DEVELOPMENT OF WATER RESOURCES IN BRAZIL

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1. INTRODUCTION

The twentieth century has seen various transitions marking the development of water resources and the environment both in Brazil and internationally Table 1). This process characterizes the relation between economic and population growth, and the search for sustainable development.

Soon after the Second World War, there was a need for great investment in infra-structure, especially in those countries which had suffered in the conflict, followed by a phase of economic and population growth in many developed countries. In this period there was great industrialization and increase in major centres of population which resulted in environmental crisis from degradation of living conditions and of natural systems.

At the beginning of the 70s pressure began to reduce these environmental impacts, with emphasis on the control of effluents from industries and cities. Brazil invested heavily in hydroelectric plants, years in which the large dams of Paraná were constructed. The environmental movement in Brazil was in conflict over the operation of a cellulose plant on the Guaiba River in Rio Grande do Sul. In the 80s, the world began to consider issues related to global climate, with particular emphasis on the accident at Chernobyl, the impacts of deforestation and the large dams. In Brazil an environmental law was passed in 1981; there was great concern about international investment in hydropower, because of its possible effects, both local and perhaps global, in regions such as Amazônia. International loans for dam construction were abolished, with great impacts on the expansion of this system in Brazil. Most firms of consultants working in hydroelectric projects reduced staff by about 90%. At the end of the 80s (in 1987) discussion began about water resources law in which groups from three sectors were in strong dispute: energy, environment and agriculture.

The 90s were marked by the following: growth of the concept of sustainable development which seeks a balance between investment for national growth and environmental conservation; development of water resources in an integrated manner, with multiple uses; the beginning of control of diffuse pollution in developed countries. International investments in Brazil, principally in the energy sector, were changed to investments in environmental recovery, with treatment of domestic and industrial effluents from cities (a stage observed in developed countries during the 70s), beginning with the great Brazilian conurbations and the great Brazilian biomes. In the institutional context, the Secretariat for Water Resources was set up half way through the decade, which supported the discussions and final approval of the law on water resources in January 1997. Some state legislation had already been passed and others were brought about by federal legislation. Thus, the first stage of institutional development in the country was completed. Also in this period, between the end of the 80s and the 90s there were reforms in the Brazilian state which allowed legislation to be passed and the formation of the water resources sector within the government. Previously, this sector had been under the control of the ministry for energy, environmental agencies and, during the period of its existence, the ministry for irrigation.

The beginning of the new century (and millenium) is marked internationally by the movement which seeks greater efficiency in the use of water resources within basic principles of Dublin and consolidated in Rio 92. The United Nations defined objectives for the millenium as the reduction of poverty, with its principal focus on water and sanitation. These objectives were consolidated in Johannesburg and discussed further in following forums, such as the 3ºWorld Water Conference held at Kyoto in 2003. In summary, these objectives seek to reduce by half the number of people without sanitation and safe drinking water, by 2015. The report commissioned by the Global Water Partnership, GWP and World Water Council (WWC) headed by Camdessus (co-ordinated by the former president of the IMF), introduced proposals on the financial and economic elements to ensure the viability of the proposed objectives. Brazil has a good range of services for water supply, when compared with most developing countries, but needs heavy investments if the sanitation objective is to be achieved.
<table>
<thead>
<tr>
<th>Period</th>
<th>Developed countries</th>
<th>Brazil</th>
</tr>
</thead>
</table>
| **1945-60**  
*Industrial and population growth* | Use of water resources: supply, navigation, energy, etc  
• Quality of river water  
• Works for flood control | Inventory of water resources;  
Initiation of hydroelectric undertakings and plans for large systems. |
| **1960-70**  
*Beginning of environmental pressure* | Effluent control;  
• Structural measures against flooding  
• Legislation on river water quality | Construction begins of large hydroelectric undertakings;  
Deterioration of water quality in rivers and lakes near to urban centres. |
| **1970-1980**  
*Beginning of environmental control* | Environmental legislation;  
• Aquifer contamination;  
• Environmental deterioration in large metropolitan areas;  
• Control at point of origin of urban runoff, domestic and industrial pollution; | Emphasis on hydroelectric plant and water supply;  
Beginning of environmental pressure lobby;  
Deterioration in river water quality from increased industrial production and urban growth. |
| **1980-90**  
*Interactions with global environment* | Impacts on global climate;  
• Concerns about forest conservation;  
• Disaster prevention;  
• Point- and non-point sources;  
• Rural pollution;  
• Control of impacts of urbanization on the environment;  
• Aquifer contamination. | Reduced investment in hydroelectric generation;  
Worsening urban conditions: floods, water quality;  
Strong impacts of drought in the North-East;  
Increased investment in irrigation;  
Environmental legislation. |
| **1990-2000**  
*Sustainable development* | Sustainable development;  
• Increased knowledge of how human activity affects environmental behaviour;  
• Environmental control in large urban centres;  
• Pressure for control of emission of gases, preservation of the ozone layer;  
• Control of aquifer contamination by non-point pollution sources. | Legislation on water resources  
• Investment in control of sanitation in large cities;  
• Increased impact of urban floods;  
• Programmes for conservation of national biomes: Amazônia, Pantanal, Cerrado and Coastal region;  
• Beginning of privatization of energy and sanitation services. |
| **2000-**  
*Emphasis on water: objectives set by the united Nations for the millenium* | Development of a world view of water;  
• Integrated use of water resources;  
• Improved quality in water affected by diffuse pollution, both rural and urban;  
• Search for solution to cross-frontier conflicts;  
• Development of water resource management within a sustainable framework. | Advances in developing institutional aspects of water;  
Privatization of energy and sanitation sectors;  
Diversification of the energy grid;  
Increased availability of water in the North-East;  
Urban drainage plans for cities. |

On the other hand, to achieve this and other objectives there is a movement led by the GWP, WWC, International Water Resource Association (IWRA) and other international NGOs, towards integrated water resource management as a means to ensure sustainable development. Brazilian legislation includes the basic principles of integrated management, so that the first stage of the process has been achieved. Institutional development after 1997 (since the water resource law was passed) has addressed the regulation and implementation of water resources legislation. This process of institutionalization was marked in Brazil by the creation of the Secretariat for Water Resources (as noted above) and subsequently by the creation of the National Agency for Water (ANA) in 2000, and
putting into practice the legislation which requires that water be charged for, and polluters be penalized through the committee and agencies within each hydrographic basin. This scenario shows promise, as there are rules and procedures which provide for the participation of all who are concerned with how water resources should be used, and how they should be preserved within a policy for economic and social development.

This paper elaborates on this recent phase of institutional development for Brazil’s water resources as an example from which the international community may profit from its advantages and avoid its problems. The following section gives a diagnosis of water resources in Brazil, from a global viewpoint. Trends and evolution of water resources in Brazil are then presented, and chapter 4 gives an evaluation of the balance between successes and difficulties.

2. OVERVIEW OF WATER RESOURCES

To appreciate the different aspects and challenges of water resource development in Brazil, this chapter gives an overview of the institutional composition needed to develop the resources sustainably for each principal sector of society.

An important source of information on support for sustainable development are the documents issued under Agenda 21 Brasileira, created with the objective of drawing up a national strategy for sustainable development, by means of dialogue between government and society. This process is being developed by the Commission for Sustainable Development Policy and Agenda 21 (CPDS). Selected themes that reflect the Brazilian reality are as follows: Sustainable agriculture; Sustainable cities; Infra-structure and Regional Integration; Management of Natural Resources; Science and Technology for Sustainable Development; Reduction of Social Inequalities. Documents on these themes can be found on the site www.agenda21.org.br. In addition to these thematic papers, regional syntheses of related events also exist. Novaes (2000) has evaluated the regional and thematic papers, and has summarized their principal aspects. The following section gives the main points from these papers that refer to water resources, giving an overview of what has occurred in most recent years.

2.1 Institutional

2.1.1 Legislation

The basic legal text forming the basis of the National Policy for Water Resources is the Law no. 9433 of 8 Janeiro 1997. This policy is based on the Dublin principles: (a) water is a public good; (b) water is a limited resource, having economic value; (c) human consumption is a priority; (d) recognition of multiple use of water resources; (e) the unit for planning purposes is the hydrographic basin; (f) management should be decentralized.

The main instruments of the Policy are Plans which aggregate rivers in classes, concede rights for use of water resources, define information networks, and charges for water use. These Plans must combine plans drawn up by States with water resource plans for individual basins. The Plans must take a long-term view, giving attention to both water quantity and quality. The framework deals with compatibility between water quality and its uses, and seeks to minimize adverse effects on quality. The procedure for granting concessions defines safeguards for water quantity and quality. Charges for water use aim to encourage the rational use of water and recognition that water is a natural resource with economic value.

The law also states that the mechanism for decentralized management shall be basin committees with executive agency support. Although decentralization is emphasized, the legislation is self-contradictory in establishing that the National Council for Water Resources shall have up to 51% of its representatives from federal agencies, a limit enforced by government. The Brazilian States, 26 in number, have only five regional representatives.
The federal law No. 9984 of 17 July 2000 concerns the creation of the National Agency for Water (ANA: Agência Nacional de Águas), the entity for implementing the National Policy for Water Resources. The main responsibilities of ANA include: granting concessions for water use in rivers under Union control; flood and drought prevention; accounting for water use in rivers under Union control; stimulating creation of committees for drainage basin management. As regards hydropower, the National Agency for Electrical Energy (Agência Nacional de Energia Elétrica –ANEEL) must work together with ANA to ensure that reserves defined for energy production are maintained.

ANA, like IBAMA, is linked to the Ministry for the Natural Environment. Through the Secretariat for Water Resources (Secretaria de Recursos Hídricos, SRH) this ministry establishes water resource policy and actions such as the National Plan for Water Resources. The National Water Resources Council is the organ for decision at Federal level. This Council is made up of Federal members (in the majority), State representatives, NGOs, water users from sectors of the community, and research agencies.

The Federal Constitution of 1988 defines a river in the Union domain as any river which flows through more than one State or which possesses an international reach. On the other hand, the law 9.433 defines a drainage basin as the appropriate planning unit. This combination of legislations has generated different interpretations in the case of basins in which the river’s headwaters are within a State, but reaches downstream lie within Federal responsibility.

The scenarios are: (a) a river whose entire course lies within the same State (up to the section of interest) and has a hydrographic basin lying in more than one State; (b) a river which flows through one State, with its hydrographic basin lying wholly inside it, whilst being a tributary of a Federal river. This lack of clarity in the law can give rise to judicial contests.

Taking the constitution and water law together, only those rivers which rise in one State and flow through it to the sea are under State control, whilst all others are under Union control. In practice, ANA has drawn up agreements with the States to set up a basin committee and State management for each sub-basin of a Federal river that lies wholly within one State. However, conflicts exist over the extent of environmental responsibility within this context, principally in the case (a) above. Environmental responsibility is related to the area influenced by the undertaking, which can often be interpreted in different ways. If the area of influence extends over more than one State, the environment affected by a licence becomes a matter of Federal concern.

2.1.2 Regulation

The concession rights for the use of water resources was defined by law No. 9.433, art 14, which states that these should be granted by act of the competent authority with executive Federal, State or Federal District power. In art. 12, this law defines how the term concession is to be interpreted: (I) derivation or capture of surface or underground water for final consumption, or for an input to some productive process; (II) release of liquid or gaseous residues, whether treated or not, for purposes of dilution, transport or final disposal; (III) use of water for hydropower generation or any other use which alters the quantity or quality regimes of water in a river.

In the case of hydropower generation, this will be subordinated to the National Plan for Water Resources, conforming to legislation in the specific sector. The concession will be suspended, partially or totally, either terminally or for some specified duration, when the terms of the concession are not obeyed. These conditions are: absence of use for three consecutive years; situations of unusual water need to cope with adverse conditions; the need to maintain river navigability. The concession cannot be granted for a period exceeding 35 years, but renewal is possible. The concession does not imply alienation of water, but the right to use it.

The charge for approved water uses was foreseen in the Law Lei 9.433, art 20. Resources resulting from the charges must be applied as a priority in the basins in which they were generated. In 2003 the charging process began for waters in the River Paraíba do Sul, by means of a call to all users of the basin to register. A wide campaign stimulated public awareness by means of radio, television and newspapers. Table 2.1 gives the result of the declaration according to type of user and State within the Paraíba do Sul river basin. The concession was given for three years, assuming the value.
declared by the user to be correct. According to ANA, a verification of users’ declarations is being developed.

Table 2.1 Summary of declarations received, classified by type of use and location of points of capture and/or release. (ANA,2003a).

<table>
<thead>
<tr>
<th>Use</th>
<th>State</th>
<th>Federal</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M.Gerais</td>
<td>S. Paulo</td>
<td>R.Janeiro</td>
</tr>
<tr>
<td>Water supply and waste-water disposal</td>
<td>63</td>
<td>56</td>
<td>46</td>
</tr>
<tr>
<td>Animal consumption</td>
<td>52</td>
<td>512</td>
<td>17</td>
</tr>
<tr>
<td>Industry/Mining</td>
<td>34</td>
<td>116</td>
<td>118</td>
</tr>
<tr>
<td>Irrigation</td>
<td>10</td>
<td>52</td>
<td>4</td>
</tr>
<tr>
<td>Other uses</td>
<td>178</td>
<td>804</td>
<td>196</td>
</tr>
</tbody>
</table>

Note: The sum of the values corresponding to the different locations need not agree with the total number of declarations shown in the final column, since not all declarations can be uniquely classified under one single category of use.

2.1.3 Natural environment.

In terms of the natural environment, the environmental licence has been defined by the State when the area of influence lies totally within it; but when an impact affects more than one State, the licence is given by IBAMA.

The great difficulty at present is that the process of implementing uses of water passes through various Federal bodies with different responsibilities, and this makes the process particularly complex in the case of hydropower installations. ANEEL issues grants without environmental licence, so that when the undertaker is given the licence there is no guarantee that water can be used since environmental aspects have not been considered. This process is totally contrary to the idea of sustainable development, since projects do not incorporate any environmental component in studies of alternatives. New procedures have been discussed within the ambit of Federal entities, and could be implemented in future, to give a single ticket of entry for projects. This process is now being discussed within government and a ruling on the subject should be produced soon.

In the concession process, the evaluation of users and the quantity of water conceded takes account of whether the remaining flow (instream or environmental flow) is sufficient for environmental conservation. No unique, well-defined criteria exist for the subject. Table 2.2 below gives criteria adopted by some Brazilian States.

In the case of a stretch of river where the main impact is from the discharge of domestic and industrial wastewater, the evaluation of its sanitary state, together with the consequent river flow, must determine a minimum acceptable discharge. Table 2.2 shows that the criterion for defining a remaining flow is related to a maximum value granted. This shows, for example, that when \( Q_{90} \) is defined as the reference flow, 20% of this value is required to guarantee enough flow in the river to maintain aquatic life and to maintain water quality. However, this methodology does not guarantee that the river will support its biota if, for example, all flow in excess of this minimum is diverted for any extended period.

In the case of a river where the main impact is for hydropower generation, attention is needed to ensure that the consequent flows will reproduce the natural variability in flow, and do not cause long-term damage to the biota of the aquatic system. Where the river is subject to various uses with their consequent impacts, ways must be found to guarantee different environmental scenarios, and of ensuring that there is enough water available to maintain remaining flow in the river.

The criteria for classifying rivers has been drawn up by the National Council for the Natural Environment (Conselho Nacional de Meio Ambiente: CONAMA) in the form of Resolution CONAMA 20, which is at present under revision. Classification of water-bodies into classes, according to their principal uses, aims to ensure that the quality of these waters is compatible with the most demanding uses for which they will be required.
Table 2.2 Legislation adopted by Brazilian States (Pereira, 2000).

<table>
<thead>
<tr>
<th>State</th>
<th>Decree</th>
<th>Criterion for reference flow</th>
<th>Minimum guaranteed flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bahia</td>
<td>6.296/1997</td>
<td>The reference value will be the annual regularized flow having 90% guarantee. The sum of the volumes to be conceded corresponds to 80% of the reference flow in the source; 95% in the case of urban water supply.</td>
<td>20% of the reference flow.</td>
</tr>
<tr>
<td>Ceará</td>
<td>23.067/1994</td>
<td>The reference value will be the regularized annual flow having 90% guarantee. The sum of the volumes to be conceded shall not exceed 90% of the reference flow.</td>
<td>10% of the reference flow.</td>
</tr>
<tr>
<td>Federal District.</td>
<td>22.359/2001</td>
<td>The reference flow for concession purposes can be ( Q_{7,10} ) or ( Q_{90} ). The sum of the flows to be conceded shall not exceed 80% of the reference flow, and 80% of regularized flows. In the case of water supply for human consumption, the maximum limit can be 90% of ( Q_{7,10} ).</td>
<td>20% of the reference flow.</td>
</tr>
<tr>
<td>Rio Grande do Norte</td>
<td>13.283/1997</td>
<td>The reference value will be the regularized annual discharge having 90% guarantee. The sum of the volumes to be conceded shall not exceed 90% of the reference flow.</td>
<td>10% of the reference flow.</td>
</tr>
<tr>
<td>Rio Grande do Sul</td>
<td>37.033/1996</td>
<td>The reference value will be the regularized annual flow with 90% guarantee. The sum of the volumes to be conceded corresponds to 80% of the source’s reference flow.</td>
<td>20% of the reference flow.</td>
</tr>
<tr>
<td>Minas Gerais</td>
<td>Portaria nº 010 de 1996</td>
<td>The sum of the volumes to be conceded corresponds to a fixed percentage 30% of ( Q_{7,10} )</td>
<td>70% of the reference flow.</td>
</tr>
</tbody>
</table>

2.1.4 Sector funding.

The water resources sector is being funded at present through legislation on financial compensation for areas flooded by hydropower reservoirs. The Law nº 9.984, of 17 July 2000 states that 6.75% of the energy produced by a hydropower must be used in this compensation, of which 0.75% is to fund activity related to implementing National Policy for Water Resources by ANA according to Federal law (ANA also has other funding sources). Of the remaining 6%, 45% is for the States, and 45% for the townships, that are affected. Of the remainder, 3% goes to the Ministry for the Environment, 3% to the Ministry for Mines and Energy, and 4% for Science and Technology. Estimates of the mean values over the last 3 years of the funds concerned are given in Table 2.3. These are the values budgeted, but unfortunately in Brazil the value of the budget is not available for execution. The Federal Treasury (Ministério da Fazenda) takes its portion, and only a part is available for execution, and this varies from year to year. Although resources may remain in an account for future use, access to them is not allowed because of the need to control the country’s public deficit. The portion effectively available for execution can be about 50% of the value available.

To summarize, the good news is that the water resources sector has a permanent source of funding, and the bad news is that even though funds are specified by law, they are not available for use because of government devices for the control of public expenditure that cover all funding.

There is legislation for charging for water use to fund decentralized activities related to water resource management within river basins. This process as beginning in the basin of the River Paraíba do Sul between São Paulo and Rio de Janeiro, because of its importance for economic strategy.
Table 2.3 Approximate mean values over the last three years, based on data from ANA and ANEEL.

<table>
<thead>
<tr>
<th>Entity</th>
<th>Portion of the total allocated %</th>
<th>Value R$ millions</th>
<th>Value in US $(*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANA</td>
<td>11.10</td>
<td>88.8</td>
<td>30.6</td>
</tr>
<tr>
<td>States</td>
<td>40.00</td>
<td>320.0</td>
<td>110.4</td>
</tr>
<tr>
<td>Townships</td>
<td>40.00</td>
<td>320.0</td>
<td>110.4</td>
</tr>
<tr>
<td>MMA</td>
<td>2.67</td>
<td>21.36</td>
<td>7.37</td>
</tr>
<tr>
<td>MME</td>
<td>2.67</td>
<td>21.36</td>
<td>7.37</td>
</tr>
<tr>
<td>Science/Technology</td>
<td>3.56</td>
<td>28.48</td>
<td>9.8</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>800</td>
<td>275.9</td>
</tr>
</tbody>
</table>

(*) estimated using US $ 1 = R$ 2.9

2.2 Urban development.

2.2.1 Impacts.

The urban population of Brazil is about 83% of the total, and is concentrated in the large conurbations of Brazilian State capital cities. These metropolitan regions (MRs) have a main nucleus and a number of surrounding cities. Rates of growth in the MR nuclei are small, while rates of growth in the surrounding cities are very high. This high growth-rate is also found in cities which are regional poles of development. Cities of more than 1 million people grow at a mean rate of 0.9% annually, while regional centres with between 100 and 500 thousand grow at annual rates of 4.8% (IBGE, 1998). Therefore, all the inadequacies from rapid urban development and environmental impacts that are observed in MRs are also found in these medium-sized cities.

Urban growth has been characterized by irregular peripheral expansion with little observance of urban regulations relating to the Plan for Growth and specifications of lot-size, as well as by the irregular occupation of public land by low-income population. This causes difficulty for any introduction of non-structural action for controlling the urban environment.

The main problems related to the occupation of space can be summarized as follows:

* Irregular expansion, mentioned above, occurs in areas where water is collected for human consumption (a result of inadequate legislation), threatening the quality water supplies to cities;

* As population increases and becomes concentrated in urban areas, the limits to available water are reached. Moreover, effluents are untreated and discharged into rivers, so that their waters cannot be used. Even in regions with plenty of water such as the city of São Paulo, there is permanent water rationing, because after use the water returned to rivers completely contaminated, putting nearby sources beyond use;

* In addition to these undesirable consequences, urban areas are impermeable and flows in small streams are canalized. The result is increased frequency of flooding causing extensive damage (Figure 2,1).

These problems result from the lack of any integrated management for urban land occupation and for urban water. The shortcomings in management is seen in the following: (a) contamination of water by irregular occupation and lack of wastewater treatment. This is brought about by unclear legislation and by a lack of management by the townships; (b) the water services in Brazilian cities have chronic problems, with losses of water during distribution and lack of rational water use at both domestic and industrial levels. When there is water shortage, the tendency is to look for new sources of water, without reducing losses and without developing new practice for rational water use; (c) there are high loads of untreated domestic and industrial effluent and of polluted stormwater discharged
into rivers, together with solid rubbish and eroded material, exacerbated by increased urban flooding as shown in data from Belo Horizonte (Fig. 2.1). All this results from deficient management of sanitation undertakings and lack of capacity in townships for managing land occupation and its impacts.

Figura 2.1 Urban growth and occurrence of floods in Belo Horizonte (adapted from Ramos, 1998)

The direct impacts of this lack of management are: (a) deterioration in people’s health: 65% of patients entering Brazilian hospitals suffer from water-borne diseases. The impact is greatest in the low-income population sector, which has less access to water infrastructure and sanitation; (b) urban floods which frequently lead to loss of life, disruption of traffic and damage to material. In January 2004, more than 80 people died in Brazil, drowned in floods or buried under landslides from hillslopes; (c) contamination of urban rivers and aquifers; (d) reduction of water safe for distribution to the population, and water rationing.

2.2.2 Institutional

An institutional overview of of the urban environment must highlight the following aspects: (a) land use and settlement control; (b) water supply and sanitation; (c) urban drainage; (d) solid waste; (e) the environment. Regarding land use, each Brazilian city was obliged to prepare an Urban Management Plan (Plano Diretor Urbano) under the Brazilian constitution of 1988. These Plans were limited to issues concerning roads, shade from buildings and a few environmental aspects, with everything else ignored. The Plans usually aim at an understanding of where the city will grow, when they should be controlling and directing growth.

Prior to this period, States were concerned in the 70s about the contamination of basins where water was collected, and generally passed some sort of legislation on collecting basins. This law, which sought to preserve basins from population settlement so as to safeguard water sources, failed to take economic pressures into consideration. The law does not allow water-collecting basins (defined for each city) to be settled and the owner of the land was obliged to pay tax on it. What then happened was total civil disobedience, since an owner would simply abandon his land, which would be invaded by low-income families; sometimes an owner would himself organize the invasion, so that he could negotiate with the township council. The result was the worst possible, since clandestine settlements would occupy water catchment areas without any structure, causing contamination of the water. There was no law enforcement by the administration since this process is very quick as started. The main lesson to be learned is that legal confiscation of private property without recompense leads to civil disobedience. An alternative market has to be created for these areas or to set up a system of compensation. In metropolitan areas there are some townships which cover a water catchment area. Generally townships that are in upstream areas of a river system or catchment area have no interest in exerting any rigid control because the impact occurs downstream of the city and beyond its jurisdiction. This scenario involves State or Federal intervention.
In the 70s, sanitation companies (which are public) were created to deal with water supply and sanitation. These companies operate and can raise funds State-wide, which townships cannot. The 1988 constitution gave townships the powers to grant concessions for water services and sanitation. Few Brazilian cities were functioning with municipal water services and the infrastructure was constructed by State enterprises. At the end of the 90s privatization of water and sanitation services was planned, as in other sectors of public administration. An impasse came about because State companies did not have service concessions in cities, which were operating without the legal basis for concession, whilst in other cities the concessions were about to lapse. Thus, the companies had no economic value to justify privatization. The government put before Congress a plan for a law to establish procedures to regularize elements of the Constitution. In this process, it was established that the State company could manage townships in metropolitan regions where there existed installations that served more than one township. It also sought to establish funding for the agency overseeing the services. However, this plan became involved in political discussions on the privatization of State companies and was not approved by Congress.

The Federal government has, under discussion, a document concerning rules for the sanitation sector, but this has not been made public at present. It should be released to the public sometime in the first half of 2004.

At present, there are a great number of cities with privatized services, some of which function at township level but with the great majority on a State-wide basis. State companies serve about 82% of the population in terms of water supply and 77% in terms of wastewater drainage (IPEA, 2002). These services are not regulated for their prices and quality of service provided. All evaluation is undertaken by the companies themselves. The Ministry of Health established standards of quality for river water and created the national agency for sanitary monitoring (Agência Nacional de Vigilância Sanitária: ANVISA), but its capacity for regulation is still limited.

Services provided by sanitation companies at present are as follows (IPEA, 2002): (a) about 92.4% of the country is covered for water supply; (b) losses of water in the distribution network are 39% on average. There are no funds available to reduce these losses, although there are funds to look for new sources of water and for construction, but since there is no fiscal control of services costs are added to the price of water; (c) on average about 50.4% of the population has sanitary drainage, and 25.6% have waste-water treatment. The efficiency of treatment over time is very low, and there is no regulatory control of results of treatment. There are many pipe networks which do not collect any wastewater, and many treatment stations are idle because townships have no legislation requiring proprietors to link their residences to the sanitary drainage system, so that they avoid extra charges for drainage. ANA (Agência Nacional de Águas) launched a programme in 2001, called PRODES, which gets to the point of the problem. This programme funds 50% of wastewater treatment works but only pays according to the efficiency of the system, for which it monitors the quantity of water treated and the level of treatment. For constructing the works, townships issue public bonds. To take part in the programme, a township must first obtain approval of the drainage basin committee. Up to 2002, 170 undertakings had been approved with a total value of R$ 1.15 billion (~ US $ 400 million) serving about 25.6 million people. However, with limited resources in 2002 the Agency only invested R $ 17 million of a total value for the undertakings of R$ 66 million (~ US $ 22 million), which is about 6% of the demand (ANA, 2003b). In 2003 the programme suffered still further from the lack of budgetary resources and it is now under evaluation by the government.

2.3 Agriculture

Both throughout the world and in Brazil, agriculture is the great consumer of water (about 70%). One hectare of flood-irrigated rice can consume the equivalent of 800 people. Modern techniques of irrigation can reduce consumption to about 50% of that for traditional cultivation. In the USA results show that water consumption can be reduced by new technologies to about 30 to 70%, at the same time increasing yield by between 20 to 90% over traditional flood-irrigation methods (Unesco, 1999). The semi-arid region of Brazil, making up about 10% of Brazilian territory, faces the great challenge of sustaining its human population under such difficult conditions, where
evapotranspiration can reach 3500 mm with rainfall about 250 to 600 mm. States such as Ceará have 60% of their land derived from crystalline formations where aquifers are practically non-existent. In many regions, such as the “sertão” in the State of Pernambuco, water in the sub-soil is saline and cannot be used without desalinization. The semi-arid region needs a volume of water sufficient to ensure availability of water in critical years, but when the residence-time of water in reservoirs is high (volume very large relative to size of inflow), the turnover in volume is small and salination occurs.

Water is the essential factor in rural development of the North-East, and the viability of economic development depends on its availability. There is an expansion of undertakings producing fruit under irrigation, which gives adequate economic return. Production is most developed in the basin of the River São Francisco, where water is more plentiful but in areas far from permanent water-courses subsistence agriculture is practised and losses are frequent. In these areas various techniques have been tried, such as sub-surface and earth dams, with relative success, but it is necessary to build up better technical knowledge of how to handle such localized methods. Various programmes for cistern construction have been developed in the North-East, with NGOs heavily involved. One of the problems is that of relief policy, such as where Lorries bring water to users; the Lorries create a linkage between local politics and the availability of water. In some regions it is found that cisterns do not collect rainwater draining from roofs because water is brought by lorry, preserving a kind of feudal dependency.

In the South and South-East, the use of irrigation still depends on reducing the costs of irrigation projects for the majority of crops, with the exception of flood-irrigated rice in the South. A large part of the agricultural sector prefers to take the risk of water shortages, which occur only in some years, instead of investing in irrigation. However, with irrigated rice there are conflicts over the use of water in the River Uruguay basin, and conflict with the needs of the environment in the Lake Mirim region. There is a natural conflict between the use of water for agriculture and for human consumption in some regions of Brazil, principally when agricultural demand is very large, as for flood-irrigated rice. The solution to the conflict lies in increasing the efficiency of irrigation systems and in adequate management of effluents polluted by agriculture.

Besides water demand of agriculture, the need for soil conservation must be emphasized, since poor soil conservation results in diffuse pollution. In a large part of southern Brazil, it has been found that a change of practice to direct seeding has important benefits, such as: reduced erosion, increased recharge to groundwater, and stabilization of recession flow in rivers. However, various regions exist in Brazil where erosion and soil degradation are serious, such as in the River Paraguay basin, where cattle and soya production have produced important alterations in the production of sediment discharged into the Pantanal, principally in the area of the River Taquari. The effects of climatic variability are also very important for the agriculture-based society of this region (Tucci, 2002).

2.4 Energy.

In the energy sector, the national framework for energy production has its basis in hydropower generation. In world terms, Brazil is one of the great producers of hydropower, with 10% of world production. Silveira and Guerra (2001) analysed the current energy crisis in the electricity sector and showed that investments in the sector between 1985 and 1995 were less than demand, which resulted in reservoir drawdown equivalent to Centre-West/South-East system, transforming a system of inter-annual regulation into a system of intra-annual regulation. Regarding the risk of failure it must be considered that since 1970 the Centre-West, South and South-East regions (where the greater part of capacity is installed) mean flows are about 30% greater than in the preceding period, showing that for the same installed capacity it is possible to generate more energy with lower risk of failure. Even with the high flows of this period, as at the limit of what can be produced. Remembering that lengthy period above and below long-term conditions can occur; the present system depends strongly on the continuation of favourable climate conditions. If climate conditions become less favourable, and increasing demand is maintained while supply is restricted, development of Brazil’s economy could be threatened by energy shortages.
Increasing the capacity depends on two main factors: (a) capacity for investment by the state and attractiveness to the private sector, which depends on adequate regulation. At the end of 2003 the government issued new regulations for the electricity sector (these were approved in January 2004 by the Chamber of Deputies and will now go before the Senate. The probability of approval is very high). The media have shown that few people understood the regulation, and there is much criticism and say that the attraction for the private sector is limited. Many companies quoted in the press have said that they will not invest. The government does not have the financial capacity to invest about US$ 3 billion annually needed to extend the supply of energy, for a modest economic growth of 2 to 3%; (b) on the other hand, in the lay-out of hydroelectric plants a number of installations exist with small volume but considerable drop for the water released, and only one or two with regularization (large volume). In recent years, large reservoirs are not being constructed because of the social problems arising from population transfer, and environmental problems, which increases still further the risk to the system as a whole from climatic fluctuations. In this scenario the trend is towards lower growth in firm energy in relation to installed capacity. The equivalent reservoir allowing regularization of water between years its diminishing in relation to installed capacity.

2.5 Navigation.

At present navigation in the interior is limited, being concentrated in the River Tietê, in the Taquari-Jaíuri and Lagoa dos Patos in the South, and in the River Amazon. The greatest difficulties are realted to the investment needed to maintain routes, and the logistics of transport systems. The growth in Brazilian agricultural production, which has passed 100 million de tons of grain (the forecast is 132 million tons of grain in 2004, or 8% of world production) requires more efficient means of transport, being concentrated at present in road transport of known low economic efficiency relative to rail and water transport. A greater transport of grain by river is found in Amazonas (River Madeira) where the grain produced in Mato Grosso (one of the highest producers of grain in the country, with even higher growth in 2003) emerges into the North Atlantic.

2.6 Critical Events.

Urban floods are one of the great calamities to which Brazil’s population is subject, and they result from: (a) inappropriate settlements springing up in the flood plains of rivers; or (b) growth of impermeable areas in cities. Rendering soil impermeable, and canalizing rivers, increases the magnitude and frequency of floods, where there is no municipal control. Mean flood flow increases by a factor of 6 or 7 relative to natural conditions (Tucci, 2001).

No adequate control policy exists, and such policy as does exist is totally inadequate, which has increased the damage in cities. Commonly, a combination of lack of knowledge and lack of interest in solving these problems is found, so that when an event occurs, a state of public calamity is declared. When this happens, the township receives funding to cover damage without the need for open competition (see comments in item 2.1). In such conditions, it is difficult to implement efficient preventive measures, which mostly involve not major works, but proper regulation of land occupancy, which generally is not attractive to politicians since it attracts few votes.

Another calamity that can occur is flooding due to dam failure. At present, no regulations exist concerning preventive programmes to ensure dam safety. This situation is worrying because one event of this kind in a cascade system of dams could result in a disastrous scenario if no preventive programmes exist to minimize its impacts. In the US and France, legislation was only introduced after major disasters. If such an event occurred in Brazil, even with some degree of anticipation, it would not be known who to withdraw from areas at risk, since the areas of risk are themselves are unknown, and it is not known who occupies them. In the past (1977) two hydropower dams failed on the River Pardo (SP); various smaller ones have failed, together with many under construction (Orós in Ceará).

Droughts, principally in the Brazilian North-East, are a common occurrence. Specific programmes exist and some actions have been taken in isolation, but there is no regional preventive programme to minimize drought impacts on the population as a whole, whether in terms of food.
supply or economic alternatives. One of the projects now in course, which could help to minimize the problem, is ProÁgua, which has a large volume of resources planned for different States of the North-East. Its results must be evaluated in terms of social indicators and population health. The construction of impoundments, wells and cisterns does not always benefit the population most in need.

2.7 Natural environment.

Conservation of water resources in the natural environment depends upon: (a) control of effluents from domestic and industrial sources, from storm drains, and control of diffuse agricultural pollution entering rivers, reservoirs and aquifers; (b) good agricultural-pastoral practices and land use; (c) controlled development of urban areas in coastal areas; (d) care in construction of hydraulic works such as reservoirs, dykes and others. However, the major limitations at present relate to: (a) lack of knowledge about integrated behaviour (Rodrigues-Iturbe, 2000) of various biomes within Brazil, because of insufficient systematic monitoring of water quality, production and transport of sediment, areas of aquifer recharge, and areas critical for good land use.

One of the main water quality problems, in addition to those of Brazilian cities, is that of effluents from food industries in the south-east of the State of Santa Catarina, which is now spreading to the States of Mato Grosso do Sul and Goiás. Brazil has substantially increased its production of pigs and chickens. The way in which the industry manages its costs is by putting production out to small undertakings, transferring responsibility for the environment to them, so that any that do not treat their effluent contribute to polluted discharge which becomes more concentrated in downstream areas of main rivers. Ironically, these same industries receive ISO environment awards for their installations, which are in effect receiving a heavy environmental subsidy from those who do their work under contract, since the cost of treating the many small discharges does not appear in the final product cost. At present there is no solution to this problem, since it requires investment in treatment of many small effluent discharges. The loads produced need to be treated as there is little prospect of recycling. The producer and the industry are not willing to pay these costs and the government has not yet found a mechanism for action.

Other important impacts with strong implications for the aquatic environment are: (a) deforestation and burning biomass: an important part of South and South-East Amazonia suffer frequent burning for transforming forest into pasture and/or areas for planting. These conditions completely change the environment and the local water cycle; (b) mining, which in parts of Mato Grosso and the South of Santa Catarina result in extensive environmental damage. Small lakes of mine-water which after 10 years still have pH of 2.5 and are severely acidified; (c) diffuse contamination of aquifers in urban and coastal areas due to high population densities and effluents released into the sub-soil; (d) the use of pesticides and their impact on rivers.

2.8 Personnel development in Science and Technology (ST).

The development and preservation of water resources depends upon professionally qualified people both for execution of various types of activity and for decision-making. Most professionals working in the area acquired their knowledge on the job, with only a small proportion being qualified by taking Master’s degrees or PhDs. At present there is a shortage of qualified people in the sector, especially as new regulations are introduced with the expansion of committees and agencies for drainage basins.

Technological and scientific development has been stimulated by special programmes of the CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico), PADCT/CIAMB, CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) e FINEP (Financiadora de Projetos) through programmes such as PROSAB and REHIDRO. Qualified groups do exist in the country but many have a restricted view of water resources. Because Brazil is a country of continental size and has great environmental variation, greater focus is needed on specializations with
interdisciplinary knowledge of regions such as Amazônia, the Cerrado, the Pantanal and the semi-arid regions (amongst others), where characteristics and problems are diverse and require medium and long-term research to support development and environmental conservation in these regions.

In 2001 CTHidro was created as the sectorial funding source for investment in ST within the field of water resources. The focus of investment was in the sense of developing knowledge to solve problems identified within the country, with a management committee defining priorities and inviting researchers to develop research according to published themes. This type of investment seeks to avoid the fragmentation of research resources, although a part of these resources are kept for spontaneously-arising projects. Investments began in September 2001, with envisaged funding of about R$ 28 million per annum, but in effect R$ 40 million have been distributed in the two years, because of constraints on public spending. In these investments, researchers have shown strong resistance of the following kind: (a) consolidated groups do not wish to receive the kind of orientation envisaged in the scheme, and press for resources to maintain them; (b) the need for a more integrated vision of the development of knowledge. These problems persist and can damage the quality of investment in research, if such groups are allowed to lobby strongly within the decision-making process.

CTHidro invested in a large number of projects in 2001 and 2002 in different areas of water resources. The areas of investment are shown in Table 2.3.

**Table 2.4 Projects approved in 2001 and 2002 (CGEE,2002)**

<table>
<thead>
<tr>
<th>Priority areas</th>
<th>Number of projects</th>
<th>Proportion of total resources (*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water sustainability in semi-arid regions</td>
<td>5</td>
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<tr>
<td>Water and integrated urban management</td>
<td>57</td>
<td>33.6</td>
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<tr>
<td>Management of impacts of climate variability on water systems and society</td>
<td>9</td>
<td>2.3</td>
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<tr>
<td>Use and conservation of soil in water systems</td>
<td>27</td>
<td>8.1</td>
</tr>
<tr>
<td>Integrated use of water systems and environmental conservation</td>
<td>8</td>
<td>4.0</td>
</tr>
<tr>
<td>Prevention and control of extreme events</td>
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<td>0.4</td>
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<tr>
<td>Water quality in drainage systems</td>
<td>25</td>
<td>10.9</td>
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<tr>
<td>Management of river basins</td>
<td>33</td>
<td>17.8</td>
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<tr>
<td>Sustainable use of water resources in coastal areas</td>
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<td>0.4</td>
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<tr>
<td>Behaviour of water systems</td>
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<tr>
<td>Development of products and processes</td>
<td>6</td>
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<tr>
<td>Training of human resources</td>
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<td>18.0</td>
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<tr>
<td>Others</td>
<td>10</td>
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<td><strong>Total grants to individuals for above projects</strong></td>
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<td></td>
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<tr>
<td><strong>Total number of projects</strong></td>
<td>407</td>
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<tr>
<td><strong>Total</strong></td>
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<td>100</td>
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</table>

(*) total invested R$ 42.8 million, roughly equivalent to US $ 14.3 millions; (**) including grants for Master’s and PhD students.

### 2.9 National Plan for Water Resources.

To synthesize the main problems in Brazil related to water resources within a spatial viewpoint, data and other elements of National Plan for Water Resources were used (FGV, 1998).

The summary was formulated for each Brazilian drainage basin (as defined by the Plan) as shown in Table 2.5, and based on the following criteria:

- Water uses: consumption, irrigation, hydropower, navigation, recreation and leisure;
- Impacts of uses: urban effluents, industrial effluents, diffuse agricultural effluents;
- Impacts on society: floods and water-borne diseases;
- Environmental impacts: deforestation, desertification, mining, erosion and soil degradation.

<table>
<thead>
<tr>
<th>Type</th>
<th>AM</th>
<th>TO</th>
<th>ANNE</th>
<th>SF</th>
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<th>PR</th>
<th>PA</th>
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- **Terms**: AM – Amazônia; TO – Tocantins; ANNE – Atlântico Sul – Norte/Nordeste; SF – São Francisco; AL – Atlântico Sul – Leste; PR – Paraná; PA – Paraguai; UR – Uruguai; AS – Atlântico Sul – Sul;
- **Assessment**: 1 outstanding importance; 2 – secondary importance. When not quoted, the topic was not defined as important for action plans in the basin; 3 minor importance. Some aspects have been inserted by the author, even though not cited in the text.

This map allows as a first step the identification of the principal aspects of water resources in different river basins, and verification of which are the real problems at national level (wide spatial extent) and which problems are more regional in character. As seen in the regional analysis, the main aspects occurring in all basins are:

(a) **Urban effluents**: deterioration of water quality in rivers near to cities, from drainage of domestic sanitary wastewater and urban drainage;

(b) **Overbank and urban flooding**: floods resulting from settlement in areas of risk in floodplains, and from urban growth;

(c) **Impacts due to inappropriate land use**: deforestation, biomass burning, soil erosion;
(d) monitoring and forecasting: limited monitoring networks need to be modernized, extended and improved for monitoring sediment and water quality; the need to develop prior knowledge of hydroclimatic conditions;

(e) legal instruments: support to States to institute State legislation and to create management bases at State level;

(f) Institution of management instruments: implementation of basin committees and agencies, development of Plans, and of mechanisms for granting concessions and for charging;

(g) Development of human resources: investment in training in water resources at all levels, to meet demand.

3. EVOLUTION AND TRENDS

3.1 Institutional overview.

The 90s was promising in terms of institutional development in water resources. The preceding chapter mentioned the legislation passed and governance through SRH and ANA at Federal level and through various entities at State level. Some Federal, and many State basin committees are functioning. The year 2003 saw charging for water introduced for the use of water in the River Paraíba do Sul.

The evolution of this institutional process on macro-management of basins appears to be following a promising path. The principal advances and difficulties identified are as follows:

- In general there is strong concern at the public level over the country’s water resources, which scarcely existed in the past. Now, there are frequent requests for information from sectors of the population;
- Various sectors have been receptive to the idea of charging for water, notably industry, although there is resistance from the agricultural sector. For example, in the State of Paraná legislation was only approved if there was no charge for agricultural use;
- There is much popular distrust concerning charges and the way in which the monies levied will be used, since recent experience with taxes approved for one purpose and then diverted to some other use, is very common in Brazil;
- If there is no agreement amongst all participants to the execution of charging, judicial action may follow which may hinder basin management;
- One of the great risks for the institutional system is in the management of resources, since the sums levied will go to the Federal treasury which, independently of the intended use of funds, can place conditions on their release, just as it does with any budget. This would kill the confidence of all the players involved, and would kill the concept of charging for water and impacts. The greatest risk to the management system could lie in the government’s own administrative practices;
- The long-term permanence of the technical structure of public administration is fundamental for the continuity of water management. Discontinuity resulting from the activity of political pressure groups must be avoided;
- While only the basin committee exists without any associated supporting agency or funds to develop activities, the result is negligible and often discourages the participation of members who see no evolution in the process of management. The committee then functions almost as in a happy hour, a place for discussion which does not lead to action and results;
- Some difficulties must still be overcome that concern governance in basin management, which is not yet clearly defined. For example, in very large basins with rivers passing through many States various committees will exist. How will decisions be taken? What will be their extent? Also the committees may interfere with each other (principally those of upstream sub-basins interfering with committees of downstream sub-basins);
• Constraints on resources have limited the activities of SRH and ANA in recent years, creating difficulties for maintenance of monitoring networks (the basic requirement for the system to work);
• The network for collecting Federal data is substantial and the data are available on the internet without charge. This is an important advance, considering that in many countries of the region obtaining data is almost an impossible task. Nevertheless, the system needs to be updated with respect to the following: (a) the data bank does not receive data collected over intervals of less than one day, which means that an important part of the information is not available and there is a risk that this information will gradually be lost; (b) the national network only monitors basins of medium size or larger ( > 500 km²), with rare exceptions. This constrains the management of smaller basins. As the States generally do no monitoring, the country encounters problems in the management of water uses typical of smaller basins, such as water supply, irrigation of small areas, environmental conservation and flooding; (c) there is a fairly large shortage in the collection and publication of data on monitoring sediment and water quality, areas where the information system is still at an early stage.

Institutional development is the basic condition for every management process in Brazil. The trend shows that there will be consolidated legal structure instituted, but with great regional variations in its implementation. In areas where conflicts over water use are intense, agreements will be reached because of the necessity of finding solutions (as in the case of Ceará, which has reached this stage). In regions without apparent conflict, prolonged discussions could occur that reduce the effectiveness of the decision process. One view is that this is positive because it is instructive, but the other view is that it does not favour the management process. However, the demonstration aspect could change this trend.

3.2 Urban development.

The water and sanitation sector is in institutional transition; the trend is towards an absence of incentive for the privatization of services and the great majority of companies will remain public. Thus, negotiation must develop between between townships and State sanitation companies over the concession of services. The main problem at present is the lack of stable instruments for investment over the short and medium term. State and Municipal companies are generally in deficit and with low capacity for investment. The quality of service in the area of sanitation is poor. A large part of networks for the collection of sanitary waste that appear in official statistics do not collect wastewater, since the links to houses have not been put in place. This volume flows directly into storm water sewers and thence to rivers without treatment. Treatment stations do not treat the volumes that they were planned for, so that the investment is ineffective and do not attend to the needs of society. Putting more resources into inefficient firms will not give the expected return. The programme PRODES for buying waste seeks to solve this problem by buying treated waste and by not paying for works that do not meet their objectives, but investment in this programme is unsure. Water and sanitation service must have supervision of the services provided, for since only one company exists, supervision for the benefit of society by means of an agency or some other mechanism will ensure an adequate quality for the service and an economic efficiency that passes the least cost to the user. At present, both service and price are established by companies without independent checks.

All these initiatives concern water supply and sanitation, but do not deal with urban drainage. Urban drainage is itself maintained outside government funding because it is alleged that no income is generated. This was the main cause of increased debt accrued by townships in the 70s. Townships drew money from the development bank (in the time of BNH), did drainage works, but did not foresee any charge for improvements, overloading municipal budgets. The problem is extremely serious and needs a wider, more integrated approach by the government, as townships have no institutional, economic and technical capacities to solve it. The common scenario is to declare a
public disaster in the State and township, whereupon the Federal government releases funds which can be used without public competition over six months (duration of the emergency). The money is usually spent on people and recovery of public infra-structure. However, no prevention programme exists which could avoid this “flood industry”. This consultant was contracted at the end of 2004 by the Ministry for Cities to draw up a paper defining strategy for an Urban Drainage Plan for the country.

Each of the problems listed (water supply, sanitary drainage, and urban drainage) is dealt with in isolation, without integrated, preventive or even recuperative, planning. As a result, there is economic damage, and serious degradation in the quality of life, with the return of water-borne disease, deaths, loss of homes and belongings, interruption of commercial and industrial activity in some areas, and so on. This phenomenon is aggravated in large cities, which require significant resources to alleviate impacts. The cost of control at the planning phase is much less than the cost of dealing with the problems after they have arisen. In this sense, the impacts would tend to spread to this type of city, where there is no degradation and where space exists for prevention. However, no management capacity exists in cities to search for improvements and sustainable development.

With management by drainage basins, which must involve participation of various players, mechanisms can be introduced that lead to reduction of impacts. However, improvement in sanitation services (which includes here both drainage and solid residues) will depend on the following: (a) legal mechanisms for covering the cost of integrated urban plans for sanitary drainage, urban drainage, and solid waste, according to the size of cities; (b) Funding mechanisms for the plan and for its implementation, with recovery of the cost of investments; (c) regulatory checking of work done by companies, using agencies which represent society as a whole.

3.3 Agriculture.

With implementation of regulations on the use of water and charging for it, two opposing processes can occur in rural areas: (a) reduction in irrigation demand in existing projects due to water charges, and rationalization in the use of water, creating better opportunities for regional sustainability where agreements and decisions of basin committees are observed; (b) increased conflict, with difficulties for implementing decisions of the basin committees. Probably, Brazil will encounter both kinds of process, but it is hoped that the first will predominate.

In the semi-arid region, the trend is for agricultural use of water in the neighbourhood of major sources of water to be for high-value crops, with subsistence agriculture in areas where water is scarcer. In some areas, fruit production and coffee have shown that return on investment is viable, principally through a greater number of crops in each year. On the other hand, this kind of undertaking requires a regular supply of water of long periods without failure, since planting is permanent. A trend for investment by agricultural undertakings in the São Francisco basin can be expected, with economic growth in the region fuelled by private investment. The long-term sustainability of the process will depend on technological improvement. In areas not covered by risk-free availability of water, where ivers are not perennial, the potential is small, as systematic recourse to irrigation for crops of low aggregate value is inefficient. Under present conditions, development will work much better where it is directed towards social sustainability by improving indicators that describe social development not necessarily related to water. The potential scenario is for the gradual solution of some of the critical problems of social sustainability, through external investments in the region, as mentioned, leading to greater demand for irrigation water, especially for irrigated fruit,grown near to perennial rivers.

The present government is studying whether water can be transported from the River São Francisco to the semi-arid region, thus reducing the vulnerability to water shortage (particularly in the case of irrigation) of an extensive region. This development could occur over a long period, since the process would be a kind of distributed subsidy, but the tendency is that investment in infra-structure does not bring a secure economic return.
Regarding programmes for soil conservation, it must be said that great regional discrepancies in activity will still occur. Those regions where farmers are better-trained and where rural extension activities are more in evidence, will show better results, as happens now. In other regions, more effective Federal activity is envisaged in terms of training people living on the land, applied research, and rural extension. The great challenges will consist of control of land settlement around the edges of Amazônia, and development of the Cerrado. The Cerrado is strongly dependent on water availability in the dry season, since months pass without rain and there is little groundwater. Good management is fundamental in this area of great agricultural potential, since although its rivers show good natural regularization they have a limited capacity to satisfy demand. This process will depend strongly on government policies for investment support.

3.4 Energy.

With the new regulations in this sector, the scope for private investment is a large unknown. The government seeks to meet two objectives through regulatory process: guaranteed energy (avoiding rationing) and low cost. For this purpose it separated generation and transmission. Vertical structures for companies will not be permitted, and there will be limits to distribution cover for generating companies. Transmission will be under government control.

At present the country needs investment of about US$ 3 to 5 billion annually, to meet demands that are growing by 2 to 4%. Since the 80s, risk of failure has increased as increases in supply have not kept pace with increasing demand. The rationing that occurred in 2001 could have occurred sooner, but from 1970 onwards rivers happened to have flows higher than previously because of climatic variability, and this increased the mean supply of MW. This increase in flow is estimated as about 30%. It occurred mainly in the River Paraná basin where 70% of Brazil’s energy is generated. In 2001, rationing brought about a marked reduction in demand for energy (of about 15 to 20%) which has become almost permanent; even in regions where there was no rationing, a reduction in demand of about 7 to 10% was observed. Economic growth and increases in demand are occurring from this plateau level, but the increase in new generating plant is not keeping pace with the trend. Therefore, regulation is essential if future rationing is to be avoided, since rationing would be even more critical as the population has already economized in its usage, and has little room for further reduction in consumption.

Associated with this scenario there is a climatic and environmental component. The climatic component concerns the question: is the increase in flow during the 70s permanent or transitory? Probably, periods of lower flows could also occur. Climate variability is a world-wide phenomenon; in the period when flows increased in South America, flows in sub-Saharan Africa showed a significant decrease. The question cannot be answered with the knowledge presently available, since climate models are not adequate for making such forecasts. The second point refers to the regulatory capacity of the system. The equivalent reservoir of the sector (i.e., the sum of the accumulated volumes of reservoirs that can produce energy) is growing smaller in relation to the total energy capacity. This means that the sector is increasingly vulnerable to a sequence of climatically-unfavourable years.

A hydroelectric system with little spare capacity is subject to risk from climate variations, both cyclical and longer-term, which could compromise economic activity over a long period, given the inertia in the system. Since it is not possible to forecast climate over the long term, it becomes necessary to conceive and plan the system not only so that it can accommodate such an emergency, but also so that it can incorporate planning for diversification of sources, and the siting of hydroelectric plants.

In terms of trend, it is expected that hydropower generating plants will predominate (> 80%) because of the available potential, but if generating companies are responsible for the risk of rationing, the number of gas-powered generating plants could increase, so as to reduce the level of energy and economic vulnerability, with pressure on prices. The new regulatory procedures have not
yet attained maturity, and time is needed before there consequences become clear, but the country cannot afford the luxury of getting things wrong, as this would compromise the nation’s entire future.

3.6 Navigation.

Grain production in Brazil has increased by about 100% over the last seven years, and if production continues to increase it will be difficult to transport grain by road, as happens now. The prospect therefore is for increased transport by rail and by water over strategic transport sections. A large area of expansion has been the Centre-West and the Cerrado. It is natural for this region to transport its produce to the North, rather than to the South. Navigation on the Rivers Madeira, Amazonas and Araguaia-Tocantins could increase. The Araguaia-Tocantins has severe physical limitations for permanent transport. On a smaller scale, transport to the South along the River Paraguay also has potential, mainly below Corumbá, since reaches further upstream are subject to environmental conflict.

3.7 Critical events and environmental conservation.

The recent Plans for Urban Drainage prepared by some Brazilian cities will probably mitigate the effects of flooding in them. However, it is likely that a considerable loss factor will persist, as it will be necessary to change the conception of design and planning held by the great majority of engineers working in drainage, who represent a whole generation of professionals.

In particular, it will be necessary to modify the technical and equivocal policy relating to flood control works. This requires a slow process of educating people in different professional sectors, many of which are still at an early stage of organization. Therefore, in spite of eventually positive changes, there will only be concrete improvements if there are marked changes of attitude amongst technical people and decision-makers in the coming years. If not, prospects in this sector will be grim indeed.

Regarding warning systems and the prevention of risk of failure of Brazilian dams, it is expected that legal mechanisms and preventive programmes will be developed where the impact of failure would be severe. There is a move in Congress to pass legislation on the subject, but its basis is dam security, i.e., a search for action to prevent dam failure, but there does not exist any element of planning for preventive mitigation when this kind of event occurs.

The effects of major droughts in Brazil have begun to be mitigated thorough adoption of preventive measures. In fact, medium-term meteorological forecasts can provide advance warning of such events several months before they occur. However, it is necessary to improve preventive programmes, applying such information in the most critical areas. As forecasting methods develop, and solutions for critical areas are implemented, the impacts of drought will become less severe.

Considering the great impacts at present affecting the water environment, conservation depends on: action to control the effects of deforestation in Amazônia, which depends on agricultural policy and an adequate level of control; global evaluation of the environmental impacts caused by a large number of hydroelectric installations in a single basin, since hitherto impacts have been studied for each installation separately; control of diffuse industrial pollution from chicken- and pig-farms in the South, South-East and Centre-West; soil conservation by good agricultural practice, and principally the control of cloacal sewage and runoff from urban rainfall, which are a major source of present degradation. This process will only be possible through efficient monitoring of water quality and the use of control procedures such as charging for pollution.

3.8 Science and Technology.

The investments by CTIDydro of funds in the sector (see Table 2.2) are based on programmes of: production of capable managers of water resources at State and municipal level, with grants for
MSc and PhD study; urban waters; the semi-arid; climate and water resources; and management of water resources.

There are proposals for technical developments in the following areas: products and equipment for hydrometry, quality of surface- and sub-surface waters, sanitation, study of water resources in Brazilian biomes, and rationalization of water in the rural environment. These proposals were concluded in January 2004, and could be used as a basis for investment in research in the sector. The technological topics identified in the proposals demonstrate the principal national problems in water resources. Table 3.1 gives the principal topics selected from a total of 69. The process of identifying topics involved about 50 specialists in water resources from different areas. For each theme, a basic document was prepared, with six technical meetings and one workshop (CGEE, 2004).

The investment in the sector has led to an increased number of researchers and professionals working in water resources. The great limitation is again the constraint on resources, which in 2002 was of the order of 50%.

<table>
<thead>
<tr>
<th>Areas</th>
<th>Technological topic</th>
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<tbody>
<tr>
<td>Quality of surface waters, Saneamento</td>
<td>Reuse</td>
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<td>Development of institutional arrangements and instruments for urban planning, and its integration with environmental sanitary planning, giving emphasis on social control social.</td>
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<td></td>
<td>Research and development in subsurface water: exploitation, techniques for infiltration and storage, areas of risk.</td>
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<td></td>
<td>Evaluation of pollution in terms of its physical, chemical and biological aspects in Brazilian environments; impacts on health and their mitigation.</td>
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<td></td>
<td>Development of materials for water supply, sanitary drainage and urban drainage.</td>
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<tr>
<td></td>
<td>Techniques for monitoring and information systems.</td>
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<tr>
<td>Climate and water resources, products and equipment</td>
<td>Monitoring of hydrographic basins at different spatial and temporal scales: monitoring of hydroclimatic variables and of areas representative of national biomes.</td>
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<td></td>
<td>Pilot projects to increase productivity and quality of information produced by monitoring networks, and for information dissemination.</td>
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<td></td>
<td>Forecasting and prediction of the consequences for water resources of natural and man-induced climate variations, and of their effects on economic and social development, including potential measures for mitigation.</td>
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<td>Racionalization of water use in rural environments</td>
<td>Alternative techniques for soil management and conservation that promote infiltration.</td>
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<td></td>
<td>Development and improvement of irrigation techniques and methods of certification leading to increased technical and economic efficiency in water use.</td>
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<td></td>
<td>Climatic forecasting and water availability as a means of evaluating risk and of safeguarding agricultural production.</td>
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4. SYNTHESIS

4.1 The problem: Development of water resources in Brazil.

Up until the 80s, Brazil was a country in which water resource management was conducted sector by sector, without any integration. The active sectors were: energy (the sector best organized as regards sectorial planning); irrigation, and in this period the country even had a Ministry for Irrigation to develop its use, principally in the North-East; the environment, with the passing of environmental legislation and the creation of State agencies for control; water supply and sanitation, represented by
water and sanitation companies; and navigation, a more marginal sector within the Ministry of Transport. Matters such as flooding and water-borne disease were dispersed within the State structure, without much importance.

In terms of institutional structure, there only existed the water code approved in 1934, and projects were approved by sectorial organs. The hydrological data base was part of the Ministry for Mines and Energy, and projects were developed with a single objective and without any basin-wide vision by sectorial entities, and with limited attention to the environment. The only planning was undertaken by the hydroelectric sector which adopted the steps: hydroelectric potential and inventory (entire basin); Viability, Basic Project and Execution, for each undertaking.

In the water and sanitation sector, State companies significantly extended water supply, but paid little regard to the collection and treatment of sanitary waste, whilst urban drainage and solid waste were of no account, despite frequent urban floods.

4.2 Actions taken.

In the second half of the 80s decade, principally after restrictions were imposed on hydropower funding by the international funding agencies, and the beginning of funding for environmental control in cities and biomes, there was increased discussion about the need for integrated water resource management within the country. The process was mainly discussed within the Brazilian Association for Water Resources (Associação Brasileira de Recursos Hídricos: ABRH) in technical terms, and without party political components which might impede its evolution and consolidation. The ABRH created a Forum for discussion at various events, and set out the elements for consensus in its letters from Salvador in 1987 (multiple uses, decentralization, national system for water resource management, improved legislation, development of technology and human resources, information systems and national policy for water resources) and from Foz de Iguaçu in 1989 (national policy for water resources, national management system, legislation, technology and human resources, and information systems: ABRH, 1995). All the principles approved in Dublin, on which Agenda 21 is based, were present in these documents.

In 1990 the sector managed to pass legislation which came to be the basis for sectorial funding, in spite of serving the interests of States and townships more fully. The law concerning financial compensation for flooding of productive agricultural land withheld 6% of the value of energy produced by an installation to compensate the State and townships, but a part of this resource is earmarked for hydrological data collection, science and technology, and hydrological studies. Nevertheless, the destination of these resources is the energy sector, which guarantees the hydrological data base in permanent form. This is the first great success, since independently of budgeting, resources are guaranteed by law for the collection of data and basic studies.

In this period, some forces had more weight than others in negotiations over legislation: The energy sector, which through its organization and resources, always dominated water resource development; the environment which countered with its assessment of potential impacts, and wished to participate in management processes; irrigation, because of the circumstances of the time, which gave it a ministry of its own. The water-supply and sanitation sector was distant from the process, principally because it acted more at State level, when the focus of discussion was at Federal level.

With the reforms in the decade of the 90s, a Secretariat for Water Resources (Secretaria de Recursos Hídricos: SRH) was created in 1995. Working together with Congress, it became possible to draw up a law which contained the principal technical elements of what had been discussed, although some points of discussion remained. In 1997, the law on water resources was finally approved after lengthy negotiation amongst the sectors involved. Having approved the legislation, the next step was to be to put it into practice. Within government, a second reform was being drawn up, leading to the creation of agencies for the control of sectorial development, when the ministries had defined their policies. ANA (Agência das Águas) was created at this time of politico-institutional governance (2000). Perhaps it would not have been created if this environment had not existed. With the creation of this Agency, the law concerning compensation for flooded land by dams was changed to provide
funds for the sector, with ANA receiving 11.1% of resources which amounted to 6.75% of the value of energy generated. Science and Technology applied to water resources received 3.67% of the compensation funds. These are considerable sums for a sector which, before the passing of legislation, had been funded by budget left-overs.

It can be said that the construction of the first phase (here termed Phase I) of institutional development of Brazil’s water resources is now concluded. In it, legal elements have been established at Federal level for management, and institutions for governance have been set up. At State level, almost all States have passed legislation, and some have set up agencies for development, although at present these are few in number.

In this period, committees and agencies for Federal and State basins were also set up, with different degrees of success. Most basins have just a committee, which has limited activity. In the sector of Science and Technology, there has been considerably increased investment in research which focusses on the problems and has permanent resources.

The phase now in development (here called Phase II) has various fronts, which are as follows:

**Sectorial legislation:** Legislation and management of water resources must be considered together, but the sectors still need elements that allow socio-economic development and sustainable environments. Principally, water supply and sanitation sectors, together with the energy sector, are developing the legal basis needed to give sustainability of development. This is the present phase of legal construction, which provides compatibility between the objectives of water resources law and sectorial development. This paper has identified various problems and actions being taken in the search for this legal basis and for the construction of an integrated management of water resources.

**Implementation and development of management instruments:** establishment of basin committees and agencies with resources given by charging for water use. For this development to happen, it is necessary for the three elements mentioned to exist; if they do not, success is difficult.

**National Plan for Water Resources, State Plans, and Basin Plans:** integrated management of water resources will be developed when the plans are drawn up. In this way it is possible to reconcile sectorial interests, establish concessions, and control the environment. This phase is under development at Federal level, in a few States, and in some basins.

**National Information System:** the hydrological information system has existed for a long time, but needs to be extended and modernized. At present, information is easily accessible to society. Extension and modernization of the data base involves: (a) inclusion of information besides that provided for basic hydrological purposes; (b) extension of the networks for data collection to cover a wider and more representative scale of basin sizes; (c) modernizing the data bank and access to information.

**Capacity building and Science and Technology:** investments have been made and it is important that they be continued, as the demand rises for qualified personnel to serve in basin agencies. In addition, development of knowledge relating to instruments for management and to water systems is essential if critical problems facing the nation are to be solved.

4.3 Results.

The preceding chapters have discussed various aspects relating to the results found in developing the water resources of Brazil. Table 4.1 shows a summary of the principal results from Phase I of the process of water resource development. Phase II is still in progress and is presenting various challenges that depend very much on the efforts and political understanding of agents involved in governance.

The main challenges are:
• The availability of funding resources, based in law, for use throughout the year. The sector has suffered in the past because although funds exist, their use is constrained;

• The resources gathered in Federal basins are also subject to constraint. This could discredit the system in which users are charged for water, since the user could challenge the payments in law, if the funds do not reach their destination;

• The challenge to develop an integrated vision of water resources in the sectorial context, such as water supply and sanitation, and energy. In the first, there is a lack of any integrated vision of the urban environment, and a search for results leading to environmental improvement downstream of cities. In the second, there are environmental conflicts and a search for projects giving more sustainable energy production.

• Broaden the process of decentralization for management of water resources, through river basin management;

• Improvement to hydrological information systems and to the management of hydrographic basins;

• Maintenance of policy for investment in Science and Technology with participation of agents of government and the scientific community, and with increased participation of industry representatives.

Table 4.1 Results of water resource development.

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Results obtained</td>
<td>1. National laws for water resources and in almost all States of the Union.</td>
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<tr>
<td></td>
<td>2. Governance: SRH for policy, ANA for management and application of policy for water resources</td>
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<td></td>
<td>3. Permanent investment in Science and Technology</td>
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<td></td>
<td>4. Financial mechanisms for the sector at Federal level</td>
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<td></td>
<td>5. Development of programmes for rural water supply in the semi-arid zone, and wastewater treatment</td>
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<tr>
<td></td>
<td>6. Maintenance of hydrological information systems</td>
</tr>
<tr>
<td>Problems encountered</td>
<td>1. Limited access to existing and authorized funds. This problem could become serious and could make management by basin committees inviable in Phase II.</td>
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<tr>
<td></td>
<td>2. Lack of activity in strategic areas such as flood management, rationalized use of water in urban and rural environments.</td>
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<td></td>
<td>3. Major decentralization in the management process. The process is still very Federal because of the composition of the Water Resources Council.</td>
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<td></td>
<td>4. Lack of integration of concessionary permits with environmental licence in the process of supplying concessions to undertakings.</td>
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<td></td>
<td>5. Lack of an integrated vision in the management of urban water resources.</td>
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<tr>
<td>Principal impacts</td>
<td>1. Marked changes in public perception concerning water management.</td>
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<tr>
<td></td>
<td>2. Reduction in river pollution with action by townships (still on a small scale relative to the dimensions of Brazil).</td>
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<td></td>
<td>3. Greater production of researchers and of research in the sector.</td>
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<td></td>
<td>4. Increased public participation in the basin committees at both Federal and State levels.</td>
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<tr>
<td>Sustainability</td>
<td>Legal sustainability is guaranteed by law. But the policy depends on each government, the economic success depends on using the allocated budget, which has been severely constrained in the last three years.</td>
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</table>

4.4 Lessons.

In developing countries like Brazil, the institutional part (in the area of water resources) has very great weight, as the country itself has passed through periods of political change during the building of democracy and the structure of the state. In 1985 the country came out of an autocratic
period and this coincided with the beginnings of discussion on water resource management. Therefore, the first lesson to be drawn is that development of the legal and institutional regime needed for water resource management required the country to be mature in terms of democracy and public participation.

The process evolved within a technical framework, with few party politics in the forum for discussion. The ABRH was an important forum because it is an association of professionals who adopted important ethical principles such as: not to grant privileges to any sector; to approve public consensus documents after the Seminars; to create forums for discussion when no consensus existed; to avoid politicisation and to maintain independence.

It has sought economic sustainability of the sector through legislation giving a guaranteed budget for: the information system, governability, and science and technology. Even with funding guaranteed by law, getting access to them is a serious problem which could compromise the entire system, and ways must be found to liberate funds from these restrictions.

A modern legislation must be based on the principles of agenda 21, including: decentralization, economic value for water, integrated use of water resources. The combined construction of basin committee, agency, and economic mechanism for sustainability is essential.

Perhaps the most important lesson of all is that the process is slow and gradual, and that it is difficult to speed it up; but building it piece by piece is important for its consolidation within society, to educate society about the problem, and to solve it in an integrated manner.

5. CONCLUSIONS.

This document cannot claim to be complete. It only presents an analysis of a rich process which can be viewed either with optimism, since important structures have been obtained over the years, or with pessimism, since much is still lacking before integrated management of water resources is a reality in a decentralized form. However it may be, the path by which water resource development is travelling in Brazil is a promising one, but it requires strong participation by society, because history is littered with cases where success was transformed to failure. Nevertheless, the will towards construction is much greater than the will towards destruction. Water resources management is no different from any other area of human activity, insofar as the process is moved by people with widely-varying interests, whether immediate or future.

The institutional construction presents a rich example for study and is to be understood as a lesson for other developing countries, despite the specific nature of each different society. The future will show whether the country succeeds in continuing its advance and becomes an example of complete success.

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