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Water Management Policy in Brazil

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Abstract

For the growing body of academic and policy research on the energy-water nexus, the case of Brazil is particularly important and interesting. Brazil has a large biofuel crop industry that makes use of extensive water resources. The country's large oil industry uses and disposes of large quantities of water, and hydropower is the nation's largest single source of electric power. Each of these elements of the energy system implicates different aspects of Brazil's policy and regulatory systems for managing water resources.

This essay, which reviews the experience managing the intersection of Brazil's energy and water issues, makes five arguments. First, as a federal system one of the most important policy issues in Brazil is the allocation of authority between the federal government and the many varied state regulatory systems that affect water. There is huge variation in state-level regulation; the most sophisticated of these systems is that of São Paulo—the state where we focus in this case study. Second, in terms of sheer volume of water consumed, Brazil's sugar crops have a huge impact on the country's water-energy nexus. However, as a practical matter, most of the sugar crop is not much affected by water policy because it is rain fed—as in most countries, water uses that affect rainfall are not much regulated whereas irrigated water is under much stricter control. Third, much of Brazil's river system crosses state boundaries, raising potential concerns about lack of policy coordination. A system of river basin committees is designed to ameliorate those concerns—however, for the most part, those committees have little practical impact on policy. Nationally, there is huge variation in the actual implementation of water laws; only three regions in the most economically developed areas of the country have implemented essentially all of the nation's administrative framework for managing water.

Fourth, we note that in theory different water-using sectors could allow for fungibility in water usage and pollution control costs across the sectors. In practice, however, a wide array of organizational and legal rigidities makes that impractical. The oil and gas sector, for example, is managed using policy and regulatory frameworks that are completely separate from other water using sectors. Fifth, and finally, we note that use of water flow for generating electricity is of paramount importance in Brazil due to the country's dependence on hydroelectricity. For years it has been known that this use of water is under-priced and under-regulated—mainly because of the close relationship between the hydroelectric sector and its regulatory bodies. There have been very limited use of market forces to encourage more efficient water behavior. In addition to some limited efforts to use water pricing, there are also auspicious experiments under way to use ecosystem services to put a proper value on watersheds. Other ideas, including smarter pricing of water flow, have been around for years yet still have had limited practical impact due to an array of political barriers we describe.

I. Introduction

As a whole, Brazil is a water abundant country. The tropical Amazon region in the north, spanning half the country, is hot and humid and generally receives more than 2,000 mm of rainfall annually. Like in most large countries, though, different regions in Brazil have vastly different climates. On the other extreme, the semi-arid northeast region has irregular rainfall averaging 750 mm to <250 mm annually and is prone to severe droughts. But most of the country receives moderate annual rainfall of between 1,000-1,500 mm.[1] The moderate climate allows many of the country's important agricultural regions to be mostly rain-fed and require irrigation for just one season of the year, if at all. Contributing to a belief of water abundance, the country has the additional advantage of sitting atop an estimated 112,000 km^3 of water in underground reserves.[2] A stable water supply is critical for the world's seventh largest economy and fifth largest country by geographic size and population.

Despite having 12% of the world's available freshwater and among the world's highest renewable freshwater supply per capita (based on 2011 World Bank data[3]), the population currently suffers from water scarcity. Some of that scarcity may be rooted in excessive water use practices stemming from a "culture of water wastefulness" based on the notion of the country's water abundance.[4] This notion led to many decades of under-investment in necessary upgrades to the water infrastructure and of a lack of attention in protecting and conserving the resource.[5] The historical culture of under-valuing this important natural resource can be seen especially during the years under military dictatorship (1964-1985) when planners put a higher priority on economic development at the expense of growing environmental degradation and water scarcity.[6]

Another contributing factor to scarcity is that most of the country's 200 million residents live in regions with only a small percentage of available freshwater. Roughly 80% of the available freshwater lies in the Amazon Basin where only 12% of the population lives. By contrast, 35% of the population lives in the semi-arid northeast with 4% of the country's water, and 11% lives in the São Paulo metropolitan area in the south with just under 2% of the nation's water resources.[7] These geographical disparities compound huge differences across socio-economic lines. The northeast region, the poorest in Brazil, has always suffered water shortages and severe recurrent droughts and crop failures. In the densely populated and urbanized South, there are huge disparities in sanitation and access to water between urban versus rural residents, and also the urban poor who often live in informal settlements without these basic services.[8]

The distribution of water consumption across sectors in Brazil is similar with other countries, though the unique feature of Brazilian rain-fed agriculture allows that sector to play a much smaller role as water consumer by comparison. According to data from the National Water Agency (ANA), the federal water agency, agriculture is the largest consumer of the country's freshwater. It takes 54% of total water consumption and consumes 72% of what it takes, with the rest returned back to canals and rivers. Industry takes 17% of water but consumes only 7% of that take; cities take 22% and consume 9%.[9] By comparison, agriculture in China takes more than 70% of water consumption[10] with a 40-50% efficiency rate.[11] Globally, agriculture is estimated to contribute to 92% of the total annual water footprint, while industry contributes about 5% and domestic water supply contributes just under 4%.[12] Brazil is the world's fourth largest water user behind China, India, and the United States.[13]

Like in many other countries, there is room for improvement in water efficiency. Reported water losses in most of Brazil's largest cities have remained consistent over recent years with little signs of improvement.[14] Data from the Brazilian National Information System on Sanitation (SNIS), a data repository on parameters such as service quality, financial performance, and institutional efficiency collected from water and wastewater utilities to allow for the performance evaluation of the utilities, reveal that approximately 4 of every 10 liters of treated water is wasted through leaks, illegal connections, and "other irregularities" in the 100 cities with populations of over 250,000.[15] There are additional problems with meter under-registration, meter readings, and water charges set too low to assign a meaningful value to the resource to curb wastefulness by consumers.[16] Sixty-two of the 100 cities had a water loss rate of 30%-60% in 2012.[17]

This paper arrives at a time when Brazil is managing a severe water crisis. Although Brazil has some models for effective water governance—for example Sabesp, the water utility owned by the state of São Paulo—independent experts argue that this crisis reflects the delayed response to the impending water crisis by the federal and state government.[18] It was not until 1997 that the federal government passed the new Water Law that formed a water resource management framework aimed at restoring the environmental conditions around bodies of water and improvement of water use efficiency. More than 15 years later some of the changes introduced by the Water Law are still being implemented. The severe drought of 2013-2014 that affected several regions in the country shined a light on the disarray of municipal, state and federal regulations, as well as the necessary investment in infrastructure that has lagged behind a rising demand for water.[19]

In this paper, we explore the role that water plays in Brazil, particularly at the intersection of energy and water issues. In order to understand the importance of water in this country, we begin by examining how this natural resource is managed first at the federal level then the state level, as well as the difficulties in implementing effective policy that can result from overlapping and sometimes unclear jurisdictional boundaries. São Paulo has at times led efforts to reform the water management system and has the most sophisticated of state-level systems and, for that reason, we focus the state-level discussion on São Paulo state in Section Three. Because waterways and river systems do not stay neatly within politically drawn boundaries, in Section Four we examine the implications of efforts to manage water resources across boundaries, using the Paraiba do Sul River Basin as a case study. The remainder of the paper is focused on specific sectors within the Brazilian economy. The paper concludes with Sections Five, Six, and Seven discussing water consumption in agriculture; water use in electricity and Brazil's potential in hydropower; and water and wastewater in the oil and gas industry.

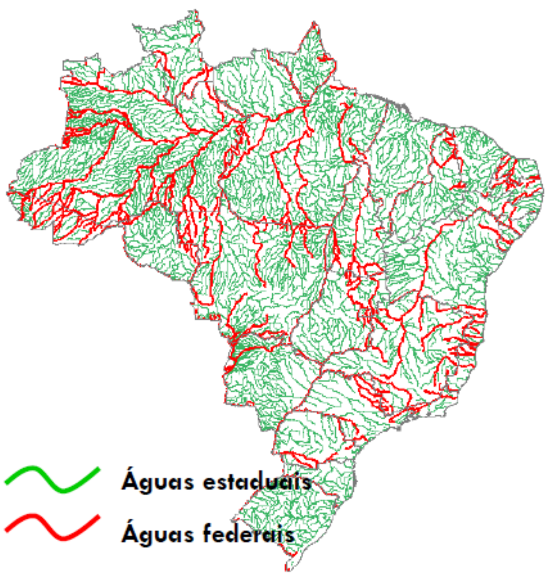
II. Brazil's Federal Water Management System

The federal government has made tremendous recent strides in reforming water policies and creating new institutional actors at the federal, state, and local levels to encourage more participatory management. Much of newly created legislation, though, has yet to be implemented as the current phase of the Brazilian government's effort to modernize the water management system began only in recent decades. Attempts to regulate the use of water in Brazil dates back to the early 1900s and the historical evolution of national legislation is often categorized into three phases.[20] The first phase is the 'Navigability Phase' marked by the 1916 Civil Code, which allowed for private ownership of water and also designated rivers as public property for the shared use of the people. The Code was primarily designed to allow cargo to float downstream.

The second phase is marked by the use of water to generate electricity—the 'Hydroelectricity Phase.'[21] With a growing industrial sector that needed electricity and coal reserves that were small and "of poor energy content", leadership long recognized the potential from hydroelectric power generation created by the country's water abundance.[22] Brazil's first public utility hydro plant went into operation in the 1880s and the numbers quickly grew in the following decades with heavy involvement from foreign companies. With very little regulation, by the 1930s the electricity sector centralized around large foreign firms and was run almost entirely by foreign operators.[23] Their dominance was most pronounced in developed areas of the country where electricity was controlled by just two foreign companies. After the Revolution of 1930, new leadership implemented political, social, and legal reforms, changing the relationship between the electricity sector and foreign companies. The Water Code of 1934 gave water its own legal regime and classified water into three categories: public, common, or private. Importantly, it set water as a commodity and framed an industrial vision of water with its primary use being the generation of energy above all other uses, to be regulated by the government.[24] In 1945, the state-run São Francisco Hydroelectric Company (Chesf) was created to transmit and generate power to the northeast region, thus marking a new period of larger plants and larger dams.[25] Between 1950 and 1979, Brazil received large inflows of international funding for large infrastructure projects resulting in intensified national debate over the role of government versus foreign private involvement in the country's infrastructure.[26] During the two decade rule under military dictatorship from 1964-1985, the hydroelectric sector grew alongside a push to nationalize the energy sector.[27] In particular, there was much interest in exploiting the hydropower potential in the Amazon region. With weak environmental protection legislation in place, four hydropower plants were installed in the Amazon region.[28] It was also in this period under the military regime that plans were drawn for construction of the controversial Belo Monte dam, which is now still under construction and only 50% complete. When complete, it will be the world's third largest hydroelectric dam and flood more than 1,500 square kilometers of rainforest.[29] Megadams take 8.6 years on average and usually more than 10 years to build.[30]

Today, water is in the 'Environmental Phase' where it is viewed as a limited resource to be managed for the public good[31] and as having "environmental value", as is formally recognized in the National Environmental Policy Act (NEPA) of 1981.[32] In 1999, then-President Fernando Henrique Cardoso supported this view of water when he said that "water resource management must be 'comprehensive' and is 'relevant' to all Brazilians." He also noted water and water resources management to be one of the central problems for the country over the next century.[33] The Federal Constitution of 1988 marks the beginning of the current management system. It introduced important changes and modeled water resource management on new concepts such as user-pays principles and participatory management. Water resources was declared to be a public asset, a significant departure from the previous Codes.[34] The Constitution also introduced changes to jurisdictional authority over specific types of waterways. Ownership rights were assigned and brought under federal, state, or municipal jurisdiction.[35] Specifically, all waterways that cross states within the country, that serve as boundaries with other countries, or that extend into foreign territory, including bank lands and river beaches, belong to the federal government.[36] By contrast, "[s]urface or subterranean waters, flowing, emerging or in deposit, with the exception…of those resulting from work carried out by the union" belong to the state.[37] The result of these designations is a complex network where the major water basins contain rivers that belong both to the federal government and the states (see Figure 1). This overlapping and sharing of jurisdictions has been cited as a source of difficulty in operating the national water management system.[38]

Figure 1: Two levels of management- Federal (red) and State (green)[39]



Problems of overlapping jurisdiction extend beyond ownership rights, reaching into many matters that relate to water either directly or indirectly. For instance, issues in the areas of conservation of nature, soil and natural resources, environmental protection, and pollution control all have concurrent jurisdiction over the treatment of water.[40] Where these jurisdictions overlap, the federal government's role is to establish general norms that will be supplemented by state legislation; where there are conflicts, federal laws supercede state laws. But in the absence of federal legislation, the states have full legislative authority. Municipalities are granted authority to legislate only on 'matters of local interest' or to 'supplement federal and state legislation as appropriate.'[41]

The Constitution of 1988 was important in establishing a foundation for jurisdictional authority over water bodies but it was considered only the first step in reforming the water system. Industrialization and rural-to-urban demographic shifts throughout the 1970s and especially the 1980s brought significantly greater demand for water and also for power generation. This led to a boom in hydroelectric plant construction to meet the power demand.[42] For the first time, the possibility of water shortages entered into the public consciousness. The Water Code of 1934, however, was outdated and left many important legislative gaps on current issues, such as on water stress, pollution, or conflicts over use. It became clear that the Code needed to be updated.[43] One critical component of the new Constitution was that it gave states latitude to implement their own water resource management systems. This later proved to be key in furthering the evolution of national legislation governing water management. Once given the option to do so, many states passed their own water legislation starting with São Paulo in 1991 and, by the time the National Water Law was formed in 1997, 11 states had their own legal regime.[44] The push by states for further reform underscored the need for the national legal regime that expressly governed water to be modernized.

A national system for shared water resource management was created in the 1997 National Water Law (No. 9433) after years of negotiations. Existing state legislation contributed substantially to the design of the federal framework[45] but, also wanting to take the lessons learned from the experiences of other countries, the federal government allowed much debate and gave careful consideration of international experiences.[46] The Law that passed was inspired by the French Water Resources Management model. It established the National Water Resources Policy (NWRP) along with a National Water Resources Management System (SINGREH) to coordinate and implement that policy.[47] This new approach provided an integrated way to view and manage water and also introduced three important changes: the river basin was designated as the territorial unit for water resources planning; water was defined as a finite resource with an economic value; and national water management was defined to be a decentralized and participatory system.[48]

The new management framework is a decentralized structure consisting of five levels of management: the National Water Resources Council (NWRC); State Water Resources Councils (SWRCs); State Water Resources Management Institutions (SWRIs); River Basin Committees (RBCs); and Water Agencies (WAs).[49]

The NWRC is comprised of representatives of federal Ministries and Secretaries engaged in water resources management, representatives of the SWRCs, water user representatives, and representatives of civil society organizations related to water resources.[50] It is responsible for establishing guidelines to implement the institutional framework and instruments contained in the NWRP, and for resolving disputes over the basins at the federal level. The SWRCs work in parallel to the NWRC with the same responsibilities at the state level. The SWRIs implement the guidelines set by the SWRCs. Some academic literature refers to RBCs as "water parliaments."[51] They were created to allow for local management according to the attributes and characteristics unique to each river basin region. They are the main tools for ground-level water resource management and, through its participatory nature, allow watershed users an opportunity to evaluate the sustainability of the watershed. These committees consist of representatives from the federal, state, and municipal governments, water users, and civil society. Following international examples, RBCs govern, plan, and supervise management at the river basin level. The WAs were intended to be the executive arm of the management system at the basin level, to implement the River Basin Plans and handle the administrative duties of issuing use permits and charging fees from the water users. But in practice it has not exactly been implemented as intended.[52]

The Water Law also created five policy instruments to help achieve integration of water resources management: 1) River Basin Plans at the national, state, and river basin level; 2) a system for classifying bodies of water according to use; 3) water rights; 4) water use charges to be reinvested in the basin; 5) Water Resources Information System.[53]

Since 1997, two additional updates to the water law have been enacted, in 2000 and 2004. The 2000 law created the National Water Agency (ANA), a federal agency responsible for implementing the NWRP and for coordinating SINGREH. It answers to the Ministry of Environment but has financial and administrative autonomy.[54] The creation of the ANA consolidated the institutional reforms of the water sector into a single entity, which some say was envisioned by the policymakers who drafted the original reform in 1997; others argue that the introduction of a central agent changes the original intent of a decentralized management system.[55] The 2004 law tried to reestablish decentralization by taking away some of ANA's powers by regulating its contracts with NGOs involving water management. It also designated revenues from water use charges for basin-level projects designed by the respective WAs.[56]

Despite the national effort to create a participatory management system involving state and river basin-level participation, in practice many states have not implemented these changes. As of 2012, only 43 RBCs were established; 39 of these RBCs were created at the state-level to manage water that falls entirely within state boundaries and four were created in river basins that fell under federal jurisdiction.[57] Most of the RBCs have been set up in the Southeast, South, and Northeast, with half of these located in the Southeast. According to the ANA, these are the regions experiencing conflict over water quantity and quality.[58] ANA 2011 data reveal that only three hydrographic regions, the most economically developed areas of the country (the river basins located in Southwest Atlantic, Paraná, and São Francisco regions), have implemented almost all of the institutional framework and instruments set forth by the Water Law; some regions have done nothing so far.[59] In fact, a large majority of states lack the administrative structure and resources to execute their functions.[60]

One important instrument introduced in the Water Law that also is not being implemented as intended is water use fees. In reality, there are many cultural and political factors that contribute to resistance on full implementation of water use fees and thus are still the exception. Only four watersheds have implemented a water fee and collected fees are so low as to have little practical value.[61] On average, collected fees represented only 6%-7% of the investment budget; by comparison, water fees in France make up 30%-40%.[62] Part of the problem in Brazil is that many people view the charge as a tax rather than a fee based on usage. ANA conducted a study to examine consumer response to price incentives. They found that in the Paraíba do Sul Basin only 25% of respondents took measures to use water more rationally after the fee of 1 cent Brazilian Real/m^3 was implemented. In the Rio Doce Basin, where the fee is 18 cents Brazilian Real/m^3, there are signs of change in consumer attitudes.[63] Contributing to the difficulty in implementing fee collection were strong interests, namely agriculture, who opposed the charges. The agribusiness sector argued that though they use water they are not large consumers since much of the water returns to the hydrological cycle and they should not have to pay for it.[64] Even where fee is collected, it has not been invested wisely. The Paraíba do Sul River watershed collected R$83 million between 2004 and 2011 in water charges and other income but by 2012 only R$25 million had been invested; the remaining sits idly in cash.[65] In an effort to help with investing the funds, the ANA and the National Confederation of Industries signed an agreement of technical cooperation to find better ways to invest the money.

There remains much to be done also on the institutional framework for water management. For instance, when a river crosses multiple watersheds or state and federal jurisdictions, which is common, several entities have decision-making authority over the water body, at times causing problems.[66] Recognizing the need for further reform, the state of Rio Grande do Sul partnered with the World Bank in June 2014 to improve fiscal management and strengthen the water resource management framework. Federally, the ANA is working to harmonize management across administrative boundaries, for instance, through the Consolidation Program of the National Pact for Water Management (PROGESTÃO) launched in 2013. This program gives states financial incentives for reaching agreed upon goals aimed at strengthening the national water management system and better integrating SINGREH into the state national water management system.[67] It is clear that the emergent water resource management system is still evolving.

III. Water Policy at the State Level

States have been instrumental in furthering the reform effort on water legislation. Granted autonomy by the National Water Law to create their own legal regime, states did just that, though it is debated whether their actions were constitutionally justifiable.[68] Once the National Law was passed, conflicts between state and federal legislation needed to be reconciled and debates centered on exactly how much legislative authority states have. Questions were raised over interpretation of whether state laws actually "regulated" or rather just "protected" the environment and "controlled" pollution, and also whether exclusive legislative powers granted to the federal authorities were applicable only to waters under federal control.[69]

In spite of the ongoing debate, a few key states led the way. Water laws in Ceará state, in the poor and semi-arid northeast, is considered the most advanced in promoting decentralized stakeholder models of management.[70] Rio de Janeiro's laws allowed state agencies to contract with local conservation groups to manage the watershed in two river basins.[71] Overall, there is huge variation in state-level regulation; the most sophisticated of these systems is that of São Paulo—the state where we focus here.

São Paulo

The state of São Paulo covers 24.5 million hectares with approximately 40 million inhabitants. While the state is not the largest by area (ranking 12th), it is the richest, most developed, and most populous. Nearly half of the state's residents live in the city of São Paulo and its metro area, which contributes one-fifth of the country's economy.[72] The area's economy is diverse, comprising mostly of public and business services, manufacturing of high tech products, and distribution and retail. Outside the metro area, agriculture and livestock farming are important activities. Among the most important crops produced in the country is sugarcane, and among its most significant exports is ethanol.[73] São Paulo state produced 59% of the country's total sugarcane and 51% of its ethanol in 2012[74] and its economy is responsible for 31% of national GDP.[75]

Concerns of effective water management have come to the fore as São Paulo deals with the consequences of the recent drought, the worst and longest drought in recorded history from 1930. The hope is that the rainy season of 2014-2015 will replenish reservoirs. Fears learned from past droughts led political leaders to choose to draw down on its main reservoir rather than face a public backlash from rationing.[76] As a result of the withdrawal, the top two of the state's five reservoirs are now dry and a third, already below a normally untouched minimum level, is being depleted.[77] The city had plans to draw from three basins in other parts of the country, but those too are experiencing drought in addition to having to supply hydropower plants. In April 2014, the governor announced fines for consumers who increase their water use and discounts for those who reduce their use. Fears of a public backlash were not unfounded. In response to announcements of cuts in April, an angry mob set fire to a bus.[78] By May 2014, water was rationed in several cities such as Sorocaba, parts of São Paulo, and Guarulhos, although the government's official stance is against rationing.[79] In desperation, São Paulo has turned to seeding clouds in the hope for rain.[80]

The São Paulo state government began efforts to create a system for integrated water resource management long before the federal system was set in place in 1997. The state government was spurred into action amid growing concerns of deteriorating water quality, increased water demand, and conflicts over water use.[81] Even in the absence of a drought, the supply of water in the São Paulo metro region has had difficulty keeping up with demand from the unexpectedly rapid pace of population growth in the past decades.[82] Rural migrants have flowed into the area, swelling the informal settlements on steep hillsides or floodplains. An estimated 20-30% of the metro region's population live in these unplanned communities that lack sewage services and access to water and electricity.[83]

The first State Water Resources Council (SWRC) was created in 1987, tasked with proposing policy, creating a management structure, and creating a state plan. The State Water Resources Plan was approved in February 1991 and that year the state enacted Law 7,663, the State Policy on Water Resources, and the Integrated System of Water Resources Management. The state system is based on three components[84]: 1) a deliberative approach that includes equal representation from the State, municipal districts, and civil society within the SWRC and within the Watershed Committees; 2) a Coordinating Committee was established to work with the National Water Resources Council and the watershed committee in evaluating the success of the State Water Resources Plan; 3) funding for the state policy is provided by the State Water Resources Fund (FEHIDRO), which receives budgetary resources from the State and Municipal Districts that receive revenue from hydroelectric power generation, from national and international loans, and by water tariffs. FEHIDRO is most visible to the public for its charge for water use.

Additionally, the state law designated the river basins as the territorial management unit—thus encouraging the management of river basins as integrated units. The first river basin was created for the Piracicaba River in 1993, after decades of degradation of the river due to sugar mills and alcohol production plants in the area discharging large quantities of pollutants into the waterway. The creation of Watershed Committees, which can also be River Basin Committees as mandated under Federal Law when they cover a river basin or group of basins, has facilitated the integrated yet decentralized management of water resources while creating a forum for local decision-making.[85]

Sewage and sanitation systems are managed by state governments in cooperation with many cities and municipalities. Nationally, wastewater treatment is a major concern with only 30-35% of the country's sewage being treated and only 40-45% of households connected to the sewage network.[86] The percentages in São Paulo are better compared to national statistics with 99% of households with access to water and 82% to sanitation. The informal settlements, however, are usually not serviced with adequate sanitation services and raw sewage is discharged into water bodies.[87] The water quality problem lies partly in the lack of infrastructure to collect and transport sewage from unserved areas and partly in industrial and agricultural dumping of effluents and pesticides. Under the Water Law, dumping of waste into waterways is allowed with the proper permits.[88] But as environmental regulations increasingly target pollution, the number of wastewater treatment plants being built has risen. São Paulo's water and wastewater services company, Sabesp, working in conjunction with other municipal governments, has set aggressive goals to achieve by 2020 universal water coverage and 95% coverage of sewage services.[89]

Sabesp, which is majority owned by the State of São Paulo, is a model of a well-managed utility company. It provides water services to 364 of 645 municipalities in the state.[90] Sabesp is ambitious in its goals to improve services and, as a result of its status as a mixed-capital company, has the benefit of being allowed to operate beyond the state, to establish subsidiaries to provide other services, and to form partnerships with the private sector.[91] While the vast majority of its activities are financed with Brazilian capital and focused on Brazil, its strategy includes forging partnerships with other public and private sanitation companies and seeking funding, in part, from international financial institutions such as the Inter-American Development Bank and the Japan International Cooperation Agency as well as the Brazilian Development Bank (BNDES). The firm is financially solid, with low debt and net operational revenue of US$5.84 billion and record net profit of US$1.03 billion (in 2010). It continually seeks financing to upgrade infrastructure and increase services and coverage in the state, in particular in metro São Paulo.[92] Being financially viable has allowed the company to focus on bringing service to low-income areas and also on adding wastewater facilities along the Alto Tietê River, which provides the metro region with 15% of its water but is critically polluted from effluent discharged by the many industries positioned along the river.[93] The company's management proved its resolve during a financial crisis in the mid-1990s. From this crisis, management "was able to reengineer itself into an efficient, decentralized, results-oriented enterprise."[94]

In addition to a restructured management system and expanded wastewater services, the government passed policies to influence consumer behavior on water use. Public education campaigns and regulation on how water is to be used encourage efficient water use practices among consumers and industry. For instance, new regulation restricts industrial use of potable water, forcing industries to find ways to reuse their wastewater or to obtain recycled water from another source.[95] In response, Sabesp has partnered with private companies to create a water reuse venture that uses the latest in membrane bioreactor technology and is expected to conserve enough drinking water to continuously supply a population of 300,000 people.[96] It is the largest water reuse project in the Southern Hemisphere and the fifth largest of its kind.[97]

A 2010 World Bank report states that the management approach in Brazil is evolving to address issues with fragmented management across municipalities and sectors,[98] and São Paulo has been at the forefront of efforts to manage that problem, which has long been known. In 2007, the state government created a regulatory agency, ARSESP, as required by federal law to regulate the state's sanitation sector to be in compliance with state and federal legislation. A Moody's Investor Report does point out, however, that a conflict of interest could arise in ARSESP's board of directors, which is composed of five members selected by the state government.[99] Also in 2007, the State Complementary Law 1,025 was passed to better coordinate management efforts between the state government, SABESP, and municipalities. The law gave the state a larger regulatory and enforcement role, created a water supply and sanitation Council to promote better collaboration between the different actors, and integrated planning and implementation activities.

Despite all of its efforts to create an effective water management system, the recent drought and its consequences are affecting São Paulo particularly hard and is testing the nascent system. Conflicts have arisen with Rio de Janeiro over use of a river that crosses state borders. Although Rio de Janeiro has remained mostly unaffected by the drought, the Jaguari Reservoir feeds the state's main water source. Upstream at the dam located in São Paulo, the São Paulo electric utility company tapped into that supply and reduced the flow despite warnings from the federal government.[100] Rio officials accused São Paulo of mismanagement and blamed the government's lack of planning for causing their crisis.[101] São Paulo eventually ceded in the matter.[102] Compounding the severity of the crisis was the fact that 2014 was an election year. Politicians delayed taking action, such as rationing, or even admitting there was a crisis[103] for fear of hurting their chance of winning.[104] The São Paulo governor seeking re-election in the October elections was accused of minimizing the crisis for political reasons.[105] While in the midst of the crisis, government officials continued to state that everything was under control.[106] Now with the elections behind them, politicians are admitting there is a crisis and the governor has pledged more funding to build new reservoirs and improve distribution, although these projects will not help in the short run.[107] The start of the new rainy season brought some relief from the drought with heavy rainstorms that flooded streets and entire neighborhoods.[108] But rains will need to continue at that level in order to avoid rationing next April when the dry season begins.

Sabesp, for its part, adopted a series of measures including stealthily reducing the city's water pressure by 75% at night[109] and providing discounts to those who reduce use, which it says was effective.[110] The state's water laws require participatory water management but during the crisis people were not only not participating but they were also not informed.[111] In the country more widely, the government has had difficulties creating a transparent regulatory system to inform and involve stakeholders including industry and the general public on processes and decision-making. These problems apparently pervade in São Paulo as well.

Case Study

The example of the Alto Tietê watershed highlights the difficulties the government faces in effecting change despite its substantial efforts to encourage a more effective and integrated management system. The Tietê River, which provides the São Paulo metro region with 15% of total water supply—for São Paulo what the River Thames is to London—was deemed biologically dead downstream from São Paulo city.[112] It is in the most critical condition of all the 22 watersheds in the state.[113] To address the river's problems, the Alto Tietê Watershed Committee was created in 1994 and a further five subcommittees were created in 1997 due to the complexity of the problems in this river basin.[114] At the same time, a campaign, Projeto Tietê, was launched in 1992 by NGOs and residents to clean up the river. Despite massive ongoing bureaucratic effort, two decades later improvement in the river basin is still not readily apparent.[115] The state governor tried to get the 35 municipalities in the basin to cooperate, with some less cooperative than others. For instance, Guarulhos, a city of 1.2 million people, did not start treating its sewage until 2010.[116] Also, the illegal settlements on the riverbanks interfered with the work of the water companies and the government had to step in to remove the people. Sabesp worked to build new wastewater facilities and expanded the existing two. Even after sewers were built, some of these households chose to stay unconnected because they were unable or unwilling to pay for the service. It is expected, though, that with continued effort the benefits of the cleanup project should be visible by 2018.[117]

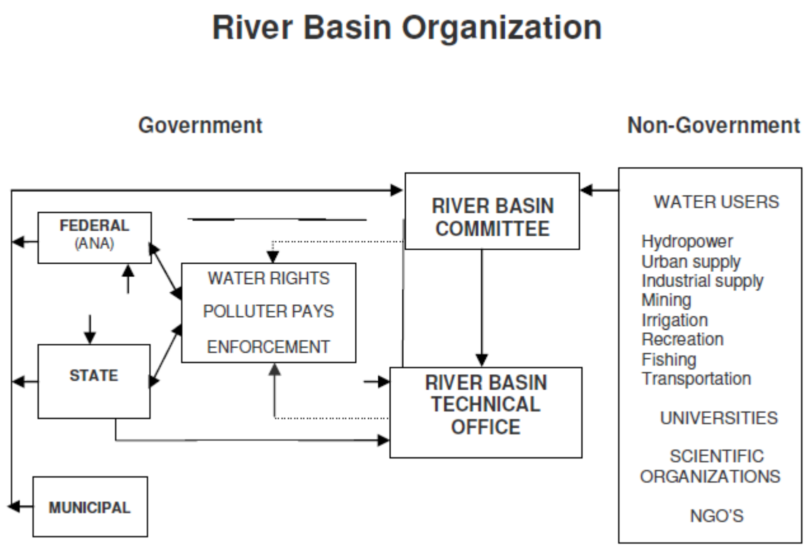
IV. Interstate Management of Water Resources

Since many of the country's waterways cross state boundaries, it became apparent that the management system should be governed at the local level according to the unique characteristics of each region. Following the international model, in 2003 the federal government (in implementing the 1997 Water Law) divided waterways by river basin. The country's 27 states were divided into 12 hydrographic regions, each with a river basin or group of river basins that share similar natural, social, or economic characteristics.[118] These hydrographic divisions do not coincide with the political divisions, nor do they consider the respective area or population covered. As a result, the distribution of hydrographic regions are highly uneven. For instance, though Rio Grande do Norte is about the same geographic size as Rio de Janeiro, it has only one-fifth the population but has 25% more hydrographic regions.[119] These river basins would be managed at the basin-level by local committees.

There are three main river basins—the Amazon, Tocantins-Araguaia, and São Francisco—and a group of sub-basins in the Plata River Basin—Paraná, Upper Paraguay and Uruguay. The remaining basins are divided according to geographic region. Some of these basins are particularly important because they cross economically important states. For instance, the Alto-Tietê River Basin supplies water to the São Paulo metro area and the Paraíba do Sul River Basin, which crosses the states of São Paulo, Rio de Janiero, and Minas Gerais, has many important industries situated along the rivers.[120]

One of the prominent features of Brazil's water management system is the active effort to solicit stakeholder input—a process that occurs mainly through the River Basin Committees (RBCs) (shown in Figure 2). The intention at the basin level was for allow for participatory management where negotiations could take place. Implementation, however, has been poor. Only a small number of RBCs have been created and the states that have created them in accordance with the Water Law have experienced problems, which some attribute to inherent limitations with the Integrated Water Resource Management model that Brazil followed.[121] A disproportionate share of the academic literature on Brazil's water management has focused on assessing the participatory management model put into practice in the basin committees[122] with opinions ranging widely. Some praise the participatory nature of the committees while others are skeptical of its effectiveness, pointing to limited participation from civil society due to, among other things, the "oligarchization, co-optation and control of councils."[123] Indeed, it has been found that, in practice, state officials often are reluctant to hand over real decision-making power and there is not enough political will to implement it.[124] One article points out, however, that decentralization is not a simple matter of reallocating responsibilities where the state failed to provide public services and infrastructure. Instead, it found that where decentralized management was preceded by no management, as is in Brazil, decentralization often includes state building where the necessary institutions for effective management does not yet exist.[125] In regions where the state or municipality lack necessary resources, this helps to explain the low rate of implementation of RBCs throughout the country.

Figure 2[126]



Because local conditions and institutions are so important in assessing inter-state water management, what follows is a case study on one of the most active RBCs.

Case Study

The Paraiba do Sul River Basin (PSRB) is one of the country's most dynamic economic areas and contributes to approximately 11% of national GDP.[127] The basin is strategically located between the states of São Paulo, Minas Gerais, and Rio de Janeiro and the region hosts coffee production, textile and food industries, the National Steel Company (the first major steel plant in Brazil), and more than 120 hydropower stations. The cost of economic development in the area was severe river degradation and serious conflicts over impacts of environmental degradation between upstream and downstream water users. The middle section of the river, where most of industry and hydroelectricity is located, was very polluted, with coliform bacteria rates 50-160 times higher than the legal threshold; and only 18% of the catchment sewage was treated.[128]

After attracting international attention for the polluted river, the River Basin Committee, CEIVAP, was established in 1996—actually before the impending Water Law that passed the following year and designed in anticipation of the regional approach that would be enshrined in that law. CEIVAP devised two master plans to guide regulatory reform to clean up the river basin. More than a decade later, the conditions of the river basin had not improved.[129] One major problem is attributed to the difficulty in reconciling federal regulations, which apply to the main river and major tributaries, with state regulations, which apply to the remaining tributaries.[130] Having to be accountable to both state and federal regulations is frequently cited as the cause for difficulty in implementing the new water legislation across all the large river basins in Brazil.[131] The complexity can be seen in PSRB where 13 tributaries or sections have their own sub-basin committees that do not necessarily communicate with each other or with CEIVAP. Rather than integrating water management, the new system appears to have created greater fragmentation.

A second problem is 'elite capture.'[132] PSRB was the first river basin to implement water charges and it was a very contentious issue. In 2000, the RBC began to discuss implementing water charges as a way to reduce dependence on federal grants. However, the committee was split on the topic and it was fiercely debated. The federal government, academics, and some NGOs favored water charges. Not surprisingly, representatives from agriculture, hydroelectricity and industry opposed any water charges. Then in 2002, the industrial sector broke the impasse when it switched sides. The reason for their change was that they wanted to be involved in creating the pricing scheme in order to secure for themselves reduced fees and to avoid regulatory scrutiny.[133] Arguments over water fees is just one example of the problem. It is argued that water policies were being manipulated by strong politico-economic players with little contribution from other committee members.[134] In fact, the capture of the decision-making process by strong groups has been a detriment to the democratic process within the RBC and has "significantly undermined the legitimacy of the new regulatory approaches, without producing the results that were expected."[135] As policy attention focused on the fierce debate over water charges, a wide array of other social and environmental issues was ignored.

This case is viewed as important for understanding the prospects for RBC management more generally in the country because CEIVAP was the first to institutionalize the collection of water fees and to create a dedicated administrative agency, AGEVAP.[136] Those early moves were auspicious, but CEIVAP arose alongside many other committees and consortia in the basin within each state that uses the river, creating redundancies[137] and difficulties with integration.[138] Some research has argued that these redundancies have enabled a network of knowledge-sharing and social learning among the committees that has actually helped with management.[139] However by 2008, five years after the water usage fee was implemented, certain sectors such as agriculture still did not pay for water.[140] Revenue from water charges remained low and contributed only 10% of investments scheduled in the Water Resources Plan for the basin.[141] Any payments so far from agriculture and hydroelectric plants have been mostly symbolic or non-existent.[142]

V. Agriculture and the Role of Biofuels

Agriculture plays an important role in the story of Brazilian water management because it is the largest user of fresh water. The country's most important agricultural products are coffee, soybeans, wheat, rice, corn, and sugarcane; its most significant exports are coffee, soybeans, beef, sugarcane, and ethanol.[143] Brazil is also the world's fifth largest producer cotton.

The agricultural climates in Brazil can be separated into two distinct categories: the wet south and the dry northeast. The more developed southern regions not only have higher rainfall and more fertile soil, but it also has more advanced agriculture technology and infrastructure. Most of the country's grains and export crops are grown in this region. By contrast, the dry northeast region has unreliable rains, less fertile soil, and a lack of agriculture infrastructure and capital for investment. With the expansion of agriculture in recent years, previously forested land has been converted for agriculture in a third region, in the Amazon basin. This push of farmland into the Amazon has led to growing concerns over and more vocal activism against the conversion of land-use in ecologically sensitive areas. For example, the expansion of soybean production had pushed into the Amazon region and is blamed for deforestation. This has rallied conservationists such as environmental NGOs to action, resulting in a 2006 moratorium on soybean production on deforested land, which has effectively slowed this practice.[144]

Agriculture is normally a major water consumer but Brazil has an advantage in some growing regions of receiving sufficient rainfall to allow crops to be mainly rain-fed, thus reducing its reliance on pumped water from the system. In those regions, mainly in the south and southeast, the agriculture industry's water demands have minimal impact on water resources. Irrigation in these regions is not much needed and is typically used to supplement rainfall from the summer months. Here, irrigation projects are mostly private ventures with technical support and credit offered by the government. By contrast, in the semi-arid northeast where many farmers cultivate for subsistence, government agencies encourage the use of irrigation for business and small-scale farmers, and most of the public irrigation schemes are located in this region.[145] Where water constraints can be overcome, corn, beans, cotton, and sugarcane are grown in this region.[146] Not surprisingly, the efficiency of public versus private irrigation projects vary greatly. Public projects tend to progress slowly and fall short of expectations while private projects expand quickly and yield high profits. It is hard to make a direct comparison, however, as many variables based on the growing region contribute to success. For instance, investment costs are generally higher in the northeast due to difficulty in accessing consistent water sources and irrigation needs are different based on the different climates in the regions.[147]

A second advantage that Brazil has in agriculture over other countries is the substantial amount of land available for expansion of irrigated croplands. Only about 15% of the potential irrigated land is being utilized[148] in contrast to many countries, including the US and China, who have reached or are close to reaching their renewable water resource limit.[149] To encourage expansion of irrigated cropland, the federal government recently passed a new National Irrigation Policy in January 2013 with the aim to double the size of the country's irrigated areas by 2020, especially in poor regions, for the purpose of increasing competitiveness of the country's agribusiness and development of certain regions, among other things.[150] The state of Rio Grande do Sul, where most of the country's flood-irrigated rice is produced, has already introduced programs aimed at expanding irrigated cropland other than rice.[151] The state of Bahia in the semi-arid northeast produces more than 30% of the nation's cotton[152] and, with the potential to expand by four times, is a principal target for irrigation expansion.[153]

The main growing regions for sugarcane, one of the most important crops for the country's economy, are in the northeast where it is irrigated and in the center-south where this crop is mainly rain-fed. Sugarcane is a water-intensive crop and, around the world where water availability is a constraining factor, growth of the sugarcane industry is limited.[154] The success of this crop in Brazil is in large part due to its advantage of being rain-fed; only about 1% of production is irrigated compared to a worldwide average of 30%.[155] Ninety percent of the country's harvest comes from the center-south region.[156] Although the northeast produces a relatively small percentage, by volume it still produces as much sugar as Russia and the region is among the world's top 10 producers.[157] With the increased use of irrigation, the northeast has seen larger yields. The 2011/2012 season reaped a bumper crop, an increase by 8% while output in the center-south fell for the first time in 11 years, by 11%.[158] This trend is expected to continue, especially as some of the growing regions in the south are coping with the effects from the drought and the northeast, accustomed to little rainfall, has come to rely more on technology than rain clouds.[159]

São Paulo is Brazil's largest producer of sugarcane and ethanol; it almost doubled sugarcane production between 1995 and 2006.[160] Farmers here apply modern irrigation technologies but irrigation is mostly not used. Sugarcane, a very water-sensitive crop, requires at least 1500mm of water and in this growing region average rainfall exceeds 1300mm.[161] A study that looked at the 2007/2008 harvest season found that 96% of water used to produce sugarcane in Brazil came from surface water, mainly rivers and streams and only 4% came from groundwater.[162] As a result, the water impact of sugarcane production is minimal in São Paulo. In other sugarcane growing regions where irrigation is used, such as the Center-West, Northeast, and some areas of the Southeast, especially in Rio de Janeiro, more active measures have been taken to reduce the impact on water. For instance, "salvage irrigation" is used after planting the sugarcane to ensure sprouting in long periods without rain and "supplementary irrigation" is used during the most critical development stage to mitigate water shortages.[163] Additionally, in response to environmental legislation, sugarcane mills implemented reuse practices to significantly reduce water withdrawals. Just three decades ago, mills withdrew 15-20 m^3 of water per ton (m^3/t) of cane; today only 1.85 m^3/t is withdrawn. In many regions, the water withdrawal permit was set at 1 m^3/t and many mills operate at 0.7 m^3/t.[164]

The advantageous climate for growing sugar and the industry's adoption of advanced technology has made Brazil one of the lowest-cost producers of sugar in the world.[165] Brazil has "longer harvesting cycles, higher sugarcane production per hectare, higher sucrose contents from the crushed sugarcane and lower losses during production of sugar and ethanol, which has yielded larger sugar outputs."[166] These productive yields allow a large portion, about 55%, of the sugarcane produced to be used for the bioethanol industry.[167]

Although the process of converting sugarcane into ethanol requires a lot of water—22 m^3/ton of sugarcane[168] or on average 3-5 million gallons for 1 million gallon of ethanol produced—the industry has adopted practices that recycle waste thus reducing the amount of resources needed.[169] Much of the water withdrawn is recycled back into the process. For instance, effluent from the ethanol industrial process, or vinasse, is rich in organic matter and nutrients and, in Brazil, is illegal to discharge into bodies of water. Instead, the vinasse is recycled back as fertilizer in the sugarcane fields.[170] A 2014 study that examined the water footprint of biofuels production in Brazil found that the blue water component (i.e. surface and groundwater) to be negligible for sugarcane ethanol, especially in São Paulo where it was the most efficient to produce in terms of water footprint.[171]

As a result of its technological advances and efficiencies in processing sugarcane and ethanol, Brazil has become the world's leading producer of sugarcane and exporter of sugarcane ethanol. In fact, the US Environmental Protection Agency designated Brazilian sugarcane ethanol as an advanced biofuel in 2010 because it reduces greenhouse gases by 61% compared to gasoline.[172]

When Brazil's federal government first made ethanol blended gasoline mandatory in the early 1940s, ethanol was primarily for use in the domestic market. The supply and demand for Brazil's sugarcane ethanol responds to political and economic factors. In the late 1970s, in response to high imported oil prices and domestic policy support for ethanol, the production of dedicated ethanol vehicles increased demand for ethanol. During the financial crisis and "lost decade" of the 1980s, which affected all of Latin America, demand fell. By 2001, when the economy had emerged from the crisis and new reform-minded governments were in place, the gasoline/ethanol market was fully liberalized[173] and demand for Brazilian ethanol and sugar has risen and fallen with market conditions since.[174] So when the price of ethanol rose in 2011 while the price of gasoline in the domestic market fell below imported price, demand for ethanol dropped. As a result, some ethanol producing factories shut down, significantly reducing supply and the country was forced to import ethanol from the US.[175]

Since 2012, the government has taken steps to reenergize the industry. It introduced tax reductions and low interest rates to invest in crop renewal and ethanol storage; it also modestly increased the price of gasoline.[176] The global demand for ethanol is expected to increase over the next 10 years and the USDA projects global production to increase by 40% and, specifically, Brazil's sugarcane ethanol production to increase by 90%—a projection that is highly sensitive to assumptions about continued policy support for biofuel consumption worldwide.[177]

Because important crops like sugarcane are dependent on rain, the drought of 2013-2014 is expected to impact crop yields, though the full effects are likely not yet known. The sugarcane yield is expected to drop by 8% from the previous year[178] though the 2014 crop will be supplemented with unharvested sugarcane from the previous year.[179] Other important rain-fed crops such as soybean[180] and corn will see a decline over the previous harvest as well,[181] though it is difficult to make comparisons since the previous year saw record levels for exports, such as for beef[182], and bumper years for crops such as coffee, soybean and corn.[183]

With the support of the federal government, agriculture is expanding and as agricultural lands push further into protected areas, such as in the Amazon basin, conservationists fear that this could threaten important water ways. In the battle against agribusiness interests, there have been some successes for environmental conservation, and these implicate both forest areas and watersheds. For example, the Três Picos State Park in Rio de Janeiro, which protects headwaters of important river basins, was expanded by 21% to 58,790 hectares. International conservation NGOs are working to develop a scheme for payment for ecosystem services provided by the park's freshwater sourcing potential.[184]

Several types of initiatives have emerged as the federal and state governments attempt to redistribute private money for environmental projects.[185] One initiative imposes a sales tax on all goods and services, which is then paid to municipalities based on the number of "conservation units" they maintain or the level of sanitation infrastructure in the municipality. This initiative has been launched by several states and aims to compensate municipal governments for loss tax revenues when land is designated as protected areas as well as to provide incentive to designate new conservation areas.[186] Another is a payment for watershed services initiative. Local management agencies charge a usage fee from a particular watershed where a portion of the payment goes to the local watershed committees. Local volunteers form committees to assess the charges and distribute payments to reforestation or environmental conservation projects within the watershed. Other initiatives require oil and gas companies in Brazil to pay royalties to either the federal or local government. These initiatives appear promising, yet many of them share similar problems of lacking a regulatory framework for administration, enforcement, and ensuring that funds will be reinvested towards environmental conservation.[187]

VI. Water for Electricity

Brazil has been using water to generate electricity for the last century and today approximately 70% of the country uses electricity generated by hydropower.[188] Since the completion of its first hydropower plant, Brazil's power sector has seen major reforms that turned the country into one of the world's largest hydropower producers, second only to China.[189] While this is often hailed an accomplishment in sustainable power generation, the country's reliance on water for electricity has proven fateful during prolonged droughts, such as the one in 2013-2014.

Brazil's hydroelectric output has been affected by the recent drought, unprecedented in its duration and sparse rainfall. In a normal year, reservoirs refill during the rainy season from December to March and are depleted during the winter from July to September. The winter of 2013 was one of the driest winters in decades while record breaking summer temperatures followed, causing energy consumption to soar; consumption increased by 10% in January 2014 compared to the previous year.[190] Earlier, in 2012, the president had pressured utilities into cutting tariffs and providing the public with cheaper power. The surge in demand that occurred in 2014 forced many distributors to buy energy from oil or gas fired plants at rising spot-market prices to make up the difference between their distribution and their allocated physical energy.[191] Fitch, a ratings agency, warned in February 2014 that the federal government needed to step in to relieve the pressure on the utilities,[192] calling to mind similarities with the last crisis in 2001 where low prices encouraged excessive consumption of power. During the 2001 crisis, late emergency measures rapidly aimed to cut back the excess during the drought but at a huge social cost.

The evolution of the hydropower sector to its current prominent role in Brazil began in the first half of the 20th century. As previously described, the 1934 Water Code laid the foundation for hydroelectric power by prioritizing water's use to generate electricity above other uses[193] and by assigning to the federal government the authority to regulate power services and the property rights of public rivers.[194] In the 1960s, a consortium of international engineering companies determined that it would be most cost-efficient to develop hydropower sites instead of thermal power plants, thus reinforcing the government's push toward developing the hydropower sector.[195]

State-owned enterprises took over the power industry and Eletrobras, created in 1962 as a holding company for the four federally owned regional suppliers, oversaw the transmission system and directed the investments and operations for much of the electricity sector.[196] With state backing, Eletrobras pursued projects that no private firm ever could finance or justify—

notably the Itaipu hydroelectric plant, the largest hydroelectric energy producer in the world at time of its construction—all in order to bring cheap electricity to the country's residents.[197] Not all states, though, accepted the federal government's imposition since some already had their own well-functioning generation and transmission companies. Intense conflict arose, particularly in the 1970s when the federal government constructed Itaipu and introduced a single tariff system aimed at raising funds to repay the massive foreign loans needed to finance the plant.[198] In tandem, the government forced (with the help of the military) the profitable companies in the South and Southeast to transfer their revenues to a fund controlled by Eletrobras to help subsidize the poor North and Northeast regions.[199] Lower tariffs encouraged energy-intensive industrial development and led to disastrous financial impacts on the power companies as demand far outstripped what was profitable to supply.

Major reform in the electricity sector came in the mid-1990s as the government privatized its economy and brought in private investors as owners and operators of the power system to be managed by independent regulators, with the government's role limited to empowering the regulator and providing strategic policy guidance.[200] The single tariff scheme was scrapped for a regime that regularly reviewed prices. As a result, power tariffs almost doubled.[201] The financial distortions imposed by nationalization policies were removed, thus allowing power companies to once again be financially viable.[202] In 1996, a new independent regulator, Aneel, was established in an effort to regain investor's trust in the reform efforts. Aneel falls under the umbrella of the Ministry of Mines and Energy (MME) but is financially and administratively independent from the government, funded by charges levied on generators and distributors.[203] Its five directors, appointed by the federal government to four-year terms, is tasked with regulating tariffs, licensing and controlling power concessions, and representing the government in disputes.

Decentralization of the power sector, however, was not a simple process. At this time, the government's energy policy focused on developing the large hydropower potential in the country. Both the Brazilian Development Bank (BNDES) and MME wanted to break up the four large regional generation companies under Eletrobras, although they had differing reasons for it. BNDES thought smaller firms would be more attractive to foreign investors while MME wanted to improve efficiency in the power system. Not surprisingly, Eletrobras opposed the break up, arguing that cooperation among hydropower plants was needed to ensure efficient operation.

To reduce the commercial risk to investors, a scheme was devised that, in the end, satisfied MME, BNDES, and Eletrobras.[204] Aneel would assign each hydropower plant an amount of 'assured energy' to be generated based on the capacity of the existing plants during the worst historical rainfall period. Excess generation during wet years would be sold as 'secondary energy' in the spot market. If a particular plant might not meet its assured energy, ONS (a not-for-profit civil association of power companies) dispatches another plant to assure "every plant 'delivers' at least the assured energy listed on its Aneel concession."[205] A financial mechanism was established to create risk-sharing among the plants. The scheme, in effect, socialized risk across the entire hydro enterprise and reduced the incentive for any single operator to worry about extreme risks—such as from severe drought—and discouraged the companies that operated the grid from investing in a more diverse source of power.

The reforms efforts, however, are not without critics. Some argue that the drought of 2001 underscored problems from unresolved issues from the reforms, exacerbated by an over-reliance on hydropower along with dangerously low reserves.[206] During that drought, the amount of water in reservoirs at the major dams reached critically low levels and the government ordered consumers to cut consumption by 20% or face fines or blackouts, causing a panicked rush among consumers to replace inefficient incandescent light bulbs with compact fluorescent bulbs.[207] The effect of this crash program was not only a large drain on the nation's macroeconomic health but also a permanent downward shift in the demand curve for electricity. The memory of the 2001 rationing and threat of blackouts was quickly recalled in 2012 when vast regions of the country experienced four blackouts. Experts say this indicates how poor of a job the government has done planning for emergencies and investing in critical infrastructure since 2001.[208]

The 2013-2014 drought has once again focused attention on the country's energy policy. The first lesson President Dilma Rousseff learned from the 2001 crisis when the government imposed rationing is that rationing is politically dangerous. Consumers' anger over rationing helped Rouseff's predecessor, Luiz Inacio Lula da Silva (Lula) win the first of two terms as president.[209] Rousseff was Lula's energy minister, then chief of staff. Since 2014 was an election year, Rousseff declared that there would be no rationing and instead, in September 2012, one month before 53 million Brazilians and 11 Brazilian states were left in the dark for up to four hours during the region's worst blackout since 2001, Rousseff announced a cut in residential electricity costs by 20% and cuts in electricity taxes in an effort to boost the industry.[210] Most of the concessions for hydro-dam operators are up for renewal between 2015 and 2017 but Rousseff announced that they were allowed to renew on key assets early only if they slashed prices.[211] The National Electric Power Agency, the industry regulator, estimates that the subsidies required to support the cuts will cost the Treasury R$8.46 billion (US$4.23 billion) per year.[212] During a period of short supply, prices should be allowed to rise; instead, most of the policy pressure has pointed in the opposite direction.

A second lesson learned from the 2001 drought was that Brazil needs to supplement hydropower with thermoelectric power, which can pick up slack in the system in the event of a drought or when hydropower fails.[213] On this front there has been some progress—thanks, in part, to new segmented electricity auctions that have been tailored to create incentives for diverse sources of new power investment (including renewable power). In 2013, as in 2001, thermal plants started running to make up for the shortfall in hydropower.[214] But this is a hugely expensive option. Thermal plants use coal, natural gas, diesel and biomass plants, and Petrobras, the state-owned oil company, has been spending US$10 million/day importing liquefied natural gas to fuel many of the power plants at a financial loss.[215] Forcing utility companies to pay high prices for power from natural gas, coal and oil plants will likely drive up inflation, already at nearly 6%, in the coming years and will cost the government 12 billion reais (USD $5.2 billion) in 2014.[216] Standard & Poor's recently downgraded the credit rating of Brazil's foreign debt and said "the costs associated with the drought could threaten growth and investment in the country."[217]

Still, the government sees large untapped potential in hydropower. With more than 55% of the country's hydro-generated capacity located in the south, the north, particularly the Amazon region, still holds much potential. Reliance on the southern Parana River Basin concentrates the system's risk to climatic vulnerabilities within that single basin.[218] To diversify that risk, the government believes hydropower infrastructure should be built in the Amazon region. This, however, is a highly contentious matter involving fights for the rights of indigenous communities, the loss of biodiversity in the tropical forest, and the change in climatic dynamics and greater carbon emission due to deforestation.[219]

Regardless of the controversy, the government is moving forward with its strategy to capitalize on the potential in the north. It plans to build at least 23 new dams in that region, of which seven will be located in the heart of the Amazon.[220] December 15, 2014 was set as the date to auction the construction of the São Luiz do Tapajós hydroelectric dam, the first of a series to be built on the Tapajós River, one of the Amazon's largest tributaries.[221] BNDES in 2012 approved a 30-year US$11.25 billion loan to the Norte Energia S.A Consortium to begin construction of the Belo Monte Dam on the Xingu River, expected to begin producing electricity in February 2015.[222] Plans for Belo Monte began in 1975 but due to delays from critics and activists, the plans were at one point shelved, then revitalized, then redesigned, then delayed in court. The dam is the most controversial dam project in Brazil today because it is located in the heart of the Amazon rain forest on the last major untapped tributary to the Amazon. When built, the Belo Monte would be the world's third largest dam and reduce the river's water flow by 80%.[223]

Those fighting the construction of dams in this region have seen minor successes. For instance, a few years earlier BNDES approved loans for construction of two dams—Santo Antonio and Jirau dams— on the Madeira River also in the face of great controversy. Those against construction on the river argue that the Madeira River, along with rivers in neighboring Bolivia and Peru, carries nutrient-rich sediments from the Andes. For hydro facilities, this sediment load creates operational and safety risks as well as potential environmental impacts. The sediment transported by these rivers feed the Amazon mainstem, which eventually dumps into the Atlantic Ocean where researchers have shown sediments play a vital role in replenishing ocean life-forms and may regulate the ocean's ability to absorb carbon.[224] In March 2014, a judge ordered the operators of both dams on the Madeira River to redo their environmental impact studies on suspicion that they caused extensive flooding in the area.[225]

As a practical reality, despite interest in expanded hydropower there are many barriers to a massive hydro building program. The Energy Ministry, mindful of this reality and the risks of being overly dependent on a single source, intends to diversify the country's source of power. Its goal is to spread its risk by limiting new supply from hydro to 50%, and get 30% from wind and biomass, and most of the rest from gas.[226]

VII. Oil, Gas, and Wastewater

Wastewater generated by the oil and gas industry is an important global issue, in part, because of the sheer volume— estimated at 250 million barrels/day for 80 million barrels/day of oil[227]— generated during exploration and production.[228] As the volume of wastewater has risen over the past decade with increased activity along with maturing fields, environmental concern over the impact of associated wastewater has also risen. Despite the concern, however, literature is sparse on assessing the environmental efficiency of the oil industry as it relates to water consumption and effluent.[229]

Wastewater treatment options, especially for offshore wells, is particularly important for Brazil because of its offshore oil and natural gas potential. There are numerous technological options that both onshore and offshore wells can employ to reduce consumption, treat and reuse, or dispose water. Still, wastewater treatment is one of the most significant challenges that the offshore oil industry faces.[230] Recent offshore oil discoveries in September 2013 by Petrobras, the national oil company, and its Indian partner IBV Brasil about 100 kilometers off the coast in the Sergipe-Alagoas Basin could contain more than 1 billion barrels of oil and is expected to produce at least 100,000 barrels a day starting in 2018.[231] Petrobras produces more than 400,000 barrels of oil daily in the pre-salt regions at Santos basin in the state of São Paulo, and Campos basin in the state of Rio de Janeiro.[232] The Campos basin produces more than half of the country's crude oil.[233] The IEA WEO 2013 has a special country focus on Brazil as it is expected to become a major oil exporter and an important player in the global energy market, based mainly on a series of recent discoveries.[234]

Although Brazil is not a major producer of natural gas compared to its neighbors (e.g., Argentina and Bolivia), there is large potential yet to be explored in the Campos and Santos basins.[235] Its natural gas reserves is estimated to be 918.6 billion m^3 of which 459 billion m^3 is proven reserves. The amount of shale gas from the Paraná basin (in the south) and the Solimões and Amazonas basins (in the Amazon forest) is estimated to be 36.2 trillion m^3 with 6.9 trillion m^3 technically recoverable.[236] However, there is still much to be learned about the geology of the country's 29 sedimentary basins[237] and still much uncertainty over the new regulatory framework for building pipelines.[238] With no R&D programs currently focused on unconventional gas, production of shale gas is still in its very early stages especially as it competes for investment with conventional gas production, which has increased by an average of 20% since 2010.[239]

There are two main federal government bodies that regulate and oversee the oil and gas industry.[240] The first, the main regulatory body for the industry is the National Agency of Oil, Natural Gas and Biofuel (ANP), an independent agency created by the 1997 Petroleum Law that falls under the Ministry of Mines and Energy. At the time ANP was created, there was a general consensus among government and the private sector that there should be less state interference in the market. The Petroleum Law was enacted specifically to open up the oil and gas industry to competition. As a direct consequence, Petrobras's influence in political decision making was drastically reduced and ANP stepped in to fill the role of an oil regulatory agency to manage the transition from a single firm monopoly to a competitive market.[241] As such, ANP regulates all activities in the sector, ensures compliance, and implements national policy; it regulates the bidding process of contracts and labor practices; and it monitors the industry through daily collection on production data from all 23 companies involved in more than 295 onshore and offshore projects throughout the country.[242] The agency is also responsible for ensuring a balance between foreign versus domestic capital investment in the oil sector.[243]

Since the passage of the Petroleum Law, two important laws regulating the industry have been enacted. The 2009 Gas Law (Law No. 11909/2009) specifically regulates the gas sector and provides clarification on the legal background for the flow of private investment in projects related to gas transportation, gas storage, and LNG facilities.[244] In response to the findings of large amounts of oil and natural gas off the coast in the region known as the pre-salt area, the government saw the need to adapt existing legislation to this new opportunity and passed the Pre-Salt Law (Law No. 12351/10) in 2010. The Pre-Salt Law regulates oil and gas activities under a production sharing regime in the pre-salt area (rather than under its long-established concession system) that put Petrobras and a new state-owned entity, Pre-Sal Petroleo (Petrosal) at the center of the activity.[245]

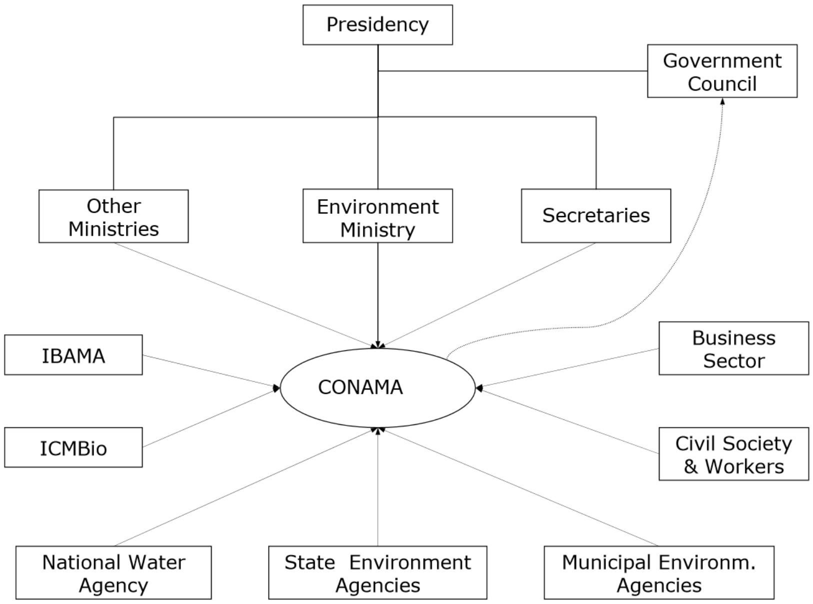
A second branch of the government that oversees the oil and gas industry falls under the purview of environmental protection. The 1981 National Environmental Policy created an administrative framework, the National Environmental System (SISNAMA), to integrate all the environmental agencies and institutes throughout the country. The agencies (federal, state, and municipal) within SISNAMA are responsible for, among other things, identifying priorities, and developing policies and regulations. Because the three levels of government share authority over environmental issues, the country's environmental laws and regulations on enforcement often simply refer to "a SISNAMA organ."[246]

Within SISNAMA, the Ministry of the Environment (MMA) is the main body that sets national environmental policies. The Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA) works with state environmental agencies to implement and enforce environmental laws. IBAMA also implements licensing processes, standards, and impact assessments. It is through its jurisdiction for licensing that the IBAMA Oil and Gas Office regulates offshore exploration activities including wastewater management.

The National Environment Council (CONAMA) is a "consultative and deliberative commission" headed by the MMA and represented by federal ministries, each state environmental agency, NGOs, and industry groups.[247] It was created to provide assistance, undertake studies, and present proposals to the Government Council and other SISNAMA organs. Its tasks as they relate to wastewater in the oil and gas industry, include establishing standards and criteria to control pollution in activities that exploit "natural resources and water resources in particular" and assisting IBAMA (when requested) on establishing standards and criteria for issuing licenses for potentially polluting activities.[248] CONAMA resolutions are voted upon by its members and, although by law CONAMA does not have rule-making authority, its resolutions are widely treated as legally binding standards[249] and the Council itself if regarded as a core rule-making authority.

The state and municipal governments have the autonomy to create local environmental rules according to their interests but must work within the rules established by the national framework.

Figure 3[250]: Framework of Environmental Regulatory Agencies



Prior to 2007, there were no regulations on offshore drilling and, instead, two laws governed pollution of surface and ground water. CONAMA Resolution no. 357/2005 classifies water bodies into 13 categories of quality and establishes conditions and standards for discharge of wastewater. Resolution no. 430/2011 supplements no. 357 and creates new standards for effluent discharge for each water class, including for volatile organic compounds and metals in industrial wastewater.[251] Additionally, Resolution 306/02, established in 2002, imposes regulation on refineries by requiring that action plans be submitted to the environmental agency and establishes procedures for environmental audits, conducted every two years, in refineries. There was no specific criteria governing offshore produced water discharge, which is notable since 90% of Brazil's oil production is offshore in very deep water and consists of mostly heavy grades.[252]

CONAMA finally created standards for offshore drilling in 2007. Resolution 393/2007 established limits for oil and grease of produced water and requires twice yearly detailed monitoring of several organic and inorganic parameters. Analysis of time series data collected from environmental monitoring efforts of produced water discharge from offshore platforms operated by Petrobras between 1996-2006 show that 99.7% of the parameter concentrations complied with the regulatory limits for "high quality seawater."[253]

Produced water is the underground water that is brought to the surface along with the oil or gas as it is extracted and its chemical properties depend on many variables of the site. Many factors influence the amount of produced water from an oil well, but on average for each m^3/day of oil produced, 3-4 m^3/day of associated water containing toxic chemicals is extracted and must be treated in order to be recycled and re-injected, or discharged according to regulatory standards.[254] The volume of water extracted is even greater in older less productive wells. Although the volume of water from gas fields is less than from oil fields, the extracted water contains higher concentrations of volatile components.[255] In Brazil, the oil and gas sector generated approximately 34,000 tons of hazardous waste in 2008; 39,000 tons in 2009; and 51,000 tons in

2010.[256] Offshore oil wells pose particular challenges partly because they can produce 7-10 times more wastewater than oil extracted from a given well.[257]

Looking downstream, Brazil has 13 refineries, 11 of which are owned by Petrobras who controls 98% of the country's refining capacity.[258] Petrobras invested little toward refineries over the last few decades, with the last one built in the 1980s, as it focused on exploration and production. But to meet National Petroleum standard and more stringent environmental regulation, Petrobras has looked to expanding processing capacity and modernizing existing refineries.

Oil refineries on average use 2.5 gallons of water for every gallon of crude oil processed and a large refinery processes 8-10 million gallons/day of "dirty" wastewater, incurring more than $100,000 per day for total water related expenditure.[259] Over the years refineries have explored ways to improve efficiencies in wastewater treatment and some refineries, such as those operated by Petrobras, have had success in localized capture and reuse.[260] For example, Replan, the largest oil refinery in Brazil with a daily processing capacity of 365,000 oil barrels, invested US$8.6 million between 1999 and 2003 in upgrading its wastewater treatment system.[261] Its efforts allowed it to reduce the waste stream from 785 m^3/hour in 1999 to 537 m^3/hour in 2002.[262] In 2010, Petrobras reported that it reused 17 billion liters of water and it aims to double that volume by 2015.[263] One of its largest water reuse projects is deployed at the Rio de Janeiro Petrochemical Complex where, once fully operational in 2014, "all the water used in its industrial processes will be supplied through reuse".[264]

The oil and gas industry in Brazil is mindful of its water consumption and, in preparation for the World Water Forum in 2012, Odebrecht, a Brazilian oil and gas company, and Itaipu Binacional, a hydroelectric power plant, coordinated a Working Group involving 14 organizations from the private sector, public sector, and civil society to publish a report on the water-energy nexus. The report, *Harmonizing Water and Energy: Time for Solutions*, presents the Brazilian perspective on the strategic issues on the water-energy nexus for the country.[265] Hydroelectric power is expected to continue to play a major role in the national strategy for power generation and, although Brazil already has established a legal framework, the report suggests that there is still much room for improving public policy to align the interface between water and energy. Figure 4 illustrates the planned expansion of energy sources through 2020. While gas plays little role in the planned expansion (on right), its role could be larger depending on the difficulties with environmental licensing of hydroelectric plants and transmission lines.

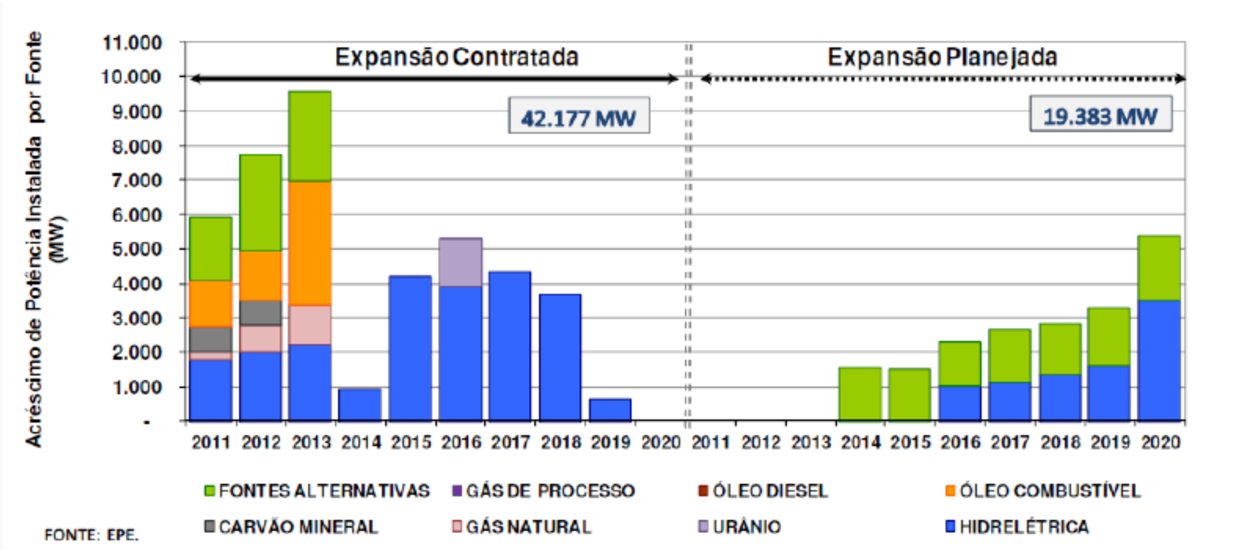


Figure 4: Expansion of Energy by Source of Electricity[266]: The left chart shows contracted expansion by source. The right chart shows planned expansion by source. (*fontes alternativas*=alternative sources; *carvão* mineral=coal; *gás de processo*=processed gas; *gás natural*=natural gas; *óleo diesel*=diesel; *urânio*=uranium; *óleo combustível*=fuel oil; *hidrelétrica*=hydroelectric)

VIII. Conclusion

The effective management of the country's water resources has important implications not only for conservation to ensure that the people have enough, as has been underscored by the recent drought, but also for use by the agriculture and energy sectors. The current water resource management system is only a few decades old and is still evolving as the federal and state governments continue to pass new legislation. One of the challenges the new decentralized, participatory management system faces is ensuring an integrated and unified system is implemented throughout the country especially in a land with vastly varying economies, populations, and topography. As such, there is huge variation in the actual implementation of water laws, with only three regions in the most economically developed areas of the country having implemented essentially all of the nation's administrative framework for managing water. Part of the government's central challenge is diffusing the perception of water as a valuable public good and natural resource that needs to be protected, conserved, and traded at an economic value that ensures a sustainable water system. So far, there has been very limited use of market forces to encourage more efficient water behavior. In addition to some limited efforts to use water pricing, there are also auspicious experiments under way to use ecosystem services to put a proper value on watersheds. Additionally the water-energy nexus is a particularly important topic in Brazil, a country with great oil and gas potential and that heavily relies on hydroelectric power. Although the federal government recognizes that much still remains to be done, as has historically been the case with water management in Brazil, it is the state governments that are making strides to fill in and lead the way where the federal government has fallen short. But, critically, the recent drought crisis that hit São Paulo particularly hard is shining a spotlight on the many areas where even state management systems are not effective. Brazil has gotten through the 2014 elections and, with a wet start to the rainy season, the drought could be abating. It appears that policy changes may now be in sight and perhaps the arguments discussed in this paper could provide a vision for politicians to start thinking about those changes.

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