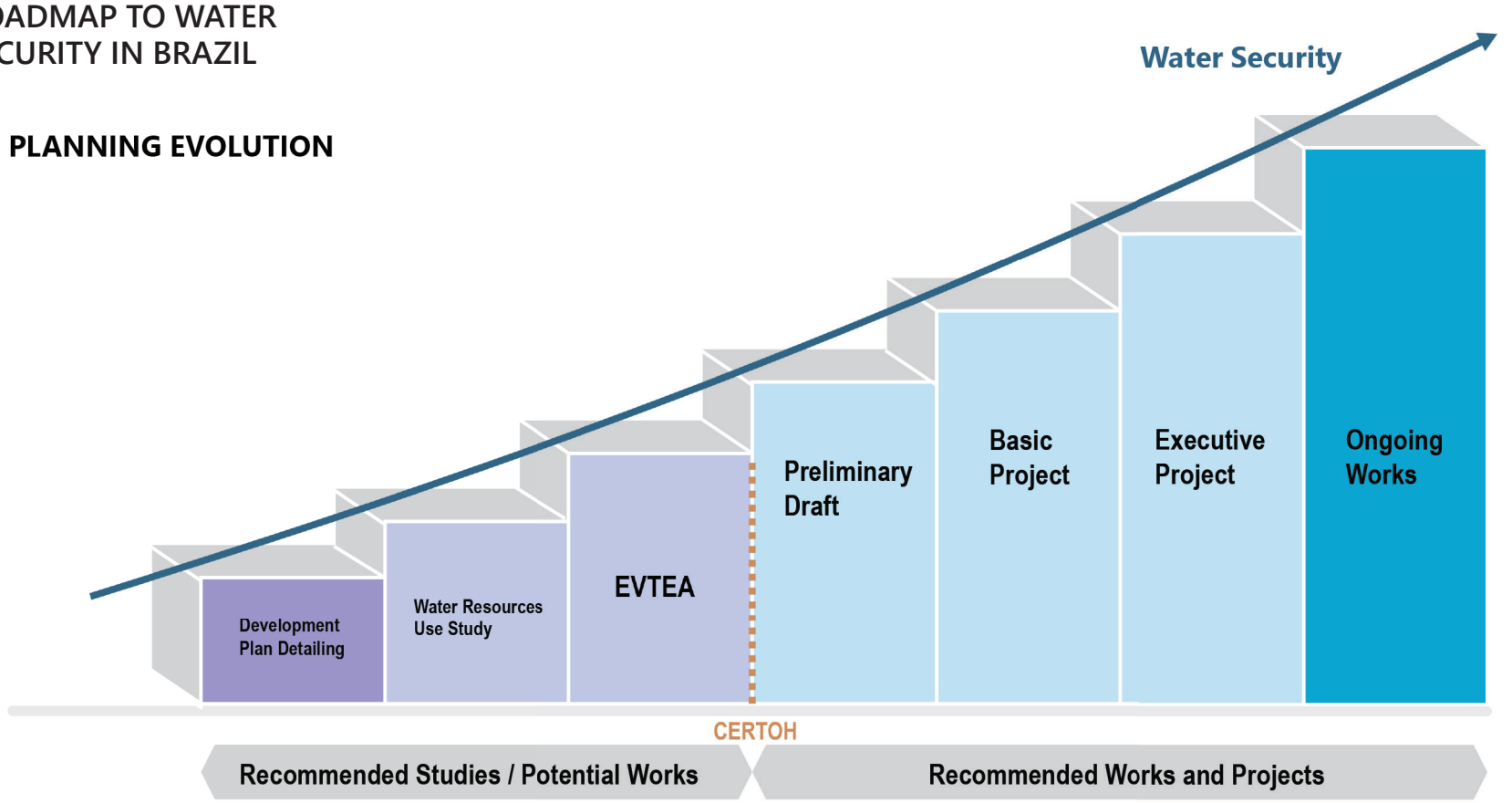
As an alternative, ANA has been seeking partnership with state and local entities to implement the decentralized and sustainable management and operation of these structures. These new arrangements, based on new institutional and economic mechanisms which may include business constortia and non-profit civil associations, could be adopted for the recommended interventions of PSH.

ROADMAP TO WATER SECURITY IN BRAZIL - 2019 TO 2035

Based on the PNSH analysis it is possible to trace a Water Security path for the Country for the 2035 horizon, indicating interventions that have proven to be adherent to the problems identified and that are in different implementation stages, from early stages to ongoing works.

ROADMAP TO WATER SECURITY IN BRAZIL

PLANNING EVOLUTION



RECOMMENDED INVESTMENTS (Billion BRL)	Development Plan Detailing	Water Resources Use Study	EVTEA	Preliminary Draft	Basic Project	Executive Project	Ongoing Works	TOTAL
Studies/Projects	18,50	97,30	71,29	233,32	156,04	101,93	-	678,38
Works	$	$	$	4.754,29	4.602,12	6.131,47	11.414,44	26.902,32
TOTAL	18,50	97,30	71,29	4.987,61	4.758,16	6.233,40	11.414,44	27.580,69

$ Confirmation of investments for potential works depends on the results of the studies.

For some water security interventions or problems identified, there are still knowledge gaps for proving the effectiveness of the solutions in the face of the PNSH assumptions. Multiple types of studies have been recommended for these cases, ranging from studies to detail regional development plans to feasibility studies. These additional studies are required for the confirmation of potential works. On the other hand, fully qualified PNSH interventions are in more advanced planning stages and require the detailing of engineering projects or the completion of ongoing works.

Therefore, the path to Water Security is anchored in the trace of an evolution of the need for investment considering the different development stages of the interventions. In this context, the roadmap begins with studies, moves on to projects, which, in turn, are materialized in works, according to the following steps:

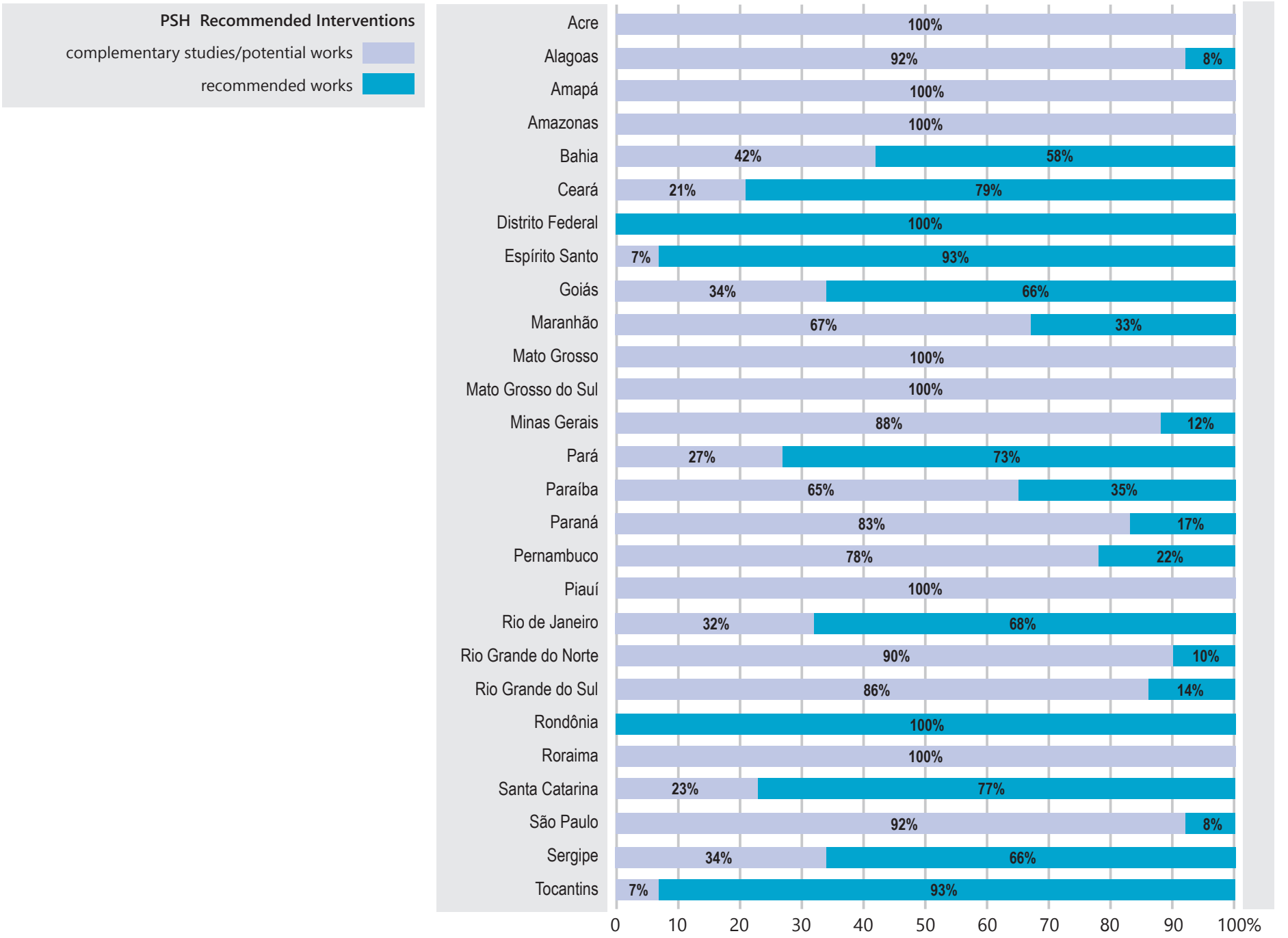
1. Study to Detail Regional Development Plans: directed to Supply-Driven interventions. This study should promote the integrated overall examination of the interventions and focus on the effectiveness of the demands to be met and on the vulnerabilities and aptitudes of the covered basins. Water infrastructure is only one of the multiple variables, additionally to the public and private sectors investment capacity for implementing the demands, the consumer market, the energy supply, transportation logistics, environmental preservation, among other variables, all of which should be considered in the evaluation and qualification of water supply driven projects.
2. Alternative studies for water resources use in complex areas or with low water security levels: study and selection of alternatives to interventions in metropolitan regions, and in regions with risks associated to water supply but with no solutions identified. In the first case, the studies should have a wide spatial scope and broad horizon and consider the interdependence of water sources and the complementarity of the infrastructure. In the second case, the studies should aim at the diagnosis and selection of alternative sources.
3. Technical-Economic and Environmental Feasibility Studies (EVTEA): recommended for interventions that need evaluation of alternatives or the optimization of previous proposals that need to be adapted considering the results of the PNSH integrated analysis.
4. Preliminary draft, basic project or executive project: interventions that were qualified by the Integrated Analysis and constitute recommended investments but are in different implementation stages.
5. Execution of works: for interventions that were authorized by the Integrated analysis and whose works are in progress.

Thus, the Water Security Program acts as a fundamental decision-making, investment programming and resource allocation tool for strategic water infrastructure implementation in Brazil. It allows the prioritizing of efforts at the appropriate stage for each intervention analyzed as to its water supply and flood control guarantees and their benefits to the population and economic activities.

From the normative point of view, The Water Infrastructure Works Assessment Certificate (CERTOH) may play the role of a regulatory tool for the Water Security Program both from the standpoint of water sustainability and operations, marking the change of status from potential works to recommended works (fully qualified interventions). In addition to conferring technical and financial viability to the intervention, the CERTOH issued by ANA seeks to assess the operability of the infrastructure to be implemented through an institutional mechanism that guarantees the continuity of the works operation, which is also related to the Institutional Component of PSH.

Water infrastructure works for untreated water reservation or supply, to be implemented or funded (in whole or in part) by public financial resources need to follow sustainability criteria established by Decree No 4,024/2001. Works valued at over 10 million BRL must have their **CERTOH** issued by ANA.

PERCENTAGE REDUCTION OF POPULATION AT RISK THROUGH PSH INTERVENTIONS BY STATE



The benefits of PSH may be analyzed based on the effect of the recommended interventions in reducing water risks identified in the Water Security Diagnosis.

In the case of the human dimension of the ISH, for the population at risk there is a planned roadmap for supplying the deficits, as indicated in the physical-financial schedule presented by State. The impacts will depend on the planning stage of the selected interventions (potential or recommended works).

92% (54.8 million inhabitants) of the total population estimated to be at higher risk (post-deficit risk) by 2035 live in the Territorial Areas analyzed. The interventions authorized as recommended works that, are in the more advanced planning stages in the path towards water security, have the capacity to benefit 18.2 million inhabitants in urban areas, who will be removed from water risk situations. The other 36.6 million inhabitants also depend on interventions in the PSH; whose potential works rely on the completion of the recommended complementary studies.

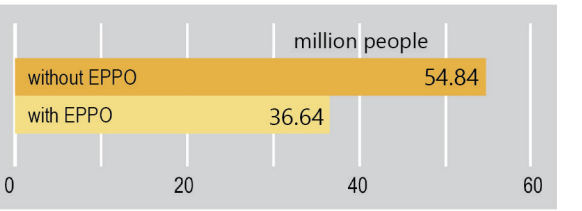
For the economic dimension of the ISH, the recommended interventions in PSH will produce a reduction of 69.8 billion BRL/year from the value-at-risk in agricultural and industrial activities associated with the use of water.

The reduction of these water risks prevents economic losses as a result of the benefits in implementing the PSH-recommended water infrastructure. By relating water scarcity risks reduction with the economic production values affected, it is possible to visualize the implementation economy potential of the program through the cost-benefit analysis.

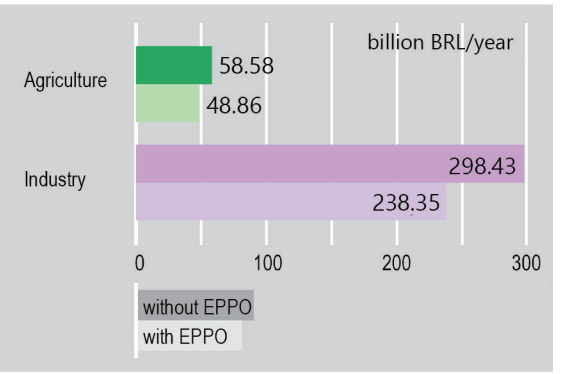
This assessment contrasts the benefits of water security solutions to the investment costs it entails. For this purpose, the 2019-2035 timeframe was considered, and the benefits of risk reduction are accounted from the year following the completion of the water infrastructure. A conservative valuation of the benefits generated by the increase in water security was performed by assigning economic risk parameters to each user sector. By comparing the costs of an intervention with the benefits it brings both in economic terms and in net present value (NPV), the cost-benefit analysis objectively reveals the potential contribution of the intervention.

By considering only recommended works in the PSH aggregate value, each BRL (1.00 BRL) invested for increasing water security generates approximately 21 BRL (20.78 BRL) in benefits. The demand for 21.9 billion BRL in interventions (costs in NPV), provides benefits of the order of 454.6 billion BRL. The benefits distribution among user sectors is 93% for services (urban population parameter), 2% for the industry and 5% for agricultural activities, mirroring the focus of the PSH-recommended interventions in urban water supply. When excluding ongoing recommended works (for which only the remaining investment values are accounted for), in order to avoid the overvaluation of the benefits, **each BRL (1.00 BRL) invested in water security generates approximately fifteen BRL (14.56 BRL) in benefits of the PSH-related intervention.**

Urban population at risk in UTAs



Economic values at risk in the UTAs



PNSH Challenges 5

Verde and Grande rivers confluence, border
between the States of São Paulo and Minas Gerais
Photo: Raylton Alves Batista/ANA Image Bank. 2015

5 Challenges to the Implementation of the PNSH

Water security concerns became more forceful in the 21st Century. The elaboration of the PNSH was largely based on the four dimensions of the water security concept – **human, economic, ecosystem and resilience** – as defined by the UN. These dimensions represent a great challenge to be overcome by Brazil, as a continental country with profound inter-regional differences, and with a territory of 8.5 million km² and a population of over 200 million inhabitants.

By 2020, the urbanization rates in Brazil may reach 90%, which means greater pressure on water resources in the human, economic and ecosystem dimensions, with the increase of urban agglomerations and productive activities demanding more water and increasing pollution sources. In the resilience dimension, one seeks to quantify the environment vulnerability to extreme events, in convergence with the climate change scenarios evaluated, which forecast the intensification of droughts and floods in the medium and long term.

In this context of growing water demands, associated with the effects of climate change, it is necessary to count on rationally planned water supply for the present and for the future through the implementation of robust infrastructure that is financially viable and properly maintained and operated, in addition to the establishing of measures for conscious water use. In parallel, the extreme effects characterized by floods should also be the focus of prevention and construction of infrastructure in more vulnerable river basins.

To tackle this broad challenge **PNSH** was drawn based on the Water Security assessment - of its four dimensions - for Brazil. The Plan presents a set of structural and strategic interventions to guarantee water supply and flood control in the country, as well as a roadmap for its implementation within the next 16 years.

The water supply interventions recommended in the PNSH observed the following general guidelines:

- Water supply of the territorial units analyzed which concentrate most of the strategic problems of the country (by State), which were characterized by the largest deficits and the highest risks to human supply and productive activities, measured through the population supplied and the agricultural and industrial production values.
- Focus on the supply of the existing and forecast deficits of water use based on effective demands as a result of estimates for current and trend scenarios.
- Use of local water resources and existing water infrastructure and works in progress. In this case, the work effectiveness is not only related to the increase in water supply, but also to the effective supply of the demand in consumption centers, which may require complementary actions to implement the due interconnections.
- Human supply through sources with guaranteed water quantity and quality, preferably conveying water directly from reservoirs avoiding dependence on rivers that were artificially made perennial.

For flood control interventions, the focus was on specific regional solutions capable of minimizing vulnerability to floods in river basins considered critical.

Both cases were object of a careful evaluation of the planning and project stages, seeking certification and viability of the benefits of a particular work as a preliminary stage and condition for detailing the construction of the infrastructure.

In addition to the indication of these interventions, the financial resources necessary for complementary studies, planning and projects were estimated (647.5 million BRL) for the execution of the recommended works (26.9 billion BRL). Also, to ensure a proper operation and maintenance of the infrastructure, O&M costs were estimated (1.2 billion BRL/year).

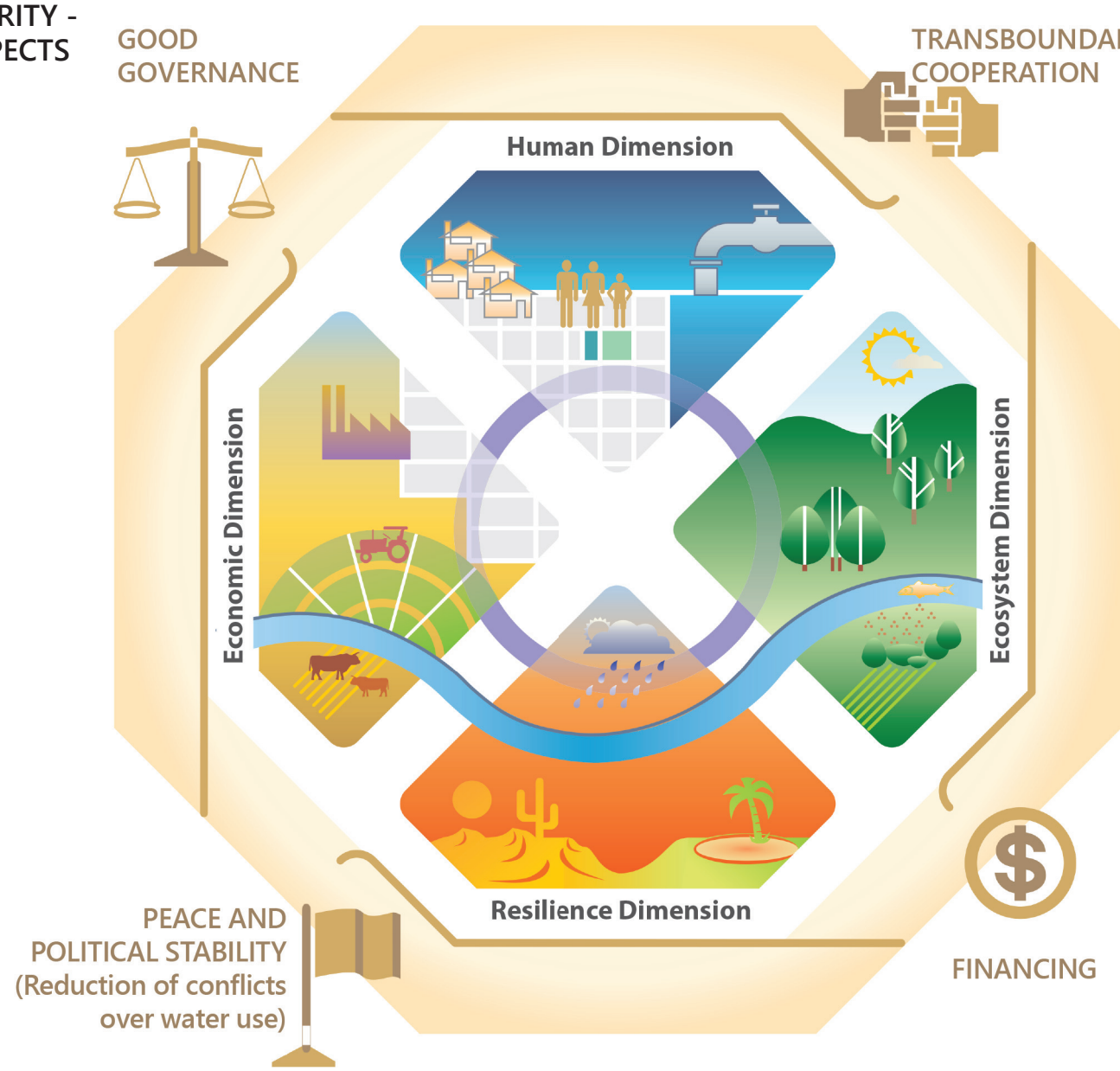
In summary, the results of PNSH seek to trace the path to water security in Brazil prioritizing the most serious problems, the necessary and indispensable steps for the effectiveness of the recommended interventions and the water access, as an essential condition for life and for productive activities. There is no meaning planning water resources and the associated infrastructure as a development booster while there are still deficits or strategic problems in the territory, posing risks of shortage or human and economic losses as a result of droughts and floods. Therefore, the PNSH basic premise is consistent with the **global water access goal of the 2030 Agenda** "leaving no one behind" by prioritizing the fulfillment of effective demands as an essential condition for sustainable development.

When broadening the Water Security concept beyond the four dimensions observed in the ISH (and in the original UN concept) it is observed that the logic established at the global level can also be applied to Brazil, given its large territorial dimension and regional diversity. In fact, good governance, cross-border cooperation (between states and river basins), peace and political stability (which can be measured by minimizing conflicts over water use) and the financing sources availability, are additional aspects to be observed so that the PNSH may be materialized and maintained. Thus, the Plan additional challenges and its main recommendations are presented below and organized into four complementary aspects of Water Security.

Governance - Institutional Arrangements

From the standpoint of institutional arrangement, the concentration of the policies of national water security, of water resources, of regional development, of water and sanitation and of irrigationin the Ministry of Regional Development, and its linkage to ANA, provide the conditions and the environment for the effective government action on implementing the recommended interventions of the Water Security Program. The Program aims at expanding water supply or preventing the effects of critical hydrological events in articulation with the other Federation entities.

WATER SECURITY - COMPLEMENTARY ASPECTS



To this end, the following points deserve attention:

- The relationship between the PNSH and the new National Water Resources Plan (PNRH), which is currently in its early stages and is to be effective in 2021, also must be well defined and ruled. Brazil's Court of Accounts (TCU) establishes the need to analyze the convenience and the opportunity for integration of the PNSH with the PNRH, so that the National Water Resources Plan will become an instrument that aggregates the various water resources management segments. In short, it is understood that the PSH is the component of strategic works of the future PNRH, which will focus on management actions and on the establishment of general guidelines for the National Water Resources Management System (SINGREH).
- In the same way as the PNSH aims to define the country main strategic and regionally relevant structuring interventions, State Water Security Plans could focus on local and state issues, as part of the State Water Resources Plans already foreseen in the National Water Resources Policy (Law No. 9,433/1997).

- The PSH-recommended interventions are also essential for the national domestic water supply and sanitation policy, since deficits in human water supply require both local solutions for scattered populations (such as cisterns, simplified supply systems, desalination systems and underground dams) and the strategic regional works identified in the PNSH. The diagnosis and the alternatives to guarantee the water supply for all 5,570 cites of the country are also treated in the Brazil Atlas – Urban Water Supply, coordinated by ANA and being currently updated.

- The effective (existing and forecast) demand base adopted for the PNSH may serve as an important input in the formulation and development of the national policies for regional development and irrigation; the use of a common technical basis of water uses is very strategic in this process.

- The interface of PNSH with Brazil's Energy Policy should also be considered, observing the essential role of the reservoirs in the Brazil's Energy Matrix (hydropower generation is the largest energy source of Brazil, accounting for 64.5% of the energy provided in the country). Considering that the focus of the PNSH is on water security for consumptive uses (human supply and productive activities), it is also important to evaluate the reservoirs (existing and planned) of the electricity sector with an approach that integrates water security and energy security aspects. An example of this integration is the Resolution No. 2081/2017 issued by ANA that establishes operating ranges for the reservoirs in the São Francisco river basin based on storage security curves. A similar procedure was also adopted during the water crisis in the Paraíba do Sul river basin.

- The new operating conditions proposed in this resolution also aimed at the need to adapt the hydraulic system of the reservoirs to a new hydrometeorological benchmark, recognizing the importance of the impacts of climate change on water resources. Considerations of eventual climate change were implicit in the PNSH by employing the most recent data on hydroclimatological variables for the calculation of water security indicators. In the future updates of the PNSH, such consideration may become more explicit and will include future climate projections from the General Circulation Models (GCMs).

Transboundary Cooperation – Use of Shared Sources

Transboundary cooperation may be understood in the Brazilian context as the sharing of the same water sources between different states, as the increasing need for integration of river basins for the supply of large urban centers (as is the case of Metropolitan Regions) and as stimulating regional development.

The feasibility of shared alternatives generally requires coordinated actions of greater technical, institutional, economic and environmental complexity. Therefore, the public power has a strategic role in organizing these actions, and in carrying out the integrated analysis of the effects and benefits of the interventions.

- As for the regional development projects, which go beyond the water security issue, a comprehensive analysis of the proposed interventions should be carried out, comparing all of the projects with the aim of quantifying its actual benefits under the perspectives of the Regional Development Plans, including an evaluation of water management measures provided by the infrastructure, and of the optimal use of water.

- The planning for future water sources use to supply Metropolitan Regions should be treated as a State Policy aiming at solving the supply problems of these regions in an integrated and long-lasting manner, involving the multiple water uses and considering not only structuring actions (infrastructure) but also other types of actions (green infrastructure, demand management, land use, etc.).

- For most at risk Metropolitan Regions, the PNSH recommends Water Resources Development Studies, with the main goal of planning actions to be performed in the next few years in these regions, and a shared water management pact between interstate river basins. These documents will provide the states and the Union with a robust planning instrument that may offer more guarantee for the public investments. Examples of this are The Water Resources Use Master Plan for the São Paulo Macro-Metropolis and the studies, plans and integration proposals for the Water Resources Use in the Recife Metropolitan, Pernambuco's Mata and Agreste (PARH-2005).

- Desalination (especially for coastal regions) and water reuse are technologies that should be explored as complementary alternatives to be used in water scarcity periods in the studies for these complex regions.

Conflict Reduction in Critical Areas

The critical basins identified as showing the lowest water security levels, the ones subject to water use conflicts regarding supply, and the ones highly vulnerable to flooding (in the case of flood control) represent an additional challenge for the PNSH's intervention strategy, indicating the need for an integrated approach to the river basins and the development of more complementary actions.

From a territorial standpoint, the water resources plans of the river basins (a National Water Resources Policy Instrument) provide important inputs for the PNSH's implementation, both in the initial water balance planning and detailing phase, as well as in the forwarding of the alternatives to water infrastructure study. Some examples are:

- The Piancó-Piranhas-Açu Plan, approved in 2016, identified critical areas that required water resources use studies, such as the Seridó region. Studies have already been developed, as a result of the Plan's implementation effort, culminating in integrated conveyance system projects necessary to guarantee urban water supply in the region, the interventions were recommended in the PNSH. In the same way, the update of the Grande River Basin Plan (tributary to the São Francisco River Basin)'s foresees a study to be initiated in 2019 for analyzing and proposing the best alternative for increasing water supply in the basin, considering the regularization and water transfer actions identified in the plan. This study is directly related to the one suggested in the PNSH to overcome this knowledge gap.

- The Paranapanema Basin Plan, approved in 2016, contains a reservoir evaluation study for highly demanding areas related to irrigation, in its Operational Guide. Similar studies (also foreseen for 2019) contemplate the São Marcos Basin (tributary to the Paranaíba River) in a first stage and the Grande River Basin probably in a second stage. These studies are also in accordance with the results identified in the water security diagnosis and in the PNSH-recommended additional study.

- The Water Resources Plan of the Paraiba do Sul river basin, in its Multi-Annual Application Plan, is also foreseen for 2019 and entails the elaboration of studies and projects regarding flood control water infrastructure integrated to the increase of water supply for the Pomba and Muriaé river basins.

The ATLAS sectoral studies series, by ANA, complete the PNSH's strategic interventions portfolio from the standpoint of complementary actions:

- The Brazil ATLAS – Urban Water Supply (2010) being now updated shall guarantee, through the broadening of its scope in terms of water security, the identification of bottlenecks and needed local solutions, urban water supply to all cities in the country.

- The Sewage ATLAS - River Basin Cleanup, launched in 2017, relates to the ecosystem dimension evaluated in the PNSH, by proposing sanitary sewage actions for the protection of water resources, focusing on sewage treatment. For many basins, sewage collection and treatment investments have the same scale as PNSH's strategic interventions. These investments are extremely important for ensuring water security from a water quality perspective.

- The Stormwater Atlas, which is currently being drafted, should focus on structuring and non-structuring complementary measures to the specific flood control dams analyzed in the PNSH. In addition to urban drainage within each municipality, it should be considered that the medium or large watercourses of the country (especially the ones highly vulnerable to flooding) are generally inter-municipal or even interstate. The methodology should cover aspects considered in river basin scale studies, in the studies developed for the Itajaí/SC River Basin, and in the studies regarding metropolitan areas, following the example of the Upper Tietê/SP Basin Macro-Drainage Plan (PDMAT).

PNSH Funding and Updating

The equating of the PNSH's potential financing sources relates to the traditional financing sources of the water and sanitation infrastructure sectors as well as to studies related to water resources management. The engagement of Government actors (Executive and Legislative powers) is essential in ensuring the availability in the budget.

The road to water security outlined allows the MDR and other institutional actors involved with programming and prioritizing necessary resources (depending on each development stage of the recommended intervention) to plan, execute, operate and maintain the infrastructure's efficiency over time.

CERTOH takes on an important role here, marking a change from potential investments to recommended investments (PSH-certified interventions). The CERTOH issued by ANA, assesses the operability of the infrastructure to be implemented, and the technical and financial viability of the interventions.

The entity responsible for the proper O&M of the Conveyance Systems is easier to be identified, this role generally falls on the water supply service providers. Integration Axes and Dams (especially flood control dams), on the other hand, do not necessarily have predefined institutional arrangements for their operation and maintenance. As a result, maintenance costs tend to be higher, due to lack of routine maintenance; infrastructure failure risks are also greater.

In this context, the National Dam Recovery Plan (PLANERB) is an example of an organization of actions for the recovery of existing infrastructure. For the new interventions planned in the PNSH, it is expected that the responsible institutions and the necessary financing sources for the proper operation and maintenance of the planned infrastructure will already be defined at the CERTOH stage, in order to avoid or minimize recovery actions. This actually marks the relationship between the PNSH and the National Dam Security Policy.

Finally, in order for the PNSH to be effectively adopted as a Water Security planning tool for the country and a reference tool in the budget planning of the strategic interventions, a systematic monitoring mechanism for its implementation is absolutely necessary. This mechanism should ensure permanent exchanges between various institutions and sectors involved in the infrastructures and actions recommended in the Plan in the federal and state spheres for the Plan's proper monitoring, evaluation and updating as necessary in the **Path to Water Security in Brazil.**

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