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Brazil

GEOGRAPHY, CLIMATE AND POPULATION

Geography

Brazil is politically divided into 26 states and one federal district. Geographically it consists of five regions: North, Northeast, Southeast, South and Centre-west. The total area of the country is just over 8.5 million km^2. It is the fifth largest country of the world, after the Russian Federation, Canada, the United States of America and China.

In 2012, the total physical cultivated area was estimated at 80 million ha, of which 91 percent (73 million ha) consisted of annual crops and 9 percent (7 million ha) of permanent crops (Table 1).

TABLE 1
Basic statistics and population

Physical areas:			
Area of the country	2012	851 577 000	ha
Agricultural land (permanent meadows and pasture + cultivated land)	2012	275 605 000	ha
• As % of the total area of the country	2012	32	%
• Permanent meadows and pasture	2012	196 000 000	ha
• Cultivated area (arable land + area under permanent crops)	2012	79 605 000	ha
- As % of the total area of the country	2012	9	%
- Arable land (temp. crops + temp. fallow + temp. meadows)	2012	72 605 000	ha
- Area under permanent crops	2012	7 000 000	ha
Population:			
Total population	2013	200 362 000	inhabitants
- Of which rural	2013	15	%
Population density	2013	24	inhabitants/km^2
Population economically active	2013	104 439 000	inhabitants
• As % of total population	2013	52	%
• Female	2013	45	%
• Male	2013	55	%
Population economically active in agriculture	2013	10 211 000	inhabitants
• As % of total economically active population	2013	10	%
• Female	2013	25	%
• Male	2013	75	%
Economy and development:			
Gross Domestic Product (GDP) (current US$)	2012	2 250 000	million US$/year
• Value added in agriculture (% of GDP)	2012	5	%
• GDP per capita	2012	11 343	US$/year
Human Development Index (highest = 1)	2013	0.744	-
Gender Inequality Index (equality = 0, inequality = 1)	2013	0.441	-
Access to improved drinking water sources:			
Total population	2012	98	%
Urban population	2012	100	%
Rural population	2012	85	%

FIGURE 1
Map of Brazil

BRAZIL

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In 2002, the total physical cultivated area was estimated at 69 million ha, of which 89 percent for annual crops. Looking at crops with a harvested area of over one million ha, the largest increases were in the harvested areas of soybeans, from 13.97 to 23.97 million or 72 percent ha, and of sugarcane, from 4.95 to 9.60 million ha or 94 percent. A large amount of land is still available for further agricultural production, especially in the Centre-west in the cerrado (savanna) areas.

Climate

The average annual precipitation for the period 1961-2007 is 1 761 mm, ranging from values of 500 mm in the semiarid Northeast to more than 3 000 mm in the North in the Amazon region. The lowest long-term average annual precipitation occurs in the San Francisco basin (1 003 mm), the East Atlantic basin (1 018 mm), the eastern part of Northeast Atlantic (1 052 mm) and Parnaíba (1 064 mm). The highest long-term average annual precipitation is observed in the Amazon region (2 205 mm), Tocantins-Araguaia (1 774 mm), the western part of Northeast Atlantic (1 700 mm) and South Atlantic (1 644 mm) (ANA, 2012).

The five geographical regions show a very wide diversification of climate (Table 2):

- The North covers almost the whole Amazon region, being the largest extension of hot and humid forest in the world. It occupies almost half of the country and the climate is hot and humid.
- The Northeast includes Brazil's semi-arid lands, which have an irregularly-distributed annual rainfall averaging from 750 mm to less than 250 mm.
- The Southeast, stretching approximately from 14 degrees south to the Tropic of Capricorn at 23.5 degrees south, receives most of its rainfall in the summer and winters are milder.
- The South is in the temperate zone with cool and relatively dry winters and warm and relatively humid summers. It has two well-defined characteristics: one is its homogeneous rainfall within the region and the other is the uniform climate, the prevalence of the mesotermic climate.
- The Centre-west stretches from the fringes of the Amazon basin in the west to the state of Goiás in the east, and from 8 degrees to 24 degrees south. At its westerly extreme it has a relatively well-distributed annual rainfall of up to 2 500 mm. Further to the east, rainfall decreases to some 1 000 mm.

TABLE 2
Temperature and precipitation by region

Average values	South	South-East	Centre-West	North-East	North
Temperature (° C)	14 - 18	24 - 18	26 - 22	20 - 28	24 - 26
Annual rainfall (mm)	1 250 - 2 000	900 - 4 400	1 250 - 3 000	250 - 2 000	1 500 - 3 000

Population

In 2013, the total population was about 200 million, of which around 15 percent was rural (Table 1). Population density is 24 inhabitants/km^2. In 2003, the total population was estimated at 182 million (18 percent rural), reflecting an average annual demographic growth rate over this period of 1.0 percent. The North is the most sparsely populated and the Southeast the most densely populated. In 2001, the population density was 21 inhabitants/km^2 varying from 3 inhabitants/km^2 in the North, to 30 in the Northeast, 74 in the Southeast, 41 in the South and 7 in the Centre-west.

In 2012, 98 percent of the total population had access to improved water sources (100 and 85 percent in urban and rural areas respectively) and 81 percent of the total population had access to improved sanitation (87 and 49 percent in urban and rural areas respectively).

ECONOMY, AGRICULTURE AND FOOD SECURITY

In 2012, the gross domestic product (GDP) was US$ 2 250 000 million and agriculture accounted for 5 percent of GDP, while in 1992 it accounted for 8 percent. In 2013, total population economically active in agriculture is estimated at 10 211 000 inhabitants (10 percent of economically active population), of which 25 percent is female and 75 percent is male.

In March 1991, the Southern Common Market (MERCOSUL) was created when Brazil, Argentina, Paraguay and Uruguay signed the Treaty of Asunción. The trade pact took effect in January 1995 as a customs union and partial free-trade zone. The aim of MERCOSUL is to allow free movement of capital, labour and services among the four countries. With the introduction in July 1994 of a new currency, the real, the annual inflation rate fell from more than 5 000 percent in 1993-1994 to just over 31 percent in 1994-1995, and all quantitative restrictions to trade were eliminated.

In the 1980s agriculture played a significant role in the country's economy, but no longer did a single crop dominate in the way sugarcane, coffee or rubber had done at their peaks. Between 1980 and 1992 farm output grew with 38 percent more rapidly than population (26 percent). In the mid-l990s Brazil was the world's largest producer of coffee and sugar (from sugarcane), second among the cocoa producers, fourth among tobacco growers, and sixth in cotton growing. Under the various programmes undertaken in the last two decades to promote diversification of crops, the production of cereals, including wheat, rice, maize, and particularly the production of soybeans has grown consistently. Forest products, especially rubber (once a vital element in Brazilian exports), as well as Brazil nuts, cashews, waxes and fibres, now come mostly from cultivated plantations and no longer from wild forest trees as in earlier days. Thanks to its wide climatic range, Brazil produces almost every kind of fruit, from tropical varieties in the North (various nuts and avocados) to citrus fruit and grapes in the temperate regions of the South.

Brazil is globally important for both food security and environmental sustainability. It meets most of its domestic demand of agricultural products, plays a major role in the international commodity markets, provides vital environmental services to the world and has a large availability of land, water and top agricultural technology (Government Office for Science, 2010).

The agro-climatic regions with their implications for irrigation are explained below:

- *North:* Due to its high rainfall, irrigation development is limited to a small area of lowland rice.
- *Northeast:* This region contains the country's poorest farmers and large numbers of landless people. Many farmers cultivate for subsistence only. Unlike other regions, water resources in most of the Northeast are a severe constraint to agriculture. One major river, the San Francisco river, dominates the region, but the topography generally requires that its water be extracted by pumping. There are a few other perennial rivers, such as the Parnaiba (Piauí/Maranhão) river, and although the government has built regulation structures on some seasonal rivers, many now run dry due to uncontrolled water extraction. Some lowland areas are suitable for flooded rice, mainly in the humid coastal strip. Where water constraints can be overcome, the warm climate favours maize, beans, cotton and sugarcane, as well as year-round multiple fruticulture and horticultural cropping and seed production. Large public-sector irrigation schemes have been constructed and allocated to both entrepreneurs and small-scale settlers, with the aim of overcoming intermittent regional food deficits while creating employment and benefiting the rural poor. Increasing use is being made of localized and sprinkler irrigation in water-scarce areas with fruit trees that are now receiving special attention from the federal and state governments.
- *Southeast:* This region is dominated by technically advanced commercial farmers, like in the extreme south. Winter irrigation allows the farmers to crop twice instead of once a year, rotating winter plantings of wheat, peas or beans with rainfed summer crops, which include cotton and sugarcane. There is also supplementary irrigation of summer crops when necessary. Although there is less of the extensive flooded rice typical of the South, the Provarzeas programme made

considerable progress also in the Southeast. It encouraged the growth of beans and other crops using supplementary irrigation in winter, in rotation with the main crop of flooded rice in summer.

- *South:* Due to frost, there are few opportunities for out-of-season winter irrigation, and although supplementary summer irrigation can save farmers from crop failures in a dry year, on average it gives only a small increase over the rainfed yields of the typical summer crops of the South: maize, beans and soybean. It has a highly developed, commercially-oriented agriculture which both large and small farmers share. As a result, irrigation development in the South has focused mainly on summer flooding of lowlands for rice production (Rio Grande do Sul). Most of this is large-scale and mechanized, and is closely integrated with cattle production, largely for reasons of weed control. Lowlands are typically planted with rice only once every three years and kept under non-irrigated pasture for the other two. From 1978 to 1988 the Government promoted conventional lowland rice irrigation on a smaller scale, under the Provarzeas programme that is now suspended.
- *Centre-west:* At its westerly extreme there is little need for irrigation. Further to the east, irrigation is required during a six-month dry season. However, most of the Centre-west is *cerrado* land, potentially productive if the soil's natural acidity and low phosphates content are corrected. Since *cerrado* soil management techniques are newly developed, only over the last decades has much of the region been opened for cultivation, mainly by advanced farmers from further south. Increasing numbers of farmers are taking advantage of the region's many perennial rivers and streams to complement their rainfed cereal, soybean, bean and cotton production with dry-season irrigated cropping. The large properties and the level land are well suited to centre-pivot and self-propelled irrigation systems, which have expanded in the last years. Free of winter temperature constraints, irrigation in the *cerrado* can greatly increase the intensity of this vast, recently occupied area.

WATER RESOURCES

Surface water and groundwater resources

For general purposes, Brazil can be divided into:

1. three river basins: the Amazon, Tocantins-Araguaia and San Francisco
2. two river basin complexes or groups:
   - the Plata river basin that has three Brazilian sub-river basins (Paraná, Upper Paraguay and Uruguay);
   - the remaining rivers flowing into the Atlantic that are divided into several basins.

The Amazon and the Tocantins-Araguaia basins in the north account for 55 percent of Brazil's total drainage area. The Amazon river, with a total length of about 6 400 km, is the world's second longest river after the Nile with a total length of 6 650 km. However, debates over the true sources of both rivers and thus their entire length are ongoing and some studies consider the Amazon to be the longest river with a length of 6 990 km and the Nile the second longest with 6 850 km. The Amazon river is the widest and deepest river and has by far the largest flow of water and drainage area. The Amazon river is navigable by ocean steamers as far as Iquitos in Peru. The San Francisco river is the largest river entirely within Brazil, flowing for over 1 609 km northward before it turns eastward into the Atlantic. The last 277 km of the lower river is navigable for ocean-going ships. The Paraná-Paraguay river system drains the south-western portion of the state of Minas Gerais. Brazil's two southernmost states are drained through the Uruguay river also into the Plata river.

The long-term average internal renewable surface water resources are estimated at 5 661.2 km^3/year (Table 3) (ANA, 2009). The Amazon basin accounts for 73.6 percent of the internal surface water resources (Table 4).

TABLE 3
Renewable water resources

Renewable freshwater resources:			
Precipitation (long-term average)	-	1 761	mm/year
	-	14 995 500	million m^3/year
Internal renewable water resources (long-term average)	-	5 661 200	million m^3/year
Total renewable water resources	-	8 646 700	million m^3/year
Dependency ratio	-	34.5	%
Total renewable water resources per inhabitant	2013	43 155	m^3/year
Total dam capacity	2010	700	million m^3

TABLE 4
Internal renewable surface water resources by basin (Source: ANA, 2009)

Basin name	**Surface water (km^3/year)**	**% of total (%)**
Amazon	4 167.3	73.6
Tocantins-Araguaia	435.2	7.7
San Francisco	89.7	1.6
Northeast Atlantic- western part	82.3	1.4
Northeast Atlantic- eastern part	24.4	0.4
Parnaiba	24.2	0.4
East Atlantic	46.8	0.8
Southeast Atlantic	99.7	1.8
South Atlantic	127.9	2.3
Plata River:		
Paraná	359.9	6.4
Paraguay	74.4	1.3
Uruguay	129.4	2.3
Total	**5 661.2**	**100.00**

The total incoming water is 2 985.5 km^3/year, of which 880 km^3/year from Colombia (Japura, Negro, and Putumayo), 1 495.5 km^3/year from Peru (Amazon, Jurua and Purús), 550 km^3/year from Plurinational State of Bolivia (Madeira), 60 km^3/year from Bolivarian Republic of Venezuela (Casiquiare). The outflow from Brazil is estimated at 585.72 km^3/year as follows: to 70 km^3/year to Uruguay (Negro and Uruguay river, which comes from Brazil to become the border between Argentina and Uruguay), 442.45 km^3/year to Argentina (Iguazu, Parana/rio de la Plata, and the Uruguay river, which comes from Brazil to become the border between Argentina and Uruguay), 73.27 km^3/year to Paraguay (Paraguay river). The Paraguay river does border Plurinational State of Bolivia only over a very short distance (35 km) and therefore is not counted as flowing from Brazil to Plurinational State of Bolivia.

Groundwater resources are not spread uniformly over the country. There are areas of shortage and others with relative abundance. There are cities with significant water availability, such as those covered by the Guarani Aquifer and sedimentary aquifers in general, and others with low availability, such as those of crystalline rocks in the semiarid part of Brazil. In the semi-arid northeastern Brazil, where water from wells is the only source of supply available in many small communities, the wells have very low flows, usually less than 3 m^3/hour or 0.8 litres/sec, and the water is highly saline. The best aquifers are located on sedimentary lands occupying 48 percent of the area of Brazil and have great potential for groundwater, because of their favourable weather conditions. The internal renewable groundwater resources in the country are estimated at 645.6 km^3/year. Annual exploitable groundwater accounts for 129.1 km^3 (ANA, 2009).

The volume of stored groundwater in Brazil less than 1 000 m deep and with good quality for human uses is estimated at 112 000 km^3, with very variable extraction rates: from less than 5 m^3/hour or 1.4 litres/sec in the metamorphic rocks of the semiarid northeast and recent deposits to 1 000 m^3/hour or 278 litres/sec in the sedimentary rocks.

The Northeast has a semiarid climate with low precipitation (average of 600 mm/year) and high potential evaporation (2 000 mm/year), and there is a predominance of metamorphic rocks with low capacity to accumulate groundwater. The rivers have intermittent flow, except for the San Francisco and Parnaíba rivers. The limited surface water availability has resulted in over-exploitation of the aquifers since the beginning of the twentieth century. In the last 40 years, however, there has been much concern to survey, evaluate and use the water resources of the region better. The region has an area of 1.6 million km^2 (20 percent of the total area of the country), comprises nine federal units and had a population of 43.9 million (27 percent of the total population of the country) in 1996. The region is divided into 24 river basins, the water resources of which vary between 820 and 850 m^3/inhabitant per year in Pernambuco and Fortaleza to 30 000 m^3/inhabitant per year in Gurupi.

The total annual internal renewable water resources in the country are estimated at 5 661.2 km^3 and the total renewable water resources account for 8 646.7 km^3. The overlap between surface water and groundwater is considered to be equal to the groundwater resources.

In 2008, total municipal wastewater produced and treated was 10.3 km^3 and 3.1 km^3 respectively (ANA, 2012). Direct use of treated municipal wastewater is estimated at 0.009 km^3.

Dams

In 2010, total dam capacity in Brazil was estimated at 700 km^3 (ANA, 2012). This figure includes all hydroelectric dams in the country, dams larger than 10 million m^3 in the Northeast and most important dams for water supply of municipalities. The most important dams in the Northeast are Castanhão (6.7 km^3), Eng. Armando Ribeiro Gonçalves (2.4 km^3), Orós (1.94 km^3), Pedra (1.64 km^3), Banabuiu (1.601 km^3), Coremas-Mãe d'água (1.358 km^3) (ANA, 2012).

Most of the dams in Brazil are used mainly for hydropower. In 2007, the installed capacity of the hydroelectric power stations is 76 757 MW, which is 76.5 percent of the total power installed capacity in Brazil (ANA, 2009). The Itaipu power plant, the largest hydroelectric plant in the world (power production is 12 600 MW and dam capacity is 29 km^3 divided equally between Brazil and Paraguay), is located on the Paraná River on the Paraguay-Brazil frontier, not far from Iguaçu Falls. New hydroelectric power stations are to be built in several already inventoried places, making a total of 107 307 MW of installed generating power in the next few decades. The Brazilian hydroelectric potential is around 258 686 MW, of which only 21 percent is being exploited. There are 8 hydroelectric dams with a total capacity larger than 20 km^3: Castro Alves (92 km^3), 14 de julho (55 km^3), Serra da Mesa (54 km^3), Tucuri I and II (50 km^3), Sobradinho (34 km^3), Furnas (23 km^3), Ilha Solteira (21 km^3) and Porto Primavera (Eng. Sergio Motta) (20 km^3).

International water issues

The Treaty of the Plata River, signed in 1969 and entered into force in 1977, worked for several years as a political interconnection between Argentina, Bolivia, Brazil, Paraguay and Uruguay. Its main objectives are the wise use of water resources; regional development with preservation of flora and fauna; physical, fluvial and terrestrial integration; and promotion of greater knowledge of the basin, its resources and potential. The treaty can be considered as a precursor, in the preservation of the environment and the generation of infrastructure and communication in line with what, over two decades later, would be MERCOSUR (CIC, 2012).

The Treaty and the international instruments that resulted from it created and gave functions to the different bodies (CIC, 2012):

- The intergovernmental coordinating committee of the countries of the Plata river basin (CIC) is the executive body of the System of the Plata river basin, composed of Argentina, Bolivia, Brazil, Paraguay and Uruguay, responsible for promoting, coordinating and monitoring the progress of multinational actions for an integrated development of the Plata river basin. It consists of representatives from each of the member countries.

- The governments of Argentina, Bolivia, Brazil, Paraguay and Uruguay signed in 1974 the Financial fund for the development of the countries of the Plata river basin (FONPLATA), an entity with international legal status, which was created to act as the financial body of the Treaty on the Plata river basin. Its mission is to give technical and financial support for studies, projects, programmes and initiatives which work to promote the harmonious development and physical integration of the members countries of the Plata river basin.
- The intergovernmental committee of the Paraguay-Parana waterway (Argentina, Bolivia, Brazil, Paraguay and Uruguay) is in charge of navigation.
- Given the importance of the Guarani aquifer in the region, shared between Argentina, Brazil and Paraguay, it was agreed in 2003 to start the “Project for environmental protection and sustainable integrated management of the Guarani aquifer system” to be financed by the Global Environment Facility (GEF), with support from the World Bank and the Organization of American States (OAS) (IICA, 2010).
- Several international commissions.

The Amazon Cooperation Treaty (TCA) was signed in 1978 by Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname and Venezuela and entered into force for Brazil in 1980. The basic scope of the TCA is to promote the harmonious development of the Amazon, in order to allow an equitable distribution of the benefits, to improve the quality of living of its peoples and to achieve the full incorporation of their Amazon territories to the respective domestic economies. In 1995, the countries members of the TCA created the Amazon Cooperation Treaty Organization (ACTO) to strengthen the implementation of the Treaty.

Other treaties include: (i) the cooperation agreement for the use of natural resources and development of the Quaraí river basin; and (ii) the treaty for the use of shared natural resources of the bordering stretches of the Uruguay river and its tributary, the Pepiri-Guaçu river, between Brazil and Argentina.

WATER USE

In 2010 total water withdrawal was estimated at 74 830 million m^3 of which 40 050 million m^3 (54 percent) for irrigation, 4 850 million m^3 (6 percent) for livestock, 17 210 million m^3 (23 percent) for municipalities and 12 720 million m^3 (17 percent) for industries (ANA, 2012) (Table 5 and Figure 2). In 2006 and 2000 total water withdrawal was estimated at 58 074 million m^3 and 50 205 million m^3 respectively (ANA, 2009). In 1996 agricultural withdrawal represented 61 percent of total withdrawal, municipalities 21 percent and industry 18 percent.

TABLE 5
Water use

Water withdrawal:			
Total water withdrawal	2010	74 830	million m^3/year
- Agriculture (Irrigation + Livestock + Aquaculture)	2010	44 900	million m^3/year
- Municipalities	2010	17 210	million m^3/year
- Industry	2010	12 720	million m^3/year
• Per inhabitant	2010	383	m^3/year
Surface water and groundwater withdrawal (primary and secondary)	2010	74 781	million m^3/year
• As % of total renewable water resources	2010	0.9	%
Non-conventional sources of water:			
Produced municipal wastewater	2008	10 300	million m^3/year
Treated municipal wastewater	2008	3 100	million m^3/year
Direct use of treated municipal wastewater	2008	9	million m^3/year
Direct use of agricultural drainage water	1996	40	million m^3/year
Desalinated water produced		-	million m^3/year

FIGURE 2
Water withdrawal by sector
Total 74 830 million m^3 in 2010

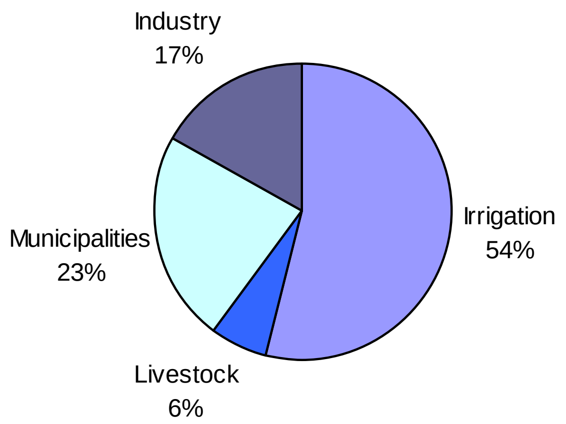


Table 6 shows water withdrawal by sector and by river basin in 2006. Paraná basin was responsible for 27 percent of the total withdrawals of the country, while it has only 6 percent of the water resources of the country, and South Atlantic Basin was responsible for 15 percent, while having only 2 percent of the water resources of the country. On the other extreme, in the Amazon basin, having 74 percent of the water resources of the country, water withdrawal was only 4 percent of the total water withdrawal of the country.

TABLE 6
Water withdrawal by sector and by basin in 2006 (Source: ANA, 2009)

Basin name	Water withdrawal (km^3/year)				% of total
	Irrigation + Livestock	Municipalities	Industry	TOTAL	(%)
Amazon	1.11	0.71	0.29	2.11	3.6
Tocantins-Araguaia	1.76	0.55	0.17	2.47	4.3
San Francisco	4.18	0.98	0.55	5.70	9.8
Northeast Atlantic- western part	0.24	0.33	0.05	0.62	1.1
Northeast Atlantic- eastern part	4.72	1.60	0.83	7.15	12.3
Parnaiba	0.98	0.24	0.04	1.26	2.2
East Atlantic	1.59	1.01	0.30	2.90	5.0
Southeast Atlantic	1.73	3.14	1.18	6.05	10.4
South Atlantic	6.09	1.12	1.47	8.68	14.9
Paraná	4.58	6.05	4.91	15.54	26.8
Paraguay	0.64	0.21	0.07	0.93	1.6
Uruguay	4.10	0.30	0.28	4.68	8.1
BRAZIL	31.70	16.23	10.14	58.07	100.0

Considering the water balance, the water availability of the Amazon river basin is high and demand low due to low population density. The most critical situations of the country are located in the Northeast Atlantic (eastern part), where the availability of water resources is very low. The basins of San Francisco and the East Atlantic have also areas with critical situations. In these regions there is usually a combination of low rainfall and high evapotranspiration. In the Paraná and Southeast Atlantic basins the water balance is critical due to the high demographic density. In the South Atlantic and Uruguay basins the water balance is critical due to the high demand for irrigation (ANA, 2009).

The use of groundwater has grown rapidly in recent decades and there are indications that this trend will continue. Water from wells and springs has been used for various purposes, such as drinking, irrigation, industry and leisure. 15.6 percent of Brazilian households rely exclusively on groundwater. Although the use of groundwater is complementary to the use of surface water in many regions, it is the main source of water in other areas. It plays an important role in the socioeconomic development of the country and of poor communities distant from public supply networks. In agriculture, the demand for groundwater has grown strongly in recent decades. It is already widely used in irrigation in several regions, such as West Bahia and the Chapada Tableland (ANA, 2009). The number of wells constructed during the period 1958-2008 is estimated at 416 000.

No information is available on the amount of wastewater directly used. In 1996, 0.04 km^3/of desalinated water was used for livestock and domestic purposes in the Northeast region.

IRRIGATION AND DRAINAGE

Evolution of irrigation development

The irrigation potential of Brazil is estimated at 29.3 million ha (Table 7 and Table 8). This includes only areas where irrigation can be developed and excludes the areas of high ecological value in the North (Amazon and Tocantins basin). In the *cerrado* areas of the Centre-west, the potential for irrigation has expanded substantially in recent years, following recent advances in soil management and irrigation techniques applicable in that region.

TABLE 7
Irrigation and drainage

Irrigation potential	-	29 350 000	ha
Irrigation:			
1. Full control irrigation: equipped area	2010	5 400 000	ha
- Surface irrigation	2010	2 619 000	ha
- Sprinkler irrigation	2010	2 446 200	ha
- Localized irrigation	2010	334 800	ha
• Area equipped for full control irrigation actually irrigated	2006	4 453 925	ha
- As % of area equipped for full control irrigation	2006	96.8	%
2. Equipped lowlands (wetland, ivb, flood plains, mangroves)		-	ha
3. Spate irrigation		-	ha
Total area equipped for irrigation (1+2+3)	**2010**	**5 400 000**	**ha**
• As % of cultivated area	2010	7	%
• % of area irrigated from surface water		-	%
• % of area irrigated from groundwater		-	%
• % of area irrigated from mixed surface water and groundwater		-	%
• % of area irrigated from non-conventional sources of water		-	%
• Area equipped for irrigation actually irrigated	2006	4 453 925	ha
- As % of total area equipped for irrigation	2006	96.8	%
• Average increase per year	1998 - 2010	5.4	%
• Power irrigated area as % of total area equipped for irrigation		-	%
4. Non-equipped cultivated wetlands and inland valley bottoms		-	ha
5. Non-equipped flood recession cropping area		-	ha
Total agricultural water managed area (1+2+3+4+5)	**2010**	**5 400 000**	**ha**
• As % of cultivated area	2010	7	%

Size of full control irrigation schemes:	**Criteria**:		
Small schemes	< - ha	-	ha
Medium schemes	> - ha and < -ha	-	ha
large schemes	> - ha	-	ha
Total number of households in irrigation		-	

TABLE 7 (Continued)
Irrigation and drainage

Irrigated crops in full control irrigation schemes:			
Total irrigated grain production		-	metric tons
• As % of total grain production		-	%
Harvested crops:			
Total harvested irrigated cropped area	2006	5 329 000	ha
• Temporary crops: total	2006	4 798 000	ha
- Rice	2006	1 129 000	ha
- Wheat	2006	19 000	ha
- Maize	2006	559 000	ha
- Onion	2006	86 000	ha
- Watermelon	2006	66 000	ha
- Pulses	2006	316 000	ha
- Soybeans	2006	624 000	ha
- Potatoes	2006	23 000	ha
- Tobacco	2006	64 000	ha
- Cotton	2006	207 000	ha
- Sugarcane	2006	1 705 000	ha
• Permanent crops: total	2006	531 000	ha
- Bananas	2006	27 000	ha
- Citrus	2006	158 000	ha
- Coffee	2006	262 000	ha
- Other fruits	2006	29 000	ha
- Permanent pastures	2006	55 000	ha
Irrigated cropping intensity (on full control area actually irrigated)	2006	120	%
Drainage - Environment:			
Total cultivated area drained	1998	1 280 000	ha
• Non-irrigated cultivated area drained		-	ha
• Area equipped for irrigation drained		-	ha
- As % of total area equipped for irrigation		-	%
Area salinized by irrigation	1998	15 000	ha
Area waterlogged by irrigation		-	ha

TABLE 8
Irrigation potential by region

Region	Lowlands "Varzeas*" (1 000 ha)	Highlands (1 000 ha)	Total Area (1 000 ha)
North	8 000	5 300	13 300
Northeast	100	900	1 000
Southeast	750	3 400	4 150
South	1 500	2 200	3 700
Centre-West	3 000	4 200	7 200
BRAZIL	**13 350**	**16 000**	**29 350**

** Varzeas are seasonally-flooded or flood-prone lowlands.*

Irrigation started in Brazil in the last century, in Rio Grande do Sul and in the semi-arid region of the Northeast. By the end of the 1960s, the Group for Integrated Studies on Irrigation and Agricultural Development (GEIDA) was created to enlarge the overall knowledge of the natural resources. It created various programmes such as the Pluri-annual Irrigation Programme (PPI) in 1969, and the National Integration Programme (PIN) in 1970. Many opportunities were given for private investments on irrigation and drainage: (i) the National Programme for Rational Use of Flood Plains (PROVARZEAS); (ii) the Programme to Finance Irrigation Equipment (PROFIR); (iii) the conception of “entrepreneurial lots” in public irrigation projects; and (iv) the implementation of the sub-sectoral Irrigation I project. In 1984 a new period started, characterized by the establishment of important programmes such as the Northeast Irrigation Programme (PROINE) and the National Irrigation Programme (PRONI), both in 1986. In that period, the role of the government was limited to the accomplishment of large works (transmission and distribution of electrical energy and macro-drainage) while the private entrepreneurs were in charge of the other investments. In 1995, the new government started preparing the national policy on irrigation and drainage.

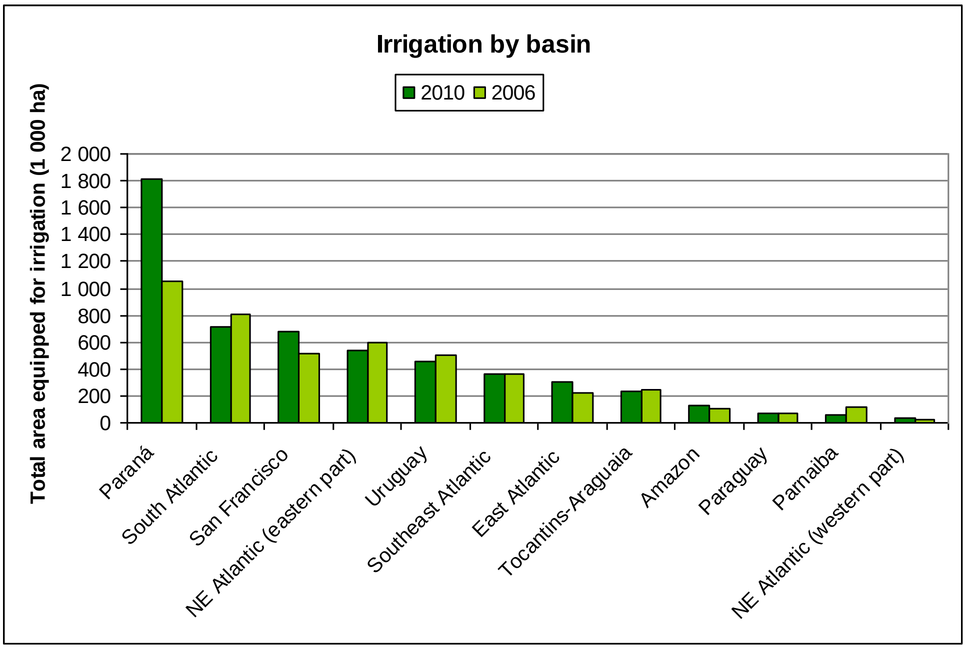
In 2010 the area equipped for irrigation was estimated at 5.40 million ha (ANA, 2012), which represents 8 percent of the cultivated area. In 2006 it was estimated at 4.60 million ha, representing 7 percent of the cultivated area (ANA, 2009), and the area actually irrigated was estimated at 4.45 million ha (IBGE, 2006). In 1996, 1985 and 1975 the area equipped for irrigation was 3.12 million, 1.96 million and 1.09 million ha respectively, while it accounted for 0.46 million ha in 1960 (Table 9).

TABLE 9
Evolution of area equipped for irrigation by region (ha)

Region	1960	1970	1975	1980	1985	1996	2006
North	457	5 640	5 216	19 189	43 244	83 023	149 671
Northeast	51 774	115 971	163 358	256 738	366 826	751 887	1 207 388
Southeast	116 174	184 618	347 690	428 821	599 564	929 189	1 377 143
South	285 391	474 663	535 076	724 568	886 964	1 096 592	1 376 422
Centre-West	1 637	14 358	35 490	47 216	63 221	260 952	490 664
BRAZIL	**455 433**	**795 291**	**1 085 831**	**1 476 532**	**1 959 819**	**3 121 644**	**4 601 288**

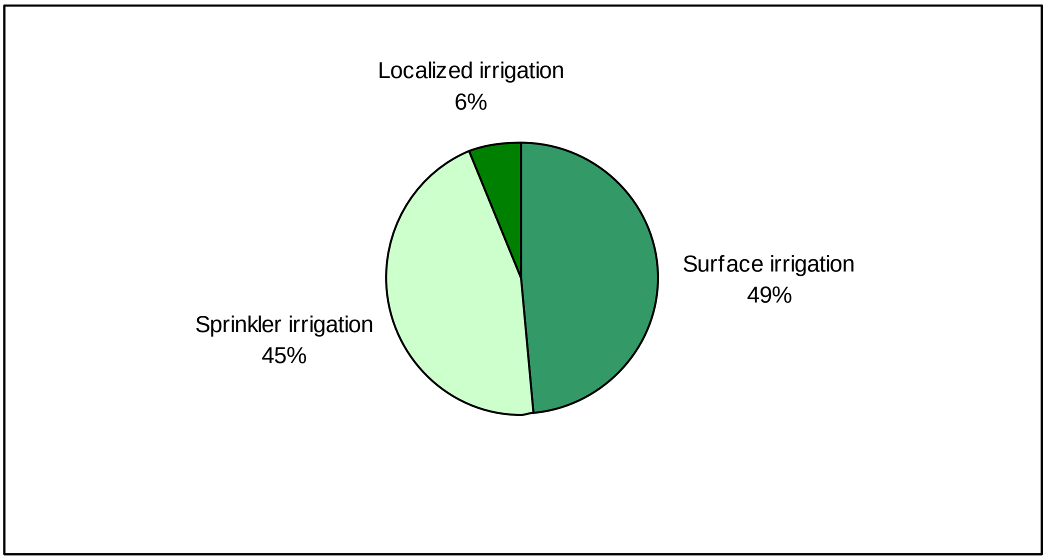
In 2006, Parana river basin accounts for by far the highest area equipped for irrigation, 1.41 million ha or 26 percent of the total area equipped for irrigation in Brazil. Northeast Atlantic (western part), Paraguay, Amazon and Paraniba basins account for the lowest irrigated area (Figure 3). Three states accounted for more than 50 percent of the total irrigated area in the country: Rio Grande do Sul (22 percent), São Paulo (17 percent) and Minas Gerais (12 percent). In Rio Grande do Sul, more than 80 percent of the irrigated area was used to grow rice under a flooding system. In contrast to what happens with other crops, the demand for water by irrigated rice is concentrated in a few months during the cultivating period. In the state of São Paulo, the irrigated area is utilized mostly for the cultivation of sugarcane, coffee, oranges and grains. In Minas Gerais the main irrigated crops are grains and coffee under centre-pivot irrigation (Government Office for Science, 2010).

FIGURE 3
Irrigation by basin (2006 and 2010)
Total 4 601 288 ha in 2006 and 5 400 000 ha in 2010



Surface irrigation represents 49 percent of the total area equipped for irrigation, while sprinkler and localized irrigation techniques account for 45 percent and 6 percent respectively (Figure 4).

FIGURE 4
Irrigation techniques on area equipped for full control irrigation
Total 5 400 000 ha in 2010



Irrigation techniques differ within Brazil. In the South, Southeast and Centre-west, rice as well as some vegetable and orchard crops are irrigated by simple flooding or using furrow irrigation. Water is diverted from numerous small streams and conveyed to the farm-gates through earth canals. This technology, together with proper land preparation and some mechanization, yields a good return. Modern irrigation technologies, which have a higher water use efficiency and require less labour, are preferred by large farmers in the *cerrados* for crops such as wheat, soybean, maize, and cotton, and by the producers of vegetables and fruits near the metropolitan areas in the Northeast. These technologies, which are increasingly used in private and public irrigation schemes, range from mobile sprinkler lines to state-of-the-art modern centre-pivot and other self-propelled irrigation equipment. In the Northeast there is a strong increase in the use of localized irrigation, due to the water scarcity in the area. Over the last decades, the area with surface irrigation has decreased and that with sprinkler irrigation for grain production and localized irrigation for fruit and vegetables has increased. Total water use efficiency is estimated, on average, at 40-65 percent for surface, 60-85 percent for sprinkler and 78-97 percent for localized irrigation methods.

Irrigated agriculture can be divided into public and private schemes:

- Public schemes (6 percent of the total irrigated area in 1996) are mostly in the northeast region (67 percent). The size of the irrigation schemes varies between 42 and 22 000 ha. Most of the investments are made by the government, which then allocates plots from 4 to 8 ha to poor or landless farmers (settlers). In addition there are some medium-size plots, from 8 to 32 ha, usually for professionals (agrarian technicians) and large-size plots, from 25 to 500 ha, for enterprises. Public irrigation systems depend on water supplies that have been developed using Government (usually Federal Government) funds. In 1998, the total cost of development of public irrigation projects in the northeast was approximately US$8 600/ha for surface irrigation, US$9 650/ha for sprinkler irrigation and US$10 150/ha for localized irrigation.
- Private schemes (94 percent in 1996) have been developed by private individuals or companies. Private development has received technical support from the Government especially under the PROVARZEAS programme and financial assistance through targeted credit lines. It comprises many forms of irrigation ranging from small-scale to large-scale, and from simple to highly sophisticated irrigation. In 1998, investment costs of private irrigation were considerably lower than in the public sector, ranging from US$1 600/ha for surface irrigation to US$2 650/ha for sprinkler irrigation and US$3 150/ha for micro-irrigation. Generally, investment costs of private irrigation are higher in the Northeast than in the other regions due to the difficulty for accessing perennial sources of water. Average costs of operation and maintenance range from US$ 35 to

95/ha. Costs can also be broken down into off-farm investment costs (water pumps, electrical support, conveyance, roads), that vary from US$4 500/ha to US$7 000/ha, and on-farm investment costs that vary from US$650/ha for simple surface irrigation methods to US$2 500/ha for localized irrigation.

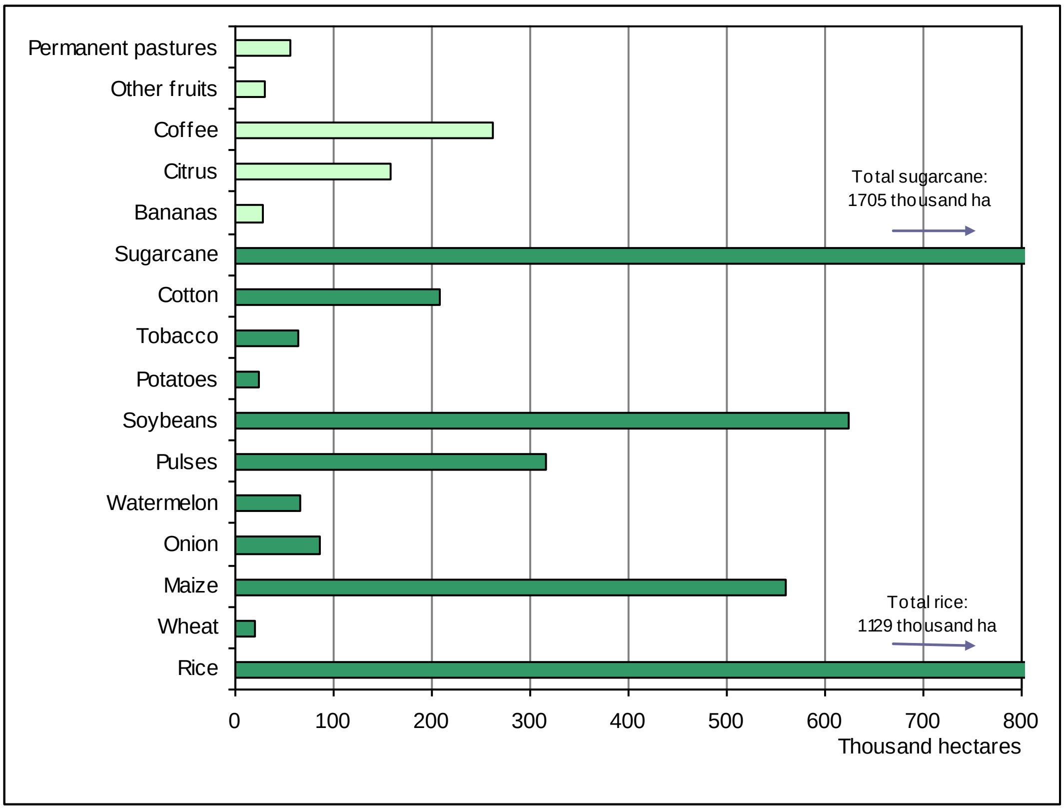
Some important irrigation areas and schemes are (ANA, 2009):

- South Atlantic and Uruguay basins: great demand of irrigation by inundation (flooded rice)
- San Francisco basin: Verde Grande basin (irrigation projects); Polo de Barreiras in the city of Barreiras (irrigated soybean production); Juazeiro and Petrolina (irrigated horticulture)
- Araguaia-Tocantins basin: Project Formoso
- Alagoas: sugarcane zone
- State of Ceara: irrigation for horticulture

Role of irrigation in agricultural production, economy and society

In 2006, the area equipped for irrigation was 4.60 million ha, the area actually irrigated 4.45 million ha and the harvested irrigated crop area covered around 5.33 million ha, meaning an irrigated cropping intensity of 120 percent (Government Office for Science, 2010). Of the total harvested irrigated crop area, 32 percent consisted of sugarcane, 21 percent of rice, 12 percent of soybeans and 11 percent of maize (Figure 5 and Table 7).

FIGURE 5
Irrigated crops on area equipped for full control irrigation
Total harvested area 5 329 000 ha in 2006 (cropping intensity on actually irrigated area: 120%)



In 1997, irrigation contributed an estimated 18 percent of total crop production in weight, and some 29 percent of total farmgate value (since irrigated crops are relatively high-value).

The range of crops grown under irrigation is diverse. In addition to basic commodities and to crops such as sugarcane and coffee, high-value crops are also grown whenever markets permit, like vegetables (some of them on a semi-industrial scale) near the important urban markets of the industrial Southeast. The same markets are supplied off-season with fruits, onions, melons and other vegetables from the Northeast. Expansion of tomato paste and other vegetable processing factories in the arid zones of the Northeast has created market opportunities for large-scale and small-scale irrigators, who increasingly export their fruit and off-season vegetables to Japan, Europe and the United States of America. Yields of crops vary widely throughout the country.

There has been a great diversity of performance between the public and private irrigation sectors. Public irrigation generally tended to progress slowly and fall short of performance expectations while private irrigation, especially in recent years, has expanded fast and often given high profits. However, direct comparisons are difficult due to regional differences in irrigation needs and opportunities, the special social needs of the impoverished Northeast and the different institutional arrangements for public and private development. In 1990 FAO, World Bank and the Government of Brazil undertook a detailed study to estimate the economic efficiency of Brazil's irrigation. On the basis of information collected, eleven different models of irrigation farming were defined to represent irrigation in Brazil. The results showed that public schemes were systematically less economically efficient than private schemes and that basic commodities (cereals, cotton, beans, soybeans) would give a much lower return than fruits and vegetables. Under these conditions, the public schemes of the Northeast, growing staple food, yielded a very low return. Net economic benefit generated per 1 000 m^3 of water averaged around US$20 for low-value crops and US$50-400 for high-value crops, while net economic returns per year were, on average, around US$250 for low-value crops and US$2 000/ha for high-value crops.

Women and irrigation

Several studies carried out in Brazil conclude that women have a subordinated position in agricultural family work and it is considered in many cases as "help" even if they do the same work as men (Chiappe, 2005). The involvement of women in agriculture has been underestimated in statistics.

According to the Constitution of Brazil property rights or concessions under the agrarian reform program may be allocated to men and women either individually or as joint owners. Though, women are usually excluded from land inheritance practices, especially in rural areas and beneficiaries of agrarian reforms have been, largely, men. In the first census of the agrarian reform organized by the National Institute of Colonization and Agricultural Reform (INCRA) in 1996, after 32 years of agrarian reform, only 12 percent of women had land registered under their name. Access to water is in most cases depends on land tenure; as a result, women may find themselves disadvantaged to obtain water for irrigation. In general, women in rural areas have less access than men to resources, particularly to land and water.

In agriculture areas where water is often unavailable, it is usually women who must carry water home from wells or stream (Chiappe, 2005).

At present, the government of Brazil is developing policies to promote equal opportunities for men and women in the rural areas (Portal Brasil, 2015).

Status and evolution of drainage systems

Little information is available in drainage, salinity and waterlogging in Brazil. The surface with drainage equipment is around 1.28 million ha, mostly in the areas with irrigation equipment. Within the framework of the PROVARZEAS programme in the 1980s, around 400 000 ha were drained. Average costs of drainage development in 1996 range between US$1 600 and US$1 800 per ha for open drainage, and from US$2 300 to US$2 700 per ha for subsurface drainage.

WATER MANAGEMENT, POLICIES AND LEGISLATION RELATED TO WATER USE IN AGRICULTURE

Institutions

In 1965, the National Department for Water and Electrical Energy (DNAEE) under the Ministry of Mines and Energy was entrusted with the management of the country's water resources. In 1979, the Ministry of the Interior (MINTER) assumed water resources planning and control functions and delivered irrigation permits. In 1986, the federal irrigation functions of MINTER were consolidated under the direction of a special Ministry of Irrigation Affairs. Two programmes were created: the Northeast Irrigation Programme (PROINE) and the National Irrigation Programme (PRONI). Their mandate was essentially the planning, coordination, promotion and monitoring of irrigation activities in collaboration with the newly established state-level Irrigation Coordinating Committees (ECEs). In 1988, PROINE and PRONI were merged into a single irrigation programme (new PRONI).

From 1995 to 1998, the Ministry of Environment, Water Resources and Amazon Affairs (MMA) was responsible for:

- Water resources: Through the Water Resources Secretariat (SRH). In addition, the National Council of Water Resources (CNRH) was created in January 1997.
- Irrigation affairs: Field implementation of federally-funded irrigation infrastructure is carried out by the Company for the Development of San Francisco Valley (CODEVASF) and the National Department for Anti-drought Works (DNOCS). CODEVASF's original mandate was to work in the San Francisco Valley, yet today it also operates outside its geographical boundaries. DNOCS is mandated to operate in the northeastern drought polygon.

In 1999, a new Ministry of Environment (MMA) was created, in charge of the management and control of the country's water resources. The irrigation affairs, though, including DNOCS and CODEVASF, were transferred to a "Special Secretariat for Regional Policies", which falls directly under the Government Council.

At national level, agricultural research is carried out by the Brazilian Agricultural Research Company (EMBRAPA). Several universities also carry out irrigation research. The National System for Technical Assistance and Rural Extension (SIBRATER) and the Brazilian Technical Assistance and Rural Extension Agency (EMBRATER), which was responsible for formulating national agricultural extension policies and for coordinating SIBRATER, were both dismantled in April 1990. Field level extension work continues to be carried out by state (EMATERs) or territorial extension agencies (ATERs).

At present, the institutional framework of the National Water Resources Policy is composed of the following actors (ANA, 2009):

- National Council of Water Resources (CNRH): responsible for the formulation of the National Water Resources Policy;
- Water Resources and Urban Environment Secretariat (SRHU): part of the Ministry of Environment (MMA), acting as executive secretariat of CNRH;
- National Water Agency (ANA): created in 2000, its main responsibility is the implementation of the National Water Resources Policy and coordination of the National Water Resources Management System (SINGREH);
- Water Resources Councils of States and the Federal District (CERHs);
- State Management Bodies: licenses, grants and monitoring of the use of water resources in state-controlled rivers;
- Basin Committee (member of SINGREH): discusses issues related to water resources management;
- Basin Agency: technical office of the Basin Committee.

Water management

Management of water resources in Brazil changed over time as a result of the decentralization of water resources management, the promulgation of the Federal Constitution and the Water Law.

In the pre-constitutional era, there were only a few movements towards a new management water model for the country. The Constitutional reform of 1988 was the first step in the creation of a National Water Law, the responsibility of which was given to the Federal Government. The reformed Constitution also established a distinction between federally controlled water, for rivers across state boundaries, and state-controlled water, for rivers and groundwater that remained completely within state boundaries. Based on this new responsibility, the states began to implement their own water resources management systems. After negotiating for years, the Federal Government approved the 1997 National Water Law aimed at incorporating modern water resources management principles and instruments into Brazil's water resources management system. A National Water Authority was created in 2000 aimed at implementing the National Water Law

The creation of the National Water Resources Management System (SINGREH) gave new force to the decentralized water management. After the Water Law, several states and the Federal District have developed their policies, have created their councils, and have developed basin committees.

During the past ten years, in the South, Southeast and Northeast regions basin committees developed in almost all territories of their states. In the Northeast, Centre-west, and almost all of the North Region, however, there are not many basin committees. There are currently 149 river basin committees in the country, 141 of which are controlled by different states. They are mostly concentrated in the states of Sao Paulo, Rio Grande do Sul, Ceará and Minas Gerais. The eight committees established under the federal government are the San Francisco, Verde-Grande, Doce, Pomba-Muriaé, Paraíba do Sul, Piracicaba, Capivari and Jundiaí (PCJ) and Paranaíba and Piranhas-Acu river basin committees.

In general, water resources management plans in the country have been elaborated with the aim to define an agenda for national, state or particular river basin water resources, seeking to establish a great pact for water use in the country. This management process includes: the constitution of the National Policy on Water Resources as a result of an extensive participatory process; state plans updated of five states of the Federation (Sao Paolo, Bahia, Pernambuco, Paraiba and Ceara); the plans of federal-controlled basins (San Francisco, Paraíba do Sul, Piracicaba, Capivari and Jundiaí (PCJ), Tocantins-Araguaia, Amazon and Doce); and the plans of state-controlled basins of national importance, such as the basins of the Alto Tietê and Guandu. For each of these plans, depending on the particularities of the regions involved, methodological innovations and improvements in the coordination and execution of work have been adopted to ensure, in an articulate and participatory process, the desired results.

In 1998, the main trend of the "Novo Modelo de Irrigaçao" project was to increase private participation and privatization of public schemes. SRH of MMA initiated in 1999 a complete irrigation study, which intends to map the actual sites of the irrigation schemes and select potential areas for irrigation projects without risk of water conflict.

The Probacias-Basin Conservation Programme, implemented by the ANA, was designed to face the problems arising from the imbalance between supply and demand water and access to water in adequate quantity and quality. The programme's main objectives are to enable the implementation of the Integrated Management Water Resources System (SINGREH), creating conditions for the effective implementation of the National Policy on Water Resources, and promote the recovery of basins.

In 2006, the Water Resources National Plan was launched, the main objective of which is to assure water availability in the quality and quantity needed for the sustainable development of Brazil. A first revision of the Plan was finished in 2011.

The National Programme for the Development of Water Resources (Proagua), initially developed only to serve the Brazilian semiarid region (Proagua-semiarid, launched in 1997 by the Water Resources Secretariat (SRH)), was expanded in 2007 to the whole country (Proágua Nacional). The National Proagua aims to improve the quality of life of the population, especially in less developed regions of Brazil, through water resource planning and management and the expansion and optimization of water infrastructure (ANA, 2009).

Finances

The number of licenses issued in Brazil in 2007 is 135 680, of which 33 percent to public water supply and 21 percent to irrigation. The Paraná River basin represents 37 percent of the total awarded in the country, followed by the San Francisco basin with 22 percent. Basins for which the main purpose is public supply, taking into account the flow granted, are East Atlantic, Southeast Atlantic and Parana, while in the South Atlantic, San Francisco, Tocantins-Araguaia and Uruguay basins the main use is irrigation.

Water rates have been established to encourage the rational use of water. For example, between 2006 and 2007, there was a reduction in the use of water consumption of around 20 percent in two basins with water charges: the Paraiba do Sul river basin and the PCJ rivers basin.

Policies and legislation

The Water Act, established in 1934, is the background for Brazilian legislation on water. Considered by legal experts to be advanced, especially considering the period in which it was enacted, it needs updating to be adapted to the Federal Constitution of 1988. In 1979 an Irrigation Law was promulgated that set government policies for irrigation development. The 1988 Constitution defines federally-controlled public waters as bodies of water or rivers which flow through, or border on, several states or a foreign country, and as state-controlled public waters those bodies of water or rivers which rise and end within the territory of a single state.

São Paulo was the first state in 1991 to establish a specific policy for water resources under its control, which established a guide to the State Policy on Water Resources and the Integrated Water Resources Management. The states of Ceará (1992), Santa Catarina (1994), Rio Grande do Africa (1994), Bahia (1995), Rio Grande do Norte (1996) and Paraíba (1996) followed, establishing also policies on water resources (ANA, 2009).

The Federal Water Law of 1997 establishes the National Water Resources Policy, and creates the National Water Resources Management System (SINGREH). It states that: water is a public good and a limited natural resource with an economic value; in situations of scarcity the priority use for water is for human and animal consumption; the river basin is the territorial unit for water management; and management of water resources should be decentralized and participatory. The National Water Resources Council (CNRH) is the highest body with the mandate to promote the coordination of water resources planning. It is the strict competence of the Federal Government to legislate on water.

The National Policy on Irrigation and Drainage (Projeto Novo Modelo de Irrigaçao) was launched in 1998.

ENVIRONMENT AND HEALTH

In 2010, taking into account the Water Quality Index (WQI) of the National Sanitation Foundation of the United States of America, of the 1 988 control river points throughout Brazil 6 percent have excellent water quality, 75 percent good, 12 percent regular, 6 percent bad and 1 percent very bad quality (ANA, 2012). In 2006, out of 1 173 control river points, 9 percent had excellent water quality, 70 percent good, 14 percent regular, 5 percent bad and 2 percent very bad quality. In 2000, out of 859 control river points, 5 percent had excellent water quality, 71 percent good, 14 percent regular, 8 percent bad and 2 percent very bad quality. Most of the control river points with bad or very bad quality are located closed to municipalities with a high population density (ANA, 2012).

Despite the country being rich in water resources, basins located in areas with a combination of low availability and extensive use of water resources are in situations of scarcity and water stress (ANA, 2009).

In 2007, there was a concentration of drought events in the arid northeast, covering the areas of the San Francisco, Parnaíba, Northeast Atlantic (eastern part), East Atlantic and a portion of the Araguaia-Tocantins basins. The Northeast Atlantic (western part), Southeast Atlantic, South Atlantic, Paraná, Paraguay, Uruguay and the Amazon basins, did not show a significant number of drought events. In 2007, of a total of 5 564 Brazilian municipalities, 788 (14 percent) had decreed an emergency due to drought, of which 88 percent are located in the Northeast region.

In 2007, of the 5 564 Brazilian municipalities, 176 (3 percent) had decreed an emergency due to flooding. Compared to droughts, the critical events of floods are fewer and have more specific characteristics, with scattered occurrences in Brazil. Among them small concentrations of these events are located in the San Francisco basin, the East Atlantic basins, specifically in the Jequitinhonha river basin, and the Southeast Atlantic basin, specifically in the basins of the Rio Doce and Paraíba do Sul (ANA, 2009).

The extension of the areas with natural waterlogging, called "*varzeas*", is 13.35 million ha (Table 8). Until 2000, waterlogging problems caused by irrigation practices have only been recorded in the Nupeba project for an area of 170 ha.

Natural saline areas in Brazil are quantified on average at 86 million ha, located especially in the driest areas with average precipitation below 1 000 mm/year. The area salinized by irrigation is estimated at 15 000 ha, mostly in the Northeast.

The National Action Plan against Desertification and Mitigation of Drought Effects (PAN-Brasil) was launched in 2004 by the Secretariat for Water Resources of the Ministry of Environment, the main objective of which is to reduce the areas affected by desertification through a variety of actions of mitigation of drought effects in eleven states of the country. To date, two studies about desertification have been performed in the state of Espirito Santo, with more to come (World Bank, 2009).

In 2001, aiming to encourage new investments in the sanitation sector to expand services of wastewater treatment in the country, ANA has developed the Basin Pollution Control Programme (Programa Despoluição de Bacias Hidrográficas (PRODES)). PRODES consist of a financial incentive to sanitation services that invest in the construction, expansion or operational improvement of sewage treatment plants.

In 2008 a National Plan on Climate Change was launched, which principal focus was to reduce the emissions of greenhouse gases. Availability of water resources and forecasting of extreme hydrological events are also included in the plan (ANA, 2012).

PROSPECTS FOR AGRICULTURAL WATER MANAGEMENT

The states with the highest potential for sustainable irrigation development are Tocantins, Amazonas, Pará, Mato Grosso, Minas Gerais, Rio Grande do Sul, Roraima, São Paulo, Paraná and Goiás. Among these states, the growth of irrigated agriculture should be more significant in the agricultural frontier of Mato Grosso and the states of Minas Gerais, Bahia, Tocantins, Roraima, and the South of Maranhão and Piauí, depending on road improvement and energy storage in these regions. The expansion of sugarcane cultivation in the next years will require substantial amounts of water for irrigation in the states of Goiás, Mato Grosso and Tocantins. It is estimated that in the next 10 years sugarcane will replace rice as the crop with the largest requirement of water resources in the country.

Brazil faces a positive perspective regarding the productive capacity of its agricultural sector. It is essential that the Government ensures a continued economic stabilization of the economy, adopts sound macroeconomic and agricultural policies, and succeeds in its efforts to reduce the domestic interest rates paid by producers and consumers. It is fundamental to maintain a strong political will to take timely the measures required for a sustained growth of agriculture and the economy (Government Office for Science, 2010).

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