Water Resource Economy: the Challenge of Efficiently Allocating a(n Increasingly) Sparse Resource

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Introduction

Economics is the social science whose focus falls squarely upon the optimal allocation of sparse resources. Multiple water uses and the dependence of human societies and world ecosystems on this element have rendered it increasingly scarcer. This shortage is made evident either through the lack of the resource properly speaking, or through conflicts over its use.

Shortages make water a key economic interest, and, as such, it is attributed an economic value. Contrary to what many people affirm, it was not the law that attributed this economic value to water, as this is not a legal condition. The economic valuation of water stems from the fact that all sparse resources end up affecting economic relations, and it is by these that its value is gauged. Shortages of water to meet basic human needs penalize those directly affected, as the greater difficulty in obtaining water is reflected in its increasingly higher price. If those who suffer this burdensome situation cannot shoulder the mounting costs, they will have to devote greater amounts of time to searching for water, thus reducing productivity in the activities that secure their livelihoods. Hence the affected properties are devalued. These are examples of the chain of effects that water shortages generate on the economic level. The costs incurred, whether in searching for water farther afield or through loss of productivity and market value of property are alternative ways of estimating the economic value of water.

And so, when the fundamentals of the National Water Resource Law (Law 9433/97) declare that "water is a limited resource, endowed with an economic value" (art.1st, item II), there is a clear redundancy: the economic value of water is derived automatically from this limitedness or scarcity. Moreover, those same fundamentals state that “in situations of shortage, human and animal consumption is to be the priority use of water resources” (item III) and “that water resource management must always ensure the multiple uses of water” (item. IV). In the former, a stipulation is made for situations of scarcity, privileging use for basic human and animal needs; in the latter, the law declares that the multiple uses of water are in the interests of society, obviously when no such shortages exist. Finally, still in its introduction, the law recognizes as a political goal “the rational and integrated use of hydric resources, including for waterway transport, with a view to sustainable development” (art.2nd, item II). “Rational use with a view to sustainable development” is, without doubt, an economic concept.

These issues have served as a preamble to a relevant affirmation: water is a Brazilian environmental asset, of strategic interest, and it provides a competitive edge on the world stage. After all, Brazil is the nation with the largest reserves of water resources, retaining something in the order of 14% of all available world stocks. If this resource is used rationally with a view to sustainable development, that is, with economic efficiency, social equality, and environmental sustainability in the long-term, it could, in the future, offer an ever-greater competitive edge that could see the country take its place among the nations with the highest human development index ratings in the world. Recognizing this, the fundamentals of the law also contain the following constitutional provision: “water is an asset in the public domain”, it belongs to the Union and to the states of the federation, such that issues relating to rational allocation can be defined with greater state control.

All of this begs the question: how is the country preparing itself to use water rationally with a view toward sustainable development? Which sectors of water usage are revealing themselves to be the most dynamic and most worthy of attention from public water resource administrators? In other words: which are the water resource scenarios that should be setting the agenda of decisions on water resource management?

These are questions the present text aims to answer. Initially, we shall present and analyze the prospective water resource scenarios on which the directives, targets and programs of the National Water Resource Plan (NWRP) were based. In the light of the results presented, we will then analyze the future prospects of the four water usage sectors with the strongest dynamics and greatest possibilities of conflict, namely: irrigated agriculture, energy production, navigation and basic sanitation. One underlying question that cannot be ignored is that of climate change and how it may be affecting the availability and uses of water. Some conclusions and recommendations will be drawn from this analysis, the goal of which will be to make forecasts and prepare public, private and third sector agents for the task of fostering the rational use of water with a view toward sustainable development, or, in economics-speak, toward the optimal allocation of a scarce resource.

World, national and regional macro-scenarios

The NWRP adopted global (Box 1) and national (Box 2) scenarios developed by the consultancy Macroplan (Brazil, 2006). These were used to draw up water resource scenarios for 2020 (Box3), with the articulations summarized in Figure 1 by six flow sequences that take into consideration the behavior of five critical uncertainties (the reader can follow these sequences by using the colors and numbers of the arrows that connect the alternatives considered for each critical uncertainty):

1. The economic activities of industry, agriculture and cattle ranching;
2. Implantation of hydroelectric plants;
3. Maintenance and expansion of the treated water and sewage network;
4. Institutional implementation of a water resource management apparatus;
5. Public investment in the protection of the environment and water resources.

Of the six flow sequences, only four (sequences 1, 2, 4 and 6) were considered plausible, given the support they would receive from social agents, while two were found to converge as a single scenario.

Box 1 – World scenarios for 2020

Scenario 1 – Long cycle of prosperity: the unbalanced development of the world's regions allows for the construction of a multi-polarity, with effective mechanisms of economic regulation and integration, permitting the insertion of new emerging nations, including Brazil, but pressing for the adoption of increasingly more stringent rules for environmental conservation and social respect.
Scenario 2 – Exclusive dynamism: global growth of a liberal and strikingly inequitable ilk sees the gulf between rich and poor countries widen, hampering the international insertion of emerging nations. The mechanisms imposed upon the financial markets, configured by socio-environmentally responsible market indexes, seem to have little or no influence over the global economic logic.
Scenario 3 – Instability and fragmentation: strong North-American unipolarity continues to prevail, but facing ever-stiffer competition and more serious threats, especially from China, spurring economic fragmentation, arrhythmic economic growth and an increase in environmental degradation.

Source: Brasil (2006).

Box 2 – National scenarios for 2020

Scenario 1 – Integrated development: high levels of economic development are associated with active social policies, with the bridging of social inequalities and improved social mobility, allowing for a reduction in poverty and social exclusion.

Scenario 2 – Modernization with social exclusion: the hegemony of "liberal" policy prevails in Brazil, with a modern, internal-grade economy, but with a State that is atrophied and/or ineffective in combating exclusion, managing to mitigate poverty slightly, but largely maintaining the current rates of social inequality.

Scenario 3 – Endogenous growth: average rates of economic development, the kind associated with a State that nurtures social inclusion, is geared toward the reduction of poverty and de-concentration of wealth, and to the emergence of a dynamic internal market through the substitution of imports.

Scenario 4 – Stagnation and poverty: a panorama of near-stagnation combined with exacerbated inequality and a loss of ability to react to internal or external factors on the part of the State and sectors of the economy.

Source: Brasil (2006).

Box 3 – National scenarios for water resources in 2020

Water for all: under the influence of a world that is growing in an integrated and continuous manner, Brazil gradually adopts a development model that leads toward the reduction of poverty and social inequalities thanks to strong rates of economic growth and consistent and integrated social policies.

Economic activities expand throughout the country, including irrigated agriculture, as well as the installation of hydroelectric stations, navigable waterways and urban infrastructure, with brusque, but declining impacts on water resources. This is all partly due to the country's insertion in the "Knowledge Economy", resolutely pillared upon aggregating value for its products and on the sustained use of its natural resources, especially its mega-biodiversity.

This all stems from the adoption of an operative management model, from considerable investments made in protecting water resources and from the adoption of new technologies, as well as the insertion of the national business class in a market that puts more and more store on socio-environmental responsibility indexes, not to mention the adoption of more efficient forms of water-use management and the harmonization of multiple water uses brought about by the strengthening of the National Water Resource Management System. In this context, there is a clear reduction in damage to water quality and in conflicts concerning water quantity. Average annual growth in GDP is expected to be in the region of 4.5%.

Water for some: both Brazil and the world in general are ruled by a heavily exclusive dynamism, with fierce growth in economic activity nationwide, but devastating impact on water resources and yawning rates of inequality. The growing demand for energy leads to the installation of various hydroelectric dams at such a rate as precludes the necessary environmental compensations and precautions, not to mention appropriate planning for multiple water uses. Despite the demand, basic sanitation services grow at mediocre levels due to paltry and selective investments. The degradation of water resources is notorious and the direct result of these activities and of an economy-centered administration that implements unworkable plans for formal social participation and little or no regulation or monitoring of water usage.

Conflicts and problems surrounding water resources grow and degradation compromises water quality. Multiple water uses are slightly better resolved thanks to economic pressures, especially from the export sector. Average annual growth is expected to reach 3.5% of GDP.

Water for few: Brazil fails to seize the few opportunities posed by an unstable and fragmented world and there is little growth in economic activities and in urban and logistical infrastructure. One result of this slow economic growth is that there is a commensurate fall in the demand for energy from new hydroelectric power plants. Investment in the protection of water resources is negligible, selective, corrective and under far from efficient state management.

Hence the conflicts and problems surrounding the supply and quality of water resources mount, especially in already deficient hydrographic regions and problem hotspots. The deterioration of groundwater in some systems and aquifers worsens, as does the state of surface water, especially due to only incipient investment in basic sanitation.

The informal economy proliferates, increasing non-compliance with environmental and water resource management practices. In this context, there is mounting pressure from uncontrolled occupation of Amazonian territory, which, in the absence of adequate development policy, has been left at the mercy of unfettered predatory agropastoral activities and the illegal exploitation of timber with no forest management planning whatsoever, as the instruments of command-control still dominant in environmental management remain incipient in the face of a profit-driven social dynamic.

In similar fashion, the incidence of endemic water-borne diseases increases and aggravates regional discrepancies, heaping further pressure on the already densely populated watersheds of the South-Southeast region. Average annual growth on GDP is expected to be 1.5%.

Source: Brasil (2006).

In the prospective visions, four water uses arise that have strong dynamics and potential to cause conflict, whether through their profligate use of water or through their interference in the hydrological and hydraulic regime:

1. Irrigated agriculture, the biggest water user in every region of the country;
2. The generation of electrical energy, which is predominantly water-based in Brazil, and which, despite being a non-consumptive use, works profound alterations in the hydrological and hydraulic regimes of the nation's water bodies;

3. Navigation, another non-consumptive use of water, but one which demands hydrological and hydraulic regimes that can curtail more basic uses;
4. Environmental sanitation, or, more specifically, the assimilation of sewage discharge by water bodies and whose nullification depends on the quality of the water and its ability to meet demands, especially those related to human and animal food security.

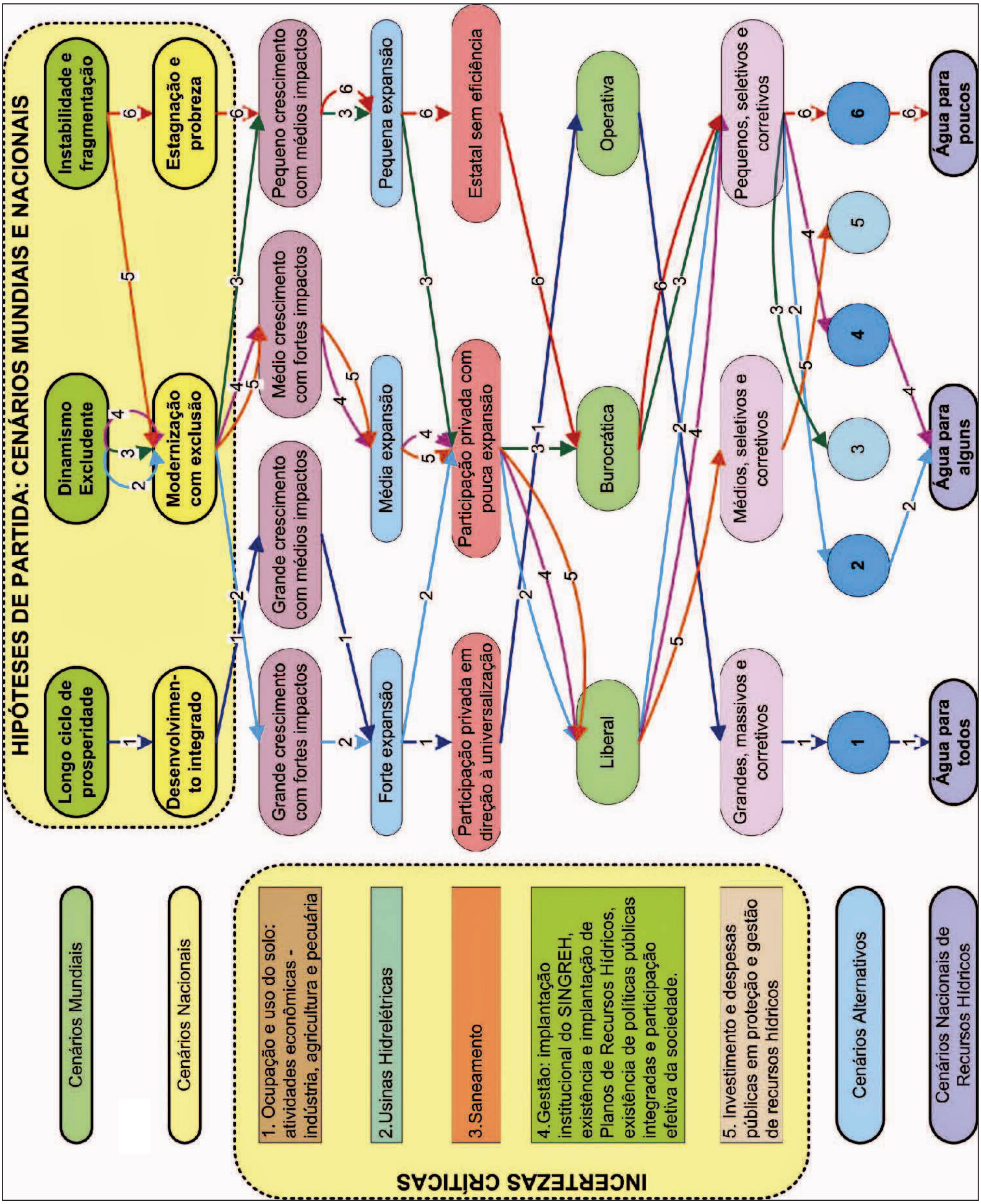
These water uses will be analyzed prospectively with regard to their projections based on the evaluation of the current conjuncture and the elements that shape the possible futures for hydric resources.

Irrigated agriculture

This use exerts the strongest quantitative pressure on water availability throughout all the regions of Brazil. The projections made here (2007) for each scenario on the National Water Resource Plan are shown in Box 4. It is important to underscore that of the roughly 3.5 million hectares currently under irrigation in Brazil, 1.2 million is used for flooded rice paddies in the south, in the South Atlantic and Uruguay watersheds. In the watersheds located in the semi-arid regions of Brazil, Parnaíba, the West Atlantic Coast and São Francisco, some 0.8 million hectares of land is irrigated using infiltration furrows, aspersion and other local methods. The remaining two million hectares are distributed throughout the Paraná, Southeast Atlantic, East Atlantic and Tocantins-Araguaia watersheds and largely employ center-pivot systems and conventional aspersion (Wagner, 2007). This categorization is important in order to provide a snapshot of the situation: heavy water use in the South, with some potential for increased efficiency without altering the technology; heavy water use in the semi-arid, with potential for heightened efficiency with technological change; and a heterogeneous situation in the rest of the country, with varying degrees of potential for increased efficiency.

Another relevant point to note is that the majority of irrigated land is privately owned. Public tracts account for a mere 160 thousand hectares, mostly located in the semi-arid. This is clear indication that an outlook for irrigation should be sought among the highly disperse private sector, although the public sector may induce the expansion of irrigated lands, thus assuming a more relevant role, as has historically been the case.

As for direct public participation, largely restricted to the semi-arid, Box 5 shows that roughly a million hectares are divested landholdings and nearly 0.3 million has infrastructure implanted for public projects, of which only 160 thousand hectares are occupied and a mere hundred thousand in operation (Wagner, 2007). This characterizes a situation in which we have a lot of idle land that could rapidly add to the region's irrigated area through public/private partnerships, the more consolidated the regulatory framework for the region becomes. According to the most optimistic 2020 scenario for the São Francisco


HIPÓTESES DE PARTIDA: CENÁRIOS MUNDIAIS E NACIONAIS
Longo ciclo de prosperidade
Dinamismo Excludente
Instabilidade e fragmentação
Desenvolvimento integrado
Modernização com exclusão
Estagnação e probreza
Grande crescimento com fortes impactos
Grande crescimento com médios impactos
Médio crescimento com fortes impactos
Pequeno crescimento com médios impactos
Forte expansão
Média expansão
Pequena expansão
Participação privada em direção à universalização
Participação privada com pouca expansão
Estatal sem eficiência
Liberal
Burocrática
Operativa
Grandes, massivos e corretivos
Médios, seletivos e corretivos
Pequenos, seletivos e corretivos
Água para todos
Água para alguns
Água para poucos
Cenários Mundiais
Cenários Nacionais
INCERTEZAS CRÍTICAS
1. Ocupação e uso do solo: atividades econômicas - indústria, agricultura e pecuária
2.Usinas Hidrelétricas
3.Saneamento
4.Gestão: implantação institucional do SINGREH, existência e implantação de Planos de Recursos Hídricos, existência de políticas públicas integradas e participação efetiva da sociedade.
5. Investimento e despesas públicas em proteção e gestão de recursos hídricos
Cenários Alternativos
Cenários Nacionais de Recursos Hídricos

Box 4
Irrigated area forecasts for each watershed region in Brazil
under each scenario drafted by the NWRP (thous. hectares)

Watershed	Irrigated area 2000=2005	Average annual increment	Irrigable potential	Average annual increment forecasted per scenario			Irrigated area in 2020 per scenario		
				Water for all	Water for some	Water for few	Water for all	Water for some	Water for few
Amazonia	92	5	9,174	14	14	7	300	300	200
Tocantins-Araguaia	134	6	6,480	24	18	11	500	400	100
Occidental Northeast	41	3	155	4	4	4	100	100	100
Parnaíba	9	1	518	3	2	1	50	40	30
Oriental Northeast	443	8	403	10	4	(3)	600	500	400
São Francisco	371	7	1,159	22	15	9	700	600	500
East Atlantic	124	3	579	20	20	13	300	300	200
SE Atlantic	295	13	1,063	33	27	20	500	400	300
South Atlantic	682	17	2,350	8	1	1	800	700	700
Uruguay	566	33	783	9	2	2	700	600	600
Paraná	874	38	5,270	22	15	2	1,200	1,100	900
Paraguay	32	2	1,630	1	1	(0)	50	40	30
TOTAL	3,663	136	29,564	170	123	68	5,800	5,080	4,260

Source: Brazil (2007)

do Parnaíba and Oriental Northeast regions, irrigated hectarage may well jump from 1.35 million to somewhere in the region of 1.7 million, thus heaping further pressure on the region and exacerbating already intense conflicts of water usage.

One critical uncertainty concerns the introduction of irrigation to sugar cane growing for ethanol production. The producer Valley (2007) informs that there are three modalities of irrigation, each with its own characteristics and costs, as presented in Box 6.

There has been considerable growth in sugar cane plantations. Netafim (2007), a company that specializes in irrigation projects and equipment, maintains that drip irrigation presents significant results in these terms. Average productivity would reach somewhere between 120 and 150 t/ha, with eight to ten cuts and renovation at 15-year intervals. Under a conventional crop regime, productivity would be between 50 and 85 t/ha, with five or six cuts and 5-yearly renovations.

Box 5 – Areas with public irrigation projects (thou. hectares)

Entity	Divested areas	Areas w/ infrastructure	Occupied Area	Areas in production
Min. of National Integration	454,369	95,342	---	75,848
Codevasf	334,239		131,983	17,091
Dnocs	127,603	44,325	40,370	17,091
Chesf	119,789	14,600	10,200	8,061
TOTAL	1,036,000	286,250	164,400	118,091

Source: Wagner (2007)

Box 6 – Types of irrigation for sugar-cane plantations

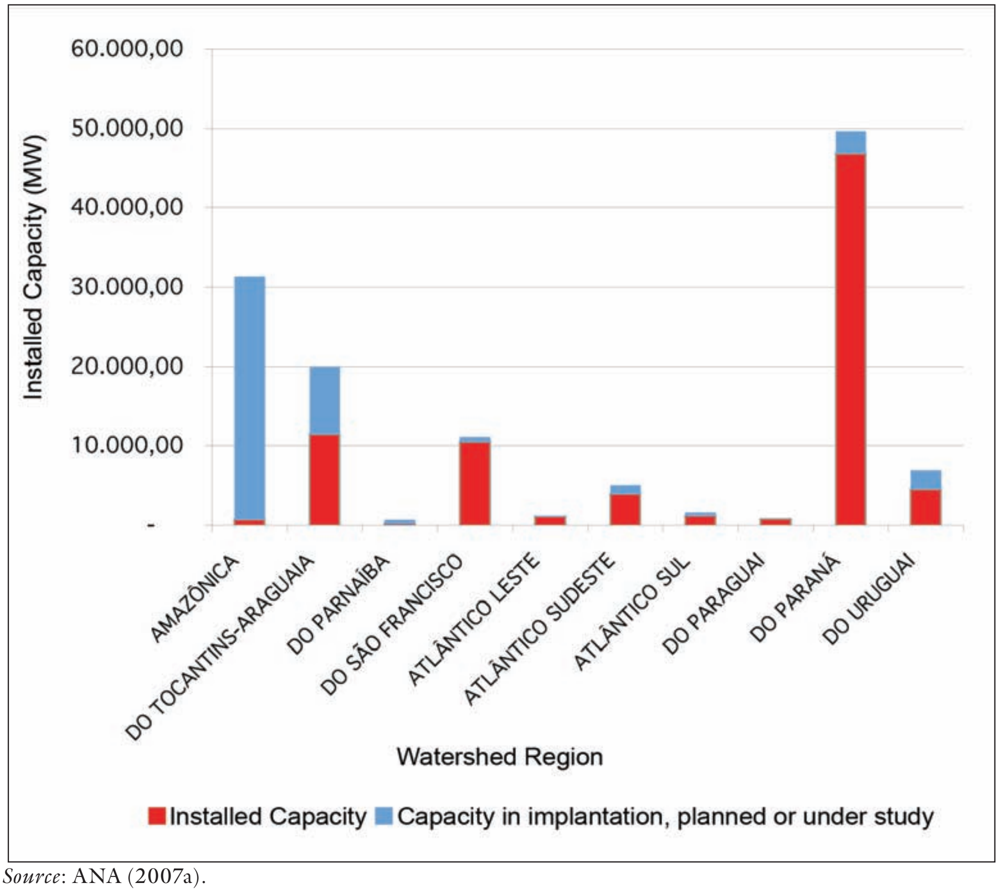
Type of irrigation	Characteristics	Consumption per Harvest	Implementation Costs	Running Costs
Salvation	Irrigation applied once per harvest, after the reaping or sowing	40 to 80mm or 400 to 800m³	US$353 to US$706/ha	Low-pressure water administration system: US$0.35 to US$0.70/mm or US$3,50 to R$7.00/m³
Supplementary	irrigation applied during harsher droughts	250 to 300 mm per harvest or 2,500 to 3,000m³	US$882 to US$1,647/ha	

Source: Valley (2007)

Irrigating can, therefore, be an interesting agricultural option for the farmer, especially in regions where there is pressure for food-producing land, as a way of increasing production in the area. Given the relatively higher technological demand of irrigated agriculture, it is possible that the introduction may intensify in regions closer to the large centers of consumption, in other words, the urban triangle formed by the cities of São Paulo, Rio de Janeiro and Belo Horizonte. This could see the 2020 projections for irrigated lands in the Paraná and SE Atlantic watersheds surpass the 1.7 million hectares estimated by the NWRP's most dynamic scenario.

Generation of electrical energy

The sector responsible for this use is the most organized in the country. Hence it was possible to obtain figures from the 2007-2016 Ten-yearly Electrical Energy Expansion Plan (PDEEE), which enables us to assess previously presented data in our projections for installed hydroelectrical energy capacity under the different scenarios, as shown in Box 7.



Source: ANA (2007a).

Figure 2
Expansion of installed generative capacity at the hydroelectrical plants in each watershed region.

Box 7

Expansion of hydroelectrical energy production by region and scenario (MW)

Watershed	Capacity installed at hydroelectric stations according to the 2007-2016 PDEEE			Installed capacity according to the NWRP estimates for 2020, per scenario		
	Current installed capacity	Capacity in implantation, planned or under study	Total capacity in 2016	Water for all	Water for some	Water for few
Amazonia	684.28	30,647.80	31,332.08	19,907	19,907	10,576
Tocantins-Araguaia	11,449.50	8,465.80	19,915.30	20,048	20,048	18,850
Occidental Northeast	-	-	-	-	-	-
Parnaíba	237.30	493.00	730.30	836	836	836
Oriental Northeast	-	-	-	8	8	8
São Francisco	10,472.50	642.00	11,114.50	11,210	11,210	11,139
East Atlantic	1,060.00	120.00	1,180.00	1,204	1,204	1,204
SE Atlantic	3,892.720	1,136.80	5,029.52	4,725	4,725	4,725
South Atlantic	1,186.20	412.00	1,598.20	1,622	1,622	1,622
Uruguay	4,500.00	2,430.60	6,930.60	6,860	6,860	6,860
Paraná	46,805.88	2,825.80	49,631.68	42,895	42,895	42,895
Paraguay	747.60	-	747.60	770	770	770
TOTAL	81,035.98	47,173.80	128,209.78	110,085	110,085	99,150

Source: Brazil (2007) & ANA (2007a)

Though the electricity sector tends to operate at a higher average growth rate to those adopted in the NWRP scenarios, and so higher values were to be expected, it is nevertheless worth noting the discrepancies between the NWRP and the PDEEE for 2007-2016, particularly in relation to the Amazon, but also to Paraná. Amazonia in particular presents an installed capacity for 2016 that is 10,000 MW higher than that forecasted under the "Water for All" scenario. Figure 2 illustrates the increase there will be for each watershed region according to the 2007-2016 PDEEE, underlining even more boldly the impact on the Amazonian Region.

In relation to this particular watershed area, environmental issues are important. Interlocutors with the Electricity Sector hold a clear position on environmental restrictions to hydroelectric plants. Firstly, they contend that hydroelectric energy is much cleaner environmentally speaking than the other sources on offer when it comes to producing large energy blocks. Among other factors, this is so because the forecasted hydroelectric stations have small reservoirs when not actually riverside. Society will face the decision as to whether expansion in energy generation should focus on this source, as it has done traditionally, or if some other, perhaps less clean sources should assume a more robust role in the energy grid. The expectation is that, in the face of rising energy prices, the public will continue to opt for hydroelectric plants and all restrictions on reservoirs may be attenuated to allow for greater generation capacity. This is a controversy now looming on the horizon and which will demand negotiation skills from all agents involved in order to redress the shortfall in the best possible way.

Navigation

The National Logistics and Transport Plan for this water use, which belongs to the transport sector, is currently in development and will determine the waterways expected to form part of the transport network. However, the interests of the transport sector, as announced by its representatives, go far beyond those set down in the National Plan. Their point of departure is that a navigable river should always retain this characteristic irrespective of whether or not a dam is built on it. Even if navigation does not currently occur, it may well be of social interest in the future, which is why plans should be made for the construction of locks on dammed stretches, even if they are not implemented over the short-term. This runs counter to the position of the Electricity Sector, which alleges that having to make provisions for a lock increases the cost of hydroelectric stations and may even render some unviable, thus forcing society to pay more for the energy it consumes.

There is therefore an important decision to be made, and one that goes beyond the sectorial ambit to become a theme worthy of consideration at the higher echelons of the National Water Resource System: in which situations is it justifiable to forgo provisions for a lock on dammed waterways, thereby interrupting the navigability of a certain stretch of river, solely to make the construction of hydroelectric stations and the energy they generate cheaper? Or, to take the reverse approach: what reduction in energy costs would justify interrupting the present or future navigability of a river?

The problem flashpoints between hydroelectric generation and navigation are in the Tocantins-Araguaia, Parnaíba do São Francisco (in virtue of the existing stations), SE Atlantic (on the Paraíba do Sul River), and Paraná (in virtue of the existing stations) watersheds.

This point of conflict between two water using sectors (incidentally, both non-consumptive users) warrants the attention of administrators and certainly calls for articulation between them. It should be noted that restrictions imposed upon hydroelectric energy, whether in virtue of navigation or for environmental reasons, will very likely lead to the intensified use of less clean sources of energy, such as coal-based thermoelectricity, or sources widely rejected by various stakeholders, such as thermoelectricity based on nuclear combustion. One way or another, there will be a rise in energy costs, and this will force the abovementioned sectors into discussions. Forecasting these environmental and economic costs is no easy task, but it is certainly of relevant interest to the inter-sectorial negotiations that will surely take place.

Sanitation: sewage treatment

In November 2007, the NGO Trata Brasil (2007) released a study commissioned from the Getúlio Vargas Foundation Center of Social Politics, entitled "Treating Brazil: Sanitation and Health". This was the first phase of a study on the social impacts of investment in basic sanitation, and the outlook was bleak. According to this document, if the expansion in sanitation services were to continue the trend set over the last fourteen years, universal access to sewage treatment, as set forth in the Modernization Program for the Sanitation Sector, would only be possible in 56 years time.

Effectively, the nation is lagging drastically behind when it comes to sewage discharge into the water system. The high sums required for Brazil to reach the target of universal access to sewage treatment raise grave doubts as to the Sanitation Sector's ability to shoulder the required investment, which is estimated, in global terms, at 120, 150 and 180 billion dollars per year in 2010, 2015 and 2020, respectively (Brazil, 2003). In addition, one can also expect some shortfall on total coverage, as there will most probably be cases in which a choice has to be made as to whether to invest in water supply or sewage treatment. In such a case there can be no doubt that the former option would be politically and socially more viable. Even with arguments to the effect that proper sanitation is a correlate of public health, a point in its favor, the latter option simply does not stand up under analysis. An Ipea study (Mendonça & Seroa da Mota, 2005) used various techniques to estimate the cost of reducing infant mortality (ages 0 to 4) rates by one death, and an increased supply of clean water and coverage by the sewage treatment network were among the variables considered. These alternatives, however, were shown to cost much more than other solutions, such as bringing down illiteracy rates among women over the age of fifteen or increasing the number of hospital beds. Furthermore, it costs 40% less to save the life of a child within the age group considered by increasing clean water supply than by expanding the sewage network. As such, tying the need for basic sanitation in with health may not be such a successful strategy.

It is also worth mentioning that the social, economic and environmental costs of watercourse pollution are considerable and extend beyond matters of public health. The main cause of this pollution is the lack or insufficiency of sewage collection and treatment systems.

Hence the nation should look for alternatives to promote sewage treatment as a means of recuperating and controlling water pollution, as funding will always go to other options when the matter at-hand is infant mortality. It is very likely that economic instruments will have to be adopted to subsidize, at least partially, the implementation of these systems, following the example of the National Water Agency's Program for the Purification of Hydric Basins (Prodes-ANA).

Climate change

Climate changes are already viewed as a major atmospheric dynamic resulting in increasingly more frequent anomalies in the hydrological regime. The Intergovernmental Panel on Climate Changes (IPCC, 2001) summed up its conclusions in a report to policymakers. Below are some of its findings:

1. The planet's climate system has changed significantly on both a national and global scale since the pre-industrial era, and some of these changes can be attributed to human activities. These activities increase the atmospheric concentrations of greenhouse gases and aerosols. In the decade commencing in 1991, the former, of anthropogenic origin, reached the highest-ever recorded levels, especially due to the use of fossil fuels, agriculture and alterations in soil use. New and more convincing proof attributes the global warming experienced over the last fifty years to human activities.
2. Regional climate change affects many biological and physical systems and there is preliminary evidence that social and economic systems are also affected. Hydrological systems, just like terrestrial and marine ecosystems, have been compromised worldwide. The higher costs associated with damage caused by meteorological phenomena and regional climate swings indicate heightened vulnerability to climate change. Preliminary evidence suggests that some social and economic systems have been aversely affected by changes in socio-economic factors, such as migrations and alterations in soil use, though it is difficult to quantify the impacts related exclusively to climate change, whether of anthropogenic or natural causes.
3. In all emissions scenarios run by the IPCC, the forecast is for an

increase in average CO_2 concentrations – from 368 ppm in 2000 to 540 to 970 ppm -, in average land surface temperature – a rise of somewhere between 1.4 and 5.8 °C -, and in average sea-levels – expected to rise by between 0.09 and 0.88m. Average annual rainfall is expected to rise, though there may be an increase or decrease in the order of 5 to 10% on a regional scale over the course of the century. It is highly probable there will be an increase in annual variability in average rainfall (that is, in its statistical ranges) in most regions. Average annual surface drainage will follow this trend.

In Brazil, depending on the region and the model used to simulate atmospheric/oceanic circulation, and supposing a 1% average annual rise in CO_2 concentrations, hydrological simulations can indicate reductions of up to 250mm/year or increases of up to 150mm/year in average annual surface drainage. Both main models point toward a reduction in the Amazon.

In 2004, the Brazilian government presented a more detailed analysis of the impact of climate changes on the nation. In general terms, and corroborating the findings of the IPCC report, the government paper revealed an increase in evidence of climate change impact on Brazilian hydrological systems; impacts that demand adaptations in water resource management, including:

- Reinforced hydro-climatologic monitoring in order to detect the onset of critical conditions;
- The exercise of caution in analyzing anthropic interventions in the hydrological cycle;
- The implementation of flexible and adaptive water resource management systems that meet the demands of an environment undergoing slow but long-term change;
- The incorporation of the angle of hydrological risk alongside those of a economic, financial, environmental, social and political nature in the analysis of possible interventions.

Conclusions

The following conclusions can be drawn from the findings obtained:

- There are present and future water-use conflicts between the different sectors mentioned above – energy generation, navigation, irrigation and sanitation – and these involve aspects of water quality and quantity.
- The Brazilian economy is accelerating and problems are therefore arising more quickly than expected.
- Large shifting trends, such as that represented by biofuels, may have a decisive effect on the water balance in some Brazilian watershed regions.
- Changing perceptions and values in the wake of rising energy costs, such as the new approach to the environmental impact of hydroelectric stations, may well prove fundamental in promoting important changes

in the hydrological regime of the country's rivers.

- An understanding of the impact of climate change has yet to be incorporated more explicitly in sector planning. It is therefore necessary that the nation take this aspect into consideration when formulating water resource policy.

Recommendations

Considering the points above, the following recommendations can be made:

- The creation of a Water Observatory to monitor and forecast the evolution of water use in Brazil should be a major priority for the nation, as it would enable us to anticipate the significant changes indicated in the nation's water use and which could have tremendous impact on the hydrological regime.
- Special attention must be paid to the ethanol production chain and the hypothesis of sugar cane irrigation.
- The environmental issues versus hydroelectric plants debate is another flashpoint that needs to be followed closely in virtue of the huge controversy it generates. This is an issue that needs suitably equipped institutions in order to further the social negotiation the debate requires.
- Another point of contention is the divergence between the transport sector and the electrical energy sector concerning watercourse navigability, and this too demands institutional strengthening and forums for negotiation between the stakeholders.
- Lastly, the country needs to instill the issue of climate change more incisively in hearts and minds of social agents involved in the water issue, so that precautionary measures can be taken in time.

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Abstract - This paper presents and analyzes water resource prospective scenarios from which the National Water Resources Plan has established its strategies, goals and programs. Based on these data the future tendencies for 4 water user sectors with greatest dynamic and conflict potential are analyzed: irrigated agriculture, energy generation, navigation and basic sanitation. Issues which cannot be ignored are the climate changes and how they can affect water supply and demands. From these analyses some conclusions and recommendations are proposed, aiming the anticipation of the future and to prepare public, private and third sector actors to promote rational use of water, focusing on the sustained development. Or, as economists used to say: the optimal allocation of a scarce resource.

Keywords: Water resources, Economy, Scenarios, Sectorial uses, Brazil, National Water Resources Plan.

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