Population and Environment: selected issues

Population and Water Resources in Brazil

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Introduction

The water cycle, stimulated by the continuous processes of evaporation and precipitation, leads many people to the erroneous idea that water is an infinite resource. But in fact, the volume of water in the earth's atmosphere has remained virtually unchanged since the beginning of human presence on the planet. In contrast however, very significant changes in natural environments have taken place over the centuries since the industrial revolution, changes that have affected the amount and quality of the water available for human consumption.

It is common knowledge that two-thirds of the Earth's surface is covered by water, but 97.5% of this entire volume is comprised of the salt water contained in the oceans. The remaining 2.5% is fresh water. Even so, approximately 90% of the planets' fresh water (2.24% of the total water on Earth) is frozen in the polar caps or located far underground. Only about 10% of the existing fresh water (0.26% of the planet's total water) is available for human consumption, in the form of lakes, underground water, and surface waterways (OMM/UNESCO, 1997).

According to Romera and Silva (1998), the volume of water on Earth can be classified in the following way: the total volume of water is 1,380,000 km^3, 1,343,000 km^3 of which consists of salt water and 37,000 km^3 of fresh water. Of these 37,000 km^3, 28,564 km^3 are in the form of ice in the polar caps, 8,288 km^3 is underground water, 128 km^3 is found in lakes and swamps, 16 km^3 is in the atmosphere in the form of moisture, and only 4 km^3 are located in the rivers (flowing water).

Another important fact is that the water is not uniformly distributed around the world. There is the case of the Amazon River, whose basin has an area of approximately 5,870,000 km^2 (about 4% of the Earth's surface) and drains almost 16% of the total fresh surface water on the planet. In contrast, the arid and semi-arid zones in the world hold approximately 40% of the world's surface water, but have only 2% of the available flowing water (OMM/UNESCO, 1997).

Rosegrant (1997) shows that the differences in the availability of water in various parts of the world are extremely serious. The availability *per capita* in Africa for example, was 9,400 m^3 per year in 1994. In Asia (not including Oceania) it was 5,100 m^3/year/person, and in Europe (not including the Soviet Union) it was even lower, 4,600 m^3/year/person. In North and Central America on the other hand, availability was 21,300 m^3/year/person while it was 48,800 in South America. The trend indicated by Rosegrant shows a fall in water availability due to increased demand and, for the year 2000, he estimated availability of

5,100 m^3/year/person in Africa, 3,300 in Asia, 4,100 in Europe, 17,500 in North and Central America, and 28,300 in South America.

Besides the irregular spatial distribution and the increasing demand, one must also consider the seasonality and the climactic variations during longer cycles. Together, these factors have led to situations of water shortages in many parts of the world. Historically, such shortages have been faced by the implementation of public works for transporting water over long distances, as did the Romans with their famous aqueducts. However, the complexity of social organization in recent times and the conflicts caused by increased demand has made this solution of transporting water from one region to another more and more difficult.

In today's context, among the factors involving water resources, the most plausible human reaction would seem to be to control the demand. The increased demand occurs mainly due to demographic growth, addressing the populations' direct needs (public supply, for example) and indirect needs (such as the increase in production of consumer goods and foodstuffs).

The pressure exerted by the growing population on the available environmental resources is usually considered the most important aspect in discussions on environmental issues in general, and specifically, regarding the water problem. Therefore, one of the most important questions regarding the relationship between population and water resources is the impact of continuous demographic growth on water resources that remains constant through time. This is basically a neo-Malthusian perspective, according to which it is sufficient to control population growth in order to maintain a situation of equilibrium in the relationship between demand and availability.[1]

However, one must go beyond this perspective, which tends to be simplistic. The relationship between population size and demand must be more clearly analyzed, especially considering that affluence is a further factor to be considered. In other words, populations with more favorable economic conditions are usually those with higher *per capita* consumption, as Seckler (1998) suggests.

From the demographic point of view there are several points to be considered which have a direct effect on the relationship between numbers and resources. Demographic growth has fallen considerably in recent decades, and the significant reduction in fertility rates in Brazil has suggested that the demographic volume in the country may stabilize in the country by mid-century. The projections available estimate a population of about 250 million in 2050.[2] This is a very high figure, but it should be relativized. In comparison with the total population of the U.S.A., for example, the availability of water is much lower there than in Brazil, while affluence in that country is also much higher. It can therefore be imagined that we have good perspectives for obtaining a balance between population and resources, but only if we are able to better manage our resources, as will be discussed below.

It is also important to call attention to the fact that there are many different intervening factors regarding environmental resources in general, and water resources in particular, that can be taken to improve our use of the water that is actually available. A number of measures can be taken toward better management of water resources, aimed at reducing waste and increasing the possibility of satisfying the growing demand. In other words, the type of use that is made of water resources is the main point to be considered.

In this paper, we intend to provide an overview of the implications of certain aspects of demographic dynamics on Brazil's water resources, calling attention to factors such as the spatial distribution of the population and the availability of the water. We will also present an analysis of the main types of water consumption, conflicts among the divergent demands for water, and impacts of the urbanization process on the available water resources.

It is not an easy task to provide a national panorama, due to the size of the country and the specific aspects inherent to the relationship between population and water resources. One of the major difficulties involved resides in the choice of a spatial unit of analysis that will allow researchers to deal with these two groups of phenomena at the same time. This is especially complex because one of the factors involved is in the sphere of social dynamics and the other in the field of the natural sciences. The sources of data on spatial distribution are very diverse, and demographic phenomena are described by administrative limits (states, municipalities and census block). Information regarding water resources on the other hand is based on river basins (although river basins can be grouped into larger basins or subdivided into micro-basins). The fact is that there is no coincidence between administrative units and the boundaries of the river basins, a fact that requires one to make adjustments and approximations in order to work with the two databases.

Another problem is the availability of recent data on the various aspects of water resources. A national information system on water resources is now being developed, but what we have currently for much of Brazil are estimates or isolated calculations on the quality and quantity of the water resources. Only the State of São Paulo has easily accessible data, although also not entirely reliable, with an appreciable historical series, a fact that allows researchers to evaluate the evolution of some of the standards regarding water over time. For this reason, at many points in the text I will refer to examples of São Paulo, although other states, such as Bahia, also have information that is becoming better known.

Spatial distribution of population and water resources

Approximately 23% of all the fresh water on the planet is in South America, and 12% is in Brazil. That is, the availability of water in Brazil is relatively high.

Nevertheless, distribution throughout the country is unequal. There are great expanses of fresh water in the Amazon basin, and significant semi-arid areas, especially in the northeast. Historically, the occupation of Brazil was strongly influenced by its waterways. In fact, the proximity of water resources was a major factor for the construction of cities.

Barth (1999) states that, according to international standards, scenarios of water scarcity occur when water availability is between 1,000 and 2,000 m^3/year/inhabitant, whereas in real scarcity, this level falls to below 1,000 m^3.

Observing the great Brazilian river basins shown in Table 1, it can be seen that the volume of water available per person per day is much higher than the minimum considered adequate in almost all the basins. The exception is Eastern Atlantic Basin 1, with approximately 1,800 m^3/year/inhabitant, placing it in a condition of water scarcity. According to Barth (1999), the worst situation is seen in the states of Pernambuco (1,300 m^3/year/inhabitant) and Paraíba (1,400 m^3/year/inhabitant). Other northeastern states, such as Rio Grande do Norte, Alagoas and Sergipe, with approximately 1,700 m^3/year/inhabitant, are also in an unfavorable situation. The Federal District (Greater Brasilia) also falls within this category of 1,700 m^3/year/inhabitant, since it associates high demographic concentration with its location near the headwaters of river basins.

It is important to consider that the average availability shown conceals broad differences in seasonality. That is, in the drier months of the year the availability of water is often much lower.

Table 1 shows the ample water availability *per capita* existing in Brazil as a whole: its volume of surface water puts Brazil as the second greatest holder of this type of resource in the world, surpassed only by Canada.

However, it is important to note that spatial distribution of both water resources and population are extremely irregular. While the Amazon Basin drains almost half of Brazil, less than 5% of Brazilian population lives in this area. The Paraná River Basin, on the other hand, which covers approximately 10% of the country's territory, serves about 1/3 of its population.

According to Barth (1999), there is reason for concern when one analyzes the scope of the sub-basins, as can be seen in the State of São Paulo. The Upper Tietê River Basin, which is home to the 18 million inhabitants of the São Paulo Metropolitan Region, has 171 m^3/year/inhabitant available, and is therefore probably one of most critical areas in the country. Only with the reversion of water from other basins is the Upper Tietê River able to supply 210 m^3/year/inhabitant, but this reversion makes the Piracicaba River Basin fall from its natural availability of 1,595 m^3 to 566 m^3. In dry periods the potential conflict between these two regions is very high, especially since these are the two most important industrial regions in Brazil.

Water resource uses

Traditionally the uses of the water resources are divided into two categories: consumption uses, where there are losses between what is drawn from the waterways and what is returned; and non-consumption uses, where there are no losses.

Among the consumption uses are irrigation, and urban and industrial uses, and non-consumption uses include hydroelectric generation, river navigation, aquaculture, ecological uses, recreation and leisure.

This categorization has been questioned, since to generate hydroelectric energy for example, a certain flow of water must be maintained in the turbines, restricting availability for other uses, such as navigation.

We will analyze here the three main uses of water in Brazil: urban (residential and commercial), industrial, and agricultural (irrigation). Estimates are that approximately 80% of the water consumed on the planet is used for irrigation

Table 1

Basic information on the Brazilian river basins

	River Basin	Area (1000 km^2)	%	Population 1996	%	Density (inh/km^2)	Flow M^3/s	Water availability (km^3/year)	Per capita availability (m^3/year/inh)	Per capita availability (m^3/day/inh)
1	Amazonas	3,900	45.8	6,687,893	4.3	1.7	133,380	4,206.3	628,938.2	1,723.1
2	Tocantins	757	8.9	3,503,365	2.2	4.6	11,800	372.1	106,219.3	291.0
3A	Northern Atlantic	76	0.9	406,324	0.3	5.3	3,660	115.4	284,063.4	778.3
3B	Northeastern Atlantic	953	11.2	30,864,744	19.6	32.4	5,390	170.0	5,510.4	15.1
4	São Francisco	634	7.4	11,734,966	7.5	18.5	2,850	89.9	7,659.0	21.0
5A	Eastern Atlantic 1	242	2.8	11,681,868	7.4	48.3	680	21.4	1,835.7	5.0
5B	Eastern Atlantic 2	303	3.6	24,198,545	15.4	79.9	3,670	115.7	4,782.8	13.1
6A	Paraguay	368	4.3	1,820,569	1.2	4.9	1,290	40.7	22,345.5	61.2
6B	Paraná	877	10.3	49,924,540	31.8	56.9	11,000	346.9	6,948.4	19.0
7	Uruguay	178	2.1	3,837,972	2.4	21.6	4,150	130.9	34,099.9	93.4
8	Southeastern Atlantic	224	2.6	12,427,377	7.9	55.5	4,300	135.6	10,911.8	29.9
	Brazil	8,512	100.0	157,070,163	100.0	18.5	182,170	5,744.9	36,575.5	100.2

Source: adapted from Freitas (1999).
1. Amazonas: Xingu, Tapajós, Madeira, Purus, Juruá, Javari, Jari, Trombetas, Negro, and Juruá
2.Tocantins: Araguaia, Lower Tocantins (States of Tocantins, Maranhão), Upper Tocantins (Goiás, Distrito Federal)
3 A. North Atlantic: Oiapoque and the coast of Amapá and Pará
3 B. Northeastern Atlantic: Mundaú, Paraíba, Capiberibe, Beberibe, Paraíba do Meio, Piranhas, Jaguaribe, Paranaíba, Itapecuru, Northeastern Coast
4. São Francisco: Upper São Francisco (Minas Gerais), Middle São Francisco (Bahia and Pernambuco)/and Lower São Francisco (Alagoas and Sergipe)
5 A. Eastern Atlantic (1): Vaza Barris, Itapicuru, Paraguacu, das Contas, Pardo, Jequetinhonha, Coast of Bahia, Mucuri
5 B. Eastern Atlantic (2): Doce, Coast of Espírito Santo, Costa of Rio de Janeiro, Paraíba do Sul
6 A. Paraná: Iguaçu, Piqueri, Ivaí, Sucuriu, Paranapanema, Aguapeí, Peixe, Tietê, São José do Dourado, Grande, Paranaíba
6 B. Paraguay: Upper Paraguay (Mato Grosso), Middle Paraguay (Mato Grosso do Sul)
7. Uruguay: Upper Uruguay, Ibicuí
8. Southeastern Atlantic: Coast of Rio Grande do Sul, Guaíba, Itajaí, Coast of Santa Catarina, Ribeira do Iguape, Coast of São Paulo

(Lanna, 1999). In any case, there is no doubt that in overall terms, irrigation is the greatest user of water resources. It is important to recall however, that the urbanization and industrialization processes have increased their share in water use, either by increasing the demand brought about by direct use, or by using bodies of water as recipients of the effluents of these processes, which in itself is a type of water use. Using the waterways as receivers of sewage or other types of waste is one of the characteristics of the urbanization process adopted in Brazil.

Urban use

Brazil went through a process of intense urbanization during the second half of the 20th century. Of the 52 million Brazilians in 1950, approximately 36% were living in urban areas, whereas, in 2000, 81% of the 170 million Brazilians lived in urban regions. The demographic displacement toward the cities was enormous, and had serious consequences. In absolute terms, the urban population rose from 19 million in 1950 to over 137 million in 2000. State investments to improve the infrastructure of the cities were insufficient, a situation that generated considerable poverty and destitution in the cities. The lack of urban infrastructure compromises the quality of the environment and directly affects the water resources, especially with regard to sewer management.

According to the Brazilian Census Office (IBGE),[3] of the 4,425 municipalities in Brazil in 1989, only about 47% had sewage collection systems, and in the 5,507 municipalities in existence in 2000, approximately 52% had some kind of sewer system. But there was a 24% increase in the number of municipalities, while sewer systems increased only 10%.

The National Census of 2000 (Table 2) showed another reason for concern: 8.3% of the private households in the country had no bathroom or any other type of sanitation facilities. This situation is quite unequal from one state to another, but it is important to emphasize that this proportion reaches 43% in Piauí and 40% in Maranhão. On the other hand, it is only 0.4% in São Paulo and 0.9% in Rio de Janeiro.

The number of permanent private households connected to broader sewer systems is still relatively low, serving less than half the entire country. It should be noted that the Federal District (Greater Brasilia) and the State of São Paulo have the highest coverage (over 80%), whereas Tocantins and Rondônia have the lowest.

It should also be mentioned that the lack of sewer systems tends to be more serious where demographic density is higher. In situations where sewage is left in the open-air or deposited in simple cesspools, the higher the density, the greatest the risk of contamination of the water tables.

Sewage collection is important since it is a decisive factor in public health. However, there is another aspect to be considered, namely, the treatment of the collected sewage. The same survey applied by the Brazilian Census Office indicates that the areas in the country with sewage collection are divided into the 1/3 that treat the collected sewage and the 2/3 that provide no type of waste treatment:

the sewage produced is simply poured *in natura* into bodies of water or into the soil. Approximately 85% of the areas that do not treat the collected sewage, simply discharge it into rivers. This type of procedure, which is common in Brazil, compromises the quality of water used for local supplies. One of the most serious effects is that the municipalities upstream compromise the quality of the water of those downstream.

Table 2

Sewer services in permanent private households for Brazil and by State, 2000

State	Total Households	General sewage or rainwater drainage system		Without bathroom or toilet facilities	
		Total	%	Total	%
Brazil	44,795,101	21,160,735	47.2	3,705,308	8.3
Rondônia	347,194	12,815	3.7	37,866	10.9
Acre	129,439	25,247	19.5	26,752	20.7
Amazonas	570,938	114,171	20.0	72,932	12.8
Roraima	74,451	7,973	10.7	8,367	11.2
Pará	1,309,033	96,890	7.4	157,745	12.1
Amapá	98,576	6,062	6.1	6,839	6.9
Tocantins	280,281	7,710	2.8	73,000	26.0
Maranhão	1,235,496	113,766	9.2	491,594	39.8
Piauí	661,366	26,479	4.0	283,985	42.9
Ceará	1,757,888	376,884	21.4	431,247	24.5
Rio Grande do Norte	671,993	111,034	16.5	67,839	10.1
Paraíba	849,378	245,493	28.9	159,082	18.7
Pernambuco	1,968,761	674,278	34.2	303,020	15.4
Alagoas	649,365	99,293	15.3	128,242	19.7
Sergipe	436,735	121,457	27.8	59,012	13.5
Bahia	3,170,403	1,094,223	34.5	762,450	24.0
Minas Gerais	4,765,258	3,249,313	68.2	240,191	5.0
Espírito Santo	841,096	473,109	56.2	21,762	2.6
Rio de Janeiro	4,253,763	2,659,082	62.5	38,331	0.9
São Paulo	10,364,152	8,466,151	81.7	45,076	0.4
Paraná	2,664,276	1,003,340	37.7	56,069	2.1
Santa Catarina	1,498,742	292,268	19.5	23,619	1.6
Rio Grande do Sul	3,042,039	834,294	27.4	74,164	2.4
Mato Grosso do Sul	562,902	66,619	11.8	13,215	2.3
Mato Grosso	645,905	101,149	15.7	53,443	8.3
Goiás	1,398,015	424,472	30.4	65,732	4.7
Federal District	547,656	45,7163	83.5	3,734	0.7

Source: Brazilian Census Office (IBGE) - *Demographic Census of 2000.*

Table 3

Destination of trash and garbage from permanent private households, for Brazil and by state, 2000

State	Total Households	Collected by cleaning services		Thrown into rivers, lakes or the ocean		Thrown into vacant lots or the street	
		Total	%	Total	%	Total	%
Brazil	44,795,101	33,263,039	74.3	193,505	0.4	3,102,584	6.9
Rondônia	347,194	190,578	54.9	1,089	0.3	17,749	5.1
Acre	129,439	64,645	49.9	3,584	2.8	18,372	14.2
Amazonas	570,938	327,565	57.4	17,380	3.0	39,526	6.9
Roraima	74,451	50,366	67.6	408	0.5	6,055	8.1
Pará	1,309,033	630,739	48.2	32,105	2.5	166,130	12.7
Amapá	98,576	65,220	66.2	6,192	6.3	5,481	5.6
Tocantins	280,281	149,778	53.4	312	0.1	33,508	12.0
Maranhão	1,235,496	379,379	30.7	12,639	1.0	333,130	27.0
Piauí	661,366	258,624	39.1	1,931	0.3	129,389	19.6
Ceará	1,757,888	895,144	50.9	9,826	0.6	399,343	22.7
Rio Grande do Norte	671,993	458,221	68.2	2,016	0.3	78,583	11.7
Paraíba	849,378	523,224	61.6	5,487	0.6	102,915	12.1
Pernambuco	1,968,761	1,231,611	62.6	19,308	1.0	356,750	18.1
Alagoas	649,365	399,960	61.6	6,951	1.1	117,805	18.1
Sergipe	436,735	282,495	64.7	2,802	0.6	60,593	13.9
Bahia	3,170,403	1,587,321	50.1	17,474	0.6	624,754	19.7
Minas Gerais	4,765,258	3,564,125	74.8	16,671	0.3	248,788	5.2
Espírito Santo	841,096	605,931	72.0	2,811	0.3	40,040	4.8
Rio de Janeiro	4,253,763	3,591,508	84.4	10,853	0.3	64,024	1.5
São Paulo	10,364,152	9,669,061	93.3	13,642	0.1	58,711	0.6
Paraná	2,664,276	2,162,458	81.2	3,009	0.1	46,219	1.7
Santa Catarina	1,498,742	1,198,949	80.0	1,343	0.1	19,962	1.3
Rio Grande do Sul	3,042,039	2,504,745	82.3	3,180	0.1	49,001	1.6
Mato Grosso do Sul	562,902	448,984	79.8	471	0.1	8,904	1.6
Mato Grosso	645,905	439,479	68.0	873	0.1	26,990	4.2
Goiás	1,398,015	1,087,138	77.8	1,093	0.1	46,134	3.3
Federal District	547,656	495,791	90.5	55	0.0	3,728	0.7

Source: Brazilian Census Office - Demographic Census of 2000.

Besides the question of sewage, there is also the problem of trash and garbage. According to data from the Census of 2000, approximately 75% of permanent private households in the country are provided with trash collection services. However, more than 190,000 households (0.4%) throw trash and garbage directly into some body of water (rivers, lakes, or the ocean). In the State of Amapá this proportion rises to 6.3%, and in Amazonas it is as high as

3%. Even considering that these states lie in areas where the volume of water is very great, the damage to these waterways may be significant with the passing of time.

Also regarding the destination of trash, approximately 7% of the households informed the census that they throw their trash into vacant lots, the proportion being higher in Maranhão (27%) and Ceará (23%). This inadequate disposal of trash may directly influence the situation of the local water resources, eventually flowing into the waterways or contaminating the water tables.

Table 4

Volume of water caught per capita (liters/month), water measurement per capita (liters/month) and water loss rates (%), by river basins in the State of São Paulo, 1992 and 1995

	Water caught per capita (liters/day)		Water measured per capita (liters/day)		Water loss rate (%)	
	1,992	1,995	1,992	1,995	1,992	1,995
State of São Paulo	260.6	288.8	153.5	157.8	41.1	45.4
Mantiqueira	191.0	210.9	155.2	165.8	18.8	21.4
Paraíba do Sul	230.7	272.2	125.8	147.2	45.5	45.9
Northern Coast Norte	357.3	357.8	257.7	210.8	27.9	41.1
Pardo	344.5	384.1	176.1	53.0	48.9	86.2
Piracicaba/Capivari/Jundiaí	294.1	256.4	105.9	74.4	64.0	71.0
Upper Tietê	253.5	310.3	168.9	194.0	33.4	37.5
Santos Costal Area	403.6	435.8	245.9	221.7	39.1	49.1
Sapucaí/Grande	258.2	260.5	156.6	163.2	39.4	37.3
Mogi-Guaçu	271.3	233.0	164.5	118.4	39.4	49.2
Sorocaba/Middle Tietê	289.8	158.4	155.0	76.2	46.5	51.9
Ribeira de Iguape/Southern Coast	138.3	163.2	97.1	100.4	29.8	38.5
Lower Pardo/Grande	302.0	396.4	185.6	260.1	38.5	34.4
Tietê/Jacaré	285.8	322.7	197.0	181.6	31.1	43.7
Alto Paranapanema	123.1	187.1	89.2	99.7	27.5	46.7
Turvo/Grande	210.6	241.1	66.7	132.4	68.3	45.1
Tietê/Batalha	187.7	240.4	81.0	146.2	56.9	39.2
Médio Paranapanema	214.6	179.4	120.2	109.5	44.0	38.9
São José dos Dourados	146.1	208.2	102.0	172.7	30.2	17.1
Lower Tietê	257.2	308.3	137.7	145.2	46.5	52.9
Aguapeí	205.5	213.5	99.5	122.3	51.6	42.7
Peixe	221.0	228.3	129.9	116.0	41.2	49.2
Pontal do Paranapanema	194.2	268.5	119.9	125.0	38.3	53.5

Source: Adapted from: Seade Foundation/*Pesquisa Municipal Unificada - PMU*. The water loss rate is obtained by subtracting the volume measured from the volume caught. This result is divided by the volume caught and multiplied by 100.

Another aspect to be considered in the discussion on urbanization is water drainage. The style of waterproofing that characterizes urban areas, with cities growing along the floors of valleys without respect to the natural marshes of the rivers, means that floods are becoming more and more frequent, and more dangerous. According to the Brazilian Census Office (IBGE), approximately 79% of the municipalities with over 20,000 inhabitants in 2000 provided urban drainage services. However, approximately 73% of these have no instruments in place to regulate their systems.

In general, it can be said that the hydrological cycle of large Brazilian cities is divided into two phases: rationing and floods.

Besides consumption, strictly speaking, there are losses in intake systems that are sometimes significant - as high as 50% in many municipalities. Table 4 shows how this situation of loss occurs in the administrative regions of the State of São Paulo. It is impressive that a region with relative water scarcity, such as the basin of the rivers Piracicaba/Capivari/Jundiaí, presents losses of approximately 70%.

These losses in the intake systems result mainly from the lack of investments in the upkeep of the systems, which are usually old and are unable to address the increasing demand.

In addition, one should also consider that the way in which the Brazilian cities expanded, without governmental planning and usually based on the interests of speculative real-estate capital make both the implementation of new systems and the maintenance of those already in operation more expensive. The process of "urban spoliation," described by Kovarick (1983), has been a constant in the development of Brazilian cities, characterized by the subdivision of areas that are at considerable distances from the regions already occupied, creating therefore, enormous empty spaces and discontinuous urban growth, with the empty areas serving as value reserves for speculative capital. This trend might be described as urban sprawl with specific Brazilian characteristics.

Industrial use

According to Lanna (1999), the amount of water used by industry varies greatly, since use depends on the raw materials, the product, technology, and the amount of recycling. In this regard, one ton of steel can be produced with $5m^3$ or with $190\ m^3$ of water, and one ton of paper can consume between $57m^3$ and $340\ m^3$.

Considering industrial activity in general, the water factor has a very low relative cost in relation to other aspects of production. Some companies have, nevertheless, invested in the reduction of their water use, either by making changes in their industrial processes or by re-using the water.

Use for irrigation

Irrigated agriculture in Brazil occupies an ever-growing area. The demand is increasing especially in the areas of agricultural expansion, such as the Central-

Western region. It has been possible to increase soybean production through the use of advanced technology, by which the fragile soil of dense woods is converted into soil capable of high production rates. Productivity in areas of dense woods has evolved much more than in other areas of soybean production in the world.

The intensive use of the soil, however, represents a serious risk, since it requires high investments in management. Where management is inadequate, the risk of erosion and silting of the waterways rises, as has been noted recently in some places.

The use of irrigation is one of the pillars of support for the technological package that characterizes the agriculture development. The expansion of the use of irrigation brings up a number of questions related to the efficiency of the processes involved and to the impacts that occur when used on a broad scale.

Legislation on water resources

Two aspects stand out in the legislation on water resources: the priority of the use of the water for supplying human populations and multiple uses of the water resources. The low effectiveness of this legislation however, can be seen for example in the generalized disobedience to Article 208 of the Federal Constitution:

> *Article 208 - Urban and industrial effluents and sewage may not be discharged into any body of water without adequate treatment.*

But there are no resources, or even political will, for investing in domestic sewage treatment. Environmental enforcement operates with relative success in regard to industry, but the greatest volume of pollution is generated by the discharge of domestic sewage. In terms of volume, taking the São Paulo Metropolitan Region as an example, more than 2/3 of the effluents discharged into bodies of water derive from domestic sewage.[4] Municipalities with large populations invest little in sewage treatment. Campinas (State of São Paulo), for example, which has approximately one million inhabitants, treats less than 5% of all collected sewage.

In drawing up federal legislation, discussions took place at a different pace. Federal Law No 9.433, which established the National Water Resource Management Policy and created the National Water Resource Management System, was approved on January 8, 1997. The initial discussions and versions had taken place in the mid-1980s.

It is important to call attention to the pre-suppositions provided in Federal Law No 9.433:

> "Chapter I: The bases
>
> I - Water is a resource in the public domain;
>
> II - Water is a limited natural resource with economic value;
>
> III - In situations of scarcity, priority use in the water resources must be given to human consumption and for drinking by animals;

IV - The management of water resources must always provide for multiple uses of water;

V - The river basins are the territorial unit for implementing the National Water Resource Management Policy and the operation of the National Water Resource Management System;

VI - The management of water resources should be decentralized and include the participation of public authorities, users, and the communities."

These basis are very clear in demonstrating the current perspective on water resources. They highlight the importance of water as public property, a factor that is becoming increasingly important in view of the growing demand and the resulting conflicts[5]. According to Canali (2000), regarding general guidelines, legal control must be emphasized as non-separable from the aspects of quantity. Management of water resources and of the environment must have a broader concept.

Another important point seen in these basis is the recognition that water is a finite resource. An important perspective is thus incorporated into the question of environment, namely, the recognition that there are limits to the use of resources that until recently had been considered inexhaustible. The finite nature of water resources brings with it the dimension of sustainability, since unsuitable use may entail the depletion of water in certain regions, making the survival of future generations in these areas impossible.

Resource management rises to a higher level when associated with economic dimension, which will require drawing up a billing system for water use. It is important to recall that under the current system, the consumers pay for water intake and treatment, but the water itself is not charged for. A bill is in progress in the São Paulo State Legislature (2002) to regulate billing for water use. On an experimental basis, the Intermunicipal Consortium of the Piracicaba and Capivari River Basins is now charging R$ 0.01 per cubic meter of water caught. This rate is paid by the companies responsible for supplying each city and has the purpose of setting up an investment fund to improve the sanitation services in the region.

Another important point dealt with in this bill is the use of water resources for the greatest possible number of purposes, provided that there are considered priorities. In this sense, the present legislation is very different from the first national water act, the "Código de Águas", that was approved in 1934. In this act the prevailing point of view was the hydropower sector. Through this legislation the power generation sector managed the water resources until the last decade of XX Century.

The recent Law emphasizes the participation of the civil society, Kelman (2000). Canali (2000) points out that "in providing the possibility for the Government, the users and the community to meet in forums with a well-delimited interest, i. e., in river basin committees, the Law then passes on the responsibility of promoting the discussion of questions concerning water uses, such as conflict solving, planning and selecting priorities, establishing mechanisms and amounts for charging water uses, including exemptions for insignificant uses, and cost-sharing criteria for multiple uses that are of common or collective interest".

Despite all the problems related to this participation (legitimization of representative participation in the river basin committees, disparity in the weight of Government and civil society votes, etc.), the democratization of decisions, the decentralization of the decision process and transparency of activities are the main goals of the Law.

Some authors say that the Brazilian Constitution contains conflicting articles concerning national management of water resources, for example Bettelhut (2000). The different interpretations established in the provisions regarding property rights to water have generated several controversies. What is taking place at the moment is the materialization of these problems in important national river basins, where the overlay between Federal Government and State Government management has generated confusion. The most sensitive question is related to charging water uses, and the management of the resulting resources.

Despite the gap that exists between the formulation of the laws and their regulation and actual implementation, it can be seen that there are great interests involved in the question of water. Within these considerations, the management of water resources is of maximum importance and requires administrative systems to organize and systematize distribution and quality. At the same time, a number of issues arise that have already come up in other situations related to discussions on the environment. One of these issues refers to the setting up of regionalization that will make sense in the scope of both public administration and environmental dynamics. By defining the river basins as planning units, the legislation explicitly encompasses a special scope for any future political measures. A municipality may be cut through the middle when a division based on river basins is established.

One example of the complexity of this issue is the Federal Committee on Water Resources, which was set up for the Paraíba do Sul River. The river basin which forms the Paraíba River cuts through the states of São Paulo, Minas Gerais and Rio de Janeiro, and includes an important industrial region of São Paulo, and one of its tributaries serves as watershed for the second largest metropolitan area in Brazil, the Greater Rio de Janeiro. Billing for the use of water was approved by this committee in March 2002. However, the discussions on billing and managing the collected funds and their political implications have postponed the beginning of the billing.

Conflicts

Conflicts appear in situations of scarcity. The conflict is evident, for instance, in the cases of droughts in the Brazilian Northeast. Kelman (2000) briefly explains the problem of this region, which is directly related to distribution in times of rainfall: in any given year, practically all precipitation falls during one semester and roughly 70% falls during just one quarter (centered in April). Most of the runoff flows to the Atlantic Ocean as flash floods, if they were not stored in reservoirs. In the State of Ceará, for example, there is only one perennial river, the Jaguaribe River; all the others are intermittent. When a sequence of dry years occurs, large portion of the population in the dry hinterland is left without water, even for drinking purposes. In these cases, trucks are used for carrying water to thirsty people; "emergency plans" are launched by Federal and State governments in order to provide jobs for the poor peasants that otherwise starve to death. The conflict in this case involves a lot of stakeholders: the population of rural areas, urban populations, cattle raising farmers and farmers who use the water of perennial rivers for irrigation.

The 2001 drought that occurred in the Brazilian South shows the conflicts among several stakeholders. The most powerful stakeholder, the hydropower sector, had problems in energy generation due to decreasing levels of water in the reservoirs. It become a problem for the country: 94% of Brazilian electricity is hydroelectric. An intensive program was undertaken to decrease consumption and energy waste. The use of water from dams for other activities, such as navigation (specially in the "Hidrovia Tietê-Paraná"), tourism and irrigation, as well as withdraw for urban use was restricted or handicapped[6].

Another latent conflict is related to the process of privatization of the water distribution systems. In discussion are the results of putting this fundamental resource in the hands of groups that are only concerned with profit.

Advances and difficulties in regard to Agenda 21

The main advance regarding the goals of Agenda 21, agreed upon at the Rio '92 Meeting, is in the legal sphere. Today we have a number of laws in place at many different levels to regulate water use. Federal legislation was enacted in 1997 and almost all the States, except those in the north, have specific legislation regarding water resources.

Final considerations

In general lines this text sought to show that Brazil has an immense volume of available fresh water, but the uses to which this essential resource is submitted has caused situations of relative scarcity in some regions of the country. Therefore, unless attitudes are taken in the near future, the situation may worsen.

Examples of efforts that are indispensable for the preservation of the country's water resources include the protection of the watersheds, recovery of the gallery forests, development of sanitation programs (sewage collection and treatment), better allocation of economic activities which require high volumes of water, and the acknowledgement of water as a finite resource.

The Brazilian water potential, used especially as raw material for generating energy, must be considered in its maximum potential, within the provisions of the legislation on multiple use. The economic and strategic potential of water cannot be ignored. It should, in fact, be used as an instrument for the country's development.

We have clearly advanced in relation to the proposals contained in Agenda 21, especially with respect to setting legislation in place that is capable of adequately addressing the specific problems of water.

However, there is still much to be done. In terms of legislation for example, we must put into practice what is already on paper.

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Notes

[1] See Falkenmark (1994).

[2] For projections, see: http://esa.un.org/unpp/

[3] Fundação IBGE. *Pesquisa Nacional de Saneamento Básico, 2000.*

[4] See EMPLASA (1993).

[5] In regions where it is scarce, especially in Northeastern Brazil, water is considered private property that can be used any way its owner may see fit. In this point, see Campos *et al.* (1999).

[6] Carmo and Tagnin (2001).