Issues of Local and Global Use of

water from the Amazon

LUIS E. ARAGÓN - MIGUEL CLÜSENER-GODT
Editors

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INTRODUCTION

Water has become one of the most critical issues of the new century and is certainly of vital importance to sustainable ecosystem management. The objective of the present monograph is to contribute substantially to discussions on water and highlight current issues that are essential for the survival of humankind. Scarcity of water in some regions and abundance of water in others, degradation of water and pollution of entire watersheds have already led to regional - and even global - conflicts. The Amazon basin, which contains 15% of the world's freshwater resources within its watershed, has become a covered resource, the subject of international debate and the object of international desire. Given the water shortage in many regions of the world, the privileged situation of the Amazon basin could inspire misguided political decisions to "right the imbalance" at the risk of undermining the sustainable use of water resources in specific ecosystems and unleashing large-scale catastrophes. The time to act is now. Corrective measures are necessary to undo the damage already done. This will demand solid scientific input. International co-operation is needed in order to tackle head on openly the most critical issues. New approaches to problem-solving must be found as well as new avenues for co-operation, not between only the countries immediately concerned but also involving the rest of the world. Hence the title of the present monograph, *Issues of Local and Global Use of Water from the Amazon.*

The current monograph was prepared to provide scientific input to the above-mentioned debate. It also was a contribution to the Third World Water Forum held in Kyoto, Japan, in March 2003. Papers selected for this publication were chosen from presentations given at two international seminars in Belem, Brazil, in June 2002 and March 2003, which involved more than 200 people from the region and brought together a series of eminent personalities working on water-related topics in the eight countries of the Amazon region. The Federal Minister for Science and Technology of Brazil was present at the 2003 seminar. The seminars were jointly organized within the framework of the South - South Co-operation Programme by UNESCO/MAB, UNU and the University of Para, Belem. They were also part of a collaboration between MAB and UNESCO's International Hydrological Programme.

The chapters of this monograph deal with many interrelated topics associated with freshwater in ecosystems with abundant water resources. There are sections about the water cycle in the Amazon, pollution, fluvial transport, energy issues, geopolitics, institutional frameworks, water resource management, and international co-operation.

The added value of this publication, within the overall debate on sustainable water use, is its focus on the Amazon watershed as a whole and its inclusion of all the Amazon countries in a holistic overview.

The reader will find reference material for future discussions on water-related issues in the Amazon destined to help determine future water-related work in the region.

Prof. Dr. Walter R. Erdelen
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for Natural Sciences,
UNESCO

1. THE SOUTH-SOUTH CO-OPERATION PROGRAMME FOR ECO-DEVELOPMENT AND THE QUESTION OF WATER IN THE AMAZON

Luis E. Aragón *
Miguel Clüsener-Godt **

The year of 2003 was declared by the UN as the International Year of Water, considering the strategic character of this resource for the new century. Many events around the world have concentrated attention on that theme.

The figures are really alarming: 97.5% of the existing water on Earth is salty water, and only part of fresh water (2.5% of the total) is useable. In conclusion, only 1% of fresh water on Earth is easily accessible, and the Amazon holds around 15% of this percentage. Water is also one of the most unequally distributed natural resources in the world: more than 40% of river waters, reservoirs and lakes are concentrated in six countries: Brazil, Russia, Canada, United States, China and India.

Regarding consumption the disparity is also preoccupying. While a North-American, for example, has 140 litres/day of water for his own use, or a French has 150 litres/day, a person from the rural area of Madagascar has only 10 litres/day of water and it is estimated that around the world, 1.5 billion people have already no access to potable

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water. If urgent measures are not taken, 2/3 of humanity will encounter water shortages by the year 2025.

What measures are needed in order to solve the problem and what is the role of the Amazon and the Humid Tropics in this process, as the question of water is becoming one of the most relevant geopolitical issues of our times?

Up to recent years, technicians had quick answers: Build big dams, remove the salt from seawater, transfer water through aqueducts from humid areas to dry areas. Nowadays, such solutions are not easily accepted, as they are very costly from the environmental and economic points of view. As a result solutions are being sought to diminish the demand. Some talks suggest the creation of an international water market through which countries with shortage of water could buy water from countries with abundance. There is even a proposal of creating an Organization of Exporting Water Countries. At the end the question is: how to conciliate the vital character of this resource with the economic value that it represents? In the final analysis there is no life without water and nature will die.

In this context the South-South Co-operation Programme for Ecodevelopment incorporated to its working agenda the analyses of the question of water in the Amazon, as a contribution to the celebrations of the 30 years of foundation of the Centre for Advanced Amazonian Studies (NAEA) of the Federal University of Pará and at the same time offering a contribution to the World Water Forum that took place in Kyoto, Japan, in March 2003.

The South-South Co-operation Programme for Ecodevelopment[1] is an initiative of the MAB/UNESCO Programme, the United Nations University and the Third World Academy of Sciences, with headquarters in the Division of Ecological Sciences of UNESCO in Paris. The Programme emerged from an International Conference organized by the Association of the Amazonian Universities (UNAMAZ), in June 1992. The main purpose of that Conference was to follow-up the World Conference on Environment and Development (UNCED) (Rio de Janeiro, 1992) and to put in practice the recommendations of Agenda 21 emanated from UNCED.

The purpose of the Programme is essentially to identify scientific capacity in the South, to foment its growth and enhancement, and to facilitate exchange and international co-operation following the principles of Agenda 21 and the declarations of the United

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[1] That programme was originally named as *South-South Co-operation Programme on Environmentally Sound Socio-Economic Development in the Humid Tropics.* Home page: http://www.unesco.org/mab/south-south/index.htm

Nations World Conferences, specially those of UNESCO on Higher Education (Paris 1998) and science (Budapest 1999).

After the International Workshop on Conservation and Development of Coastal Zones in Latin America, held in Florianopolis, Brazil in December 2000, the South-South Co-operation Programme enlarged its agenda, including activities related to management and conservation of coastal areas in Latin America. The estuary of the Amazon was considered one of the most important zones of this area[2].

From that agenda a series of activities co-ordinated by NAEA related to the question of water in the Amazon emerged. Those activities culminated with the edition of this volume published in co-edition with UNESCO, in Portuguese and English[3].

In December 2001 took place in Belém the International seminar *Science and higher education in the Amazon: Experiences of Conservation and Development in Coastal Zones of the Amazon and Alternatives of International Co-operation*[4]. After that seminar it was concluded that water was an intervening factor in the life cycle and in all human activities in these areas. As a result specific actions concerning water in the Amazon were programmed including a contribution for the World Water Forum of Kyoto.

In June 2002 took place in Belém an International Workshop that counted with the participation of specialists from Brazil and other Amazonian countries. In this workshop terms of reference concerning issues related to water in the Amazon were defined. Afterwards, UNESCO contracted specialists within the context of the South-South Co-operation Programme to elaborate documents following the terms of reference defined in the workshop.

Finally the International Seminar *Issues regarding the global and local use of water in the Amazon* was organized in Belém, 9-13 March 2003. That seminar represented the highest moment of NAEA´s 30 years celebrations. The documents prepared by the specialists were discussed, broadening the scope of those studies with contributions of

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2 Vieira, Paulo Freire (Org.) *Conservação da biodiversidade biológica e cultural em zonas costeiras: enfoques e experiências na América Latina e o Caribe.* Florianópolis: APED Editora, 2003.

3 The Portuguese version includes all the chapters of the English version plus other materials produced at the seminar that discussed the issue. See Aragón, Luis E. e Miguel Clüsener-Godt (Orgs.) *Problemática do Uso Local e Global da Água da Amazônia.* Belém: UNESCO/NAEA, 2003.

4 Aragón, Luis E. (Org.) *Conservação e desenvolvimento no estuário e litoral amazônicos.* Belém: NAEA, 2003.

commentators. More than 200 people attended the seminar including scientists, students, professors and planners from Brazil and abroad. The Minister of Science of Technology of Brazil at that time, participated of the closing session of the seminar.

The book that is now published includes the papers contracted by UNESCO. The texts identify, discuss and offer elements that will contribute to international debates, selecting the most important issued related to the use of water in the Amazon, considering its abundance in this region.

The book is divided into nine parts besides this introductory chapter. Chapter 2 analyses issues related to ethics of the use of water, management of water resources, sovereignty of the Amazonian countries and problems resulting from the unequal distribution of water in the world. The author proposes an analysis of all those elements considering their socio-environmental character and their impact in the global and local dimensions. The chapter concludes that the question of water resources cannot be taken alone, but related to the management of natural resources as a whole, the territory and the habitat and therefore related to regional development in general. Finally, this chapter indicates the need of focusing the issue of management of water resources in conformity with the principles of Agenda 21.

Chapter 3 focuses on the anthropogenic impacts on the hydrological cycle of the Amazon. Besides the description of the hydrological cycle that explains the origin of water in this part of the world, several anthropogenic actions are discussed. Externalities, positive and negative, of the hydrological cycle are also considered.

Chapter 4 analyses the most important factors of pollution of water resources in the Amazon identifying their critical levels of occurrence, their risks and their consequences.

Chapter 5 deals with transport. A characterization of river basins in the Amazon is made. A comparative analysis of the transportation systems existing in the region is made identifying the physical facilities and difficulties of navigation, the local and regional political and economic problems of navigation, the situation and possibilities of river transportation for cargo and passengers. The Chapter also alerts about the environmental risks of those activities and the construction of hydro ways.

Chapter 6 refers to energy. Emphasis is made on economics and political ecology of the use of water as energy source. Among the issues included are the importance of water resources in the Amazon within the energy matrix, the characterization of environmental impacts, the social conflicts related to environmental questions involving the construction of dams in the region and the role of those dams in the development model, principally in Brazil.

Geopolitics of the use of water is the theme of Chapter 7. Emphasis is made on the challenge that represents the access to fresh potable water for the governability of Earth in the 21st Century. The Chapter also discusses the need for conciliation of paradoxical attributes of water resources. Water constitutes a vital good but it is also an economic good of strategic value. The role of the Amazonian countries concerning this issue is also considered.

Chapter 8 refers to the institutional framework that regulates the use of water. This Chapter studies the Brazilian case but pointing out the importance of this theme for the whole Amazon region or other Amazonian countries. A description is made of constitutional norms and regulations and of other specific legislation concerning water resources at different administrative levels. Different institutional systems of water resource management are discussed stressing the need of elaborating co-ordinated actions with all countries of the Amazon basin. The strategic role of the Organization of the Amazon Co-operation Treaty in this question is also considered.

Management of water resources is treated in Chapter 9. After analysing comparatively different models of water resources management in the Amazonian countries, key elements were identified to formulate public policies socially just, ecologically prudent and economically responsible in the region.

Finally, Chapter 10 deals with the importance of international co-operation for the production and dissemination of knowledge related to the sustainable use of water resources in the Amazon region. Among other aspects this Chapter analyses the following: The importance of the South-South co-operation and the principles that should fundament that co-operation; the role of universities, research institutes and NGOs in the production and dissemination of knowledge related to water resources; the transformation of knowledge into action; the role, effectiveness and perspectives of the Amazon Co-operation Treaty. Several examples of interuniversity co-operation already existing in the region are mentioned as well as other mechanism of implementing international co-operation involving the question of water in the Amazon.

To conclude, we should recognize the relevance and quality of the texts included in this book. They were all practically written by authors from the Amazonian countries that are deeply concerned with the destiny of the Amazon region. Furthermore, the great majority of the authors work in institutions of the Amazon region itself. In some ways, therefore, this book constitutes a reference when thinking the Amazon region from the inside. This view of the Amazon cannot be ignored even if it provokes discussions and controversies. For NAEA, it could not be a better contribution, on its 30th Anniversary.

We thank to all people, organizations and institutions that made this project and publication possible. At UNESCO Division of Ecological Sciences, in Paris, thanks to its Director at the time, Peter Bridgewater and to the Co-ordinator of the South-South Co-operation Programme, Miguel Clüsener-Godt, who recognized the importance of the question of water in areas with abundance of this resource and provided resources and technical assistance for the execution of the activities.

UNESCO/Brasilia co-ordinated the translation of the texts and the edition of the Portuguese version of the book. Thanks to its Director, Jorge Werthein, to the Co-ordinator of the area of science, Celso Schenkel, and to the team of the editorial sector of the Office for their collaboration in this initiative.

UNESCO/Montevideo co-ordinated the edition of the English version of the book. We thank Claudia S. Karez, specialist of the Ecological Sciences Programme, by her support during the whole process and the personnel of the editorial sector of the Office for their collaboration and dedication.

The United Nations University was always represented and followed the development of the activities. Our sincere thanks to the Rector of the University, Hans Van Ginkel, to the Director of the Institute of Advanced Studies of the University, A. H. Zakri and to the special advisor, Marco Antonio Dias, by their support and enthusiasm in this initiative. The involvement of Marco Antonio Dias was important to guarantee the participation of the Ministry for Science and Technology at the time, Roberto Amaral of the closing session of the seminar. Our special recognition to the Ministry for the attention given to the invitation of the Federal University of Pará.

Our special thanks also to the Rector of the Federal University of Para, Alex Bolonha Fiúza de Mello, who supported since the beginning this initiative and provided all the facilities possible for the success of the project. The noble contribution of NAEA, on its 30th anniversary was not only the edition of this book. NAEA participated in many other ways in the whole project. Thanks to the team of scientist of NAEA and to the administrative staff who were always ready to attend the necessities of the project. Finally, thanks to the authors, commentators and participants in general of the activities of this project.

2. PLURAL ELOCUTION: IN SEARCH OF A CERTAIN UNCERTAINTY. WATER THAT SEES THE SUN: NO COLOR, NO ODOR, NO FLAVOR

Armando Dias Mendes *

Warning

This Introduction may be read in two different ways.

The simplified method is to just read the first small sections of each topic.

The complete method includes the paragraphs associated with each topic.

The simplified method provides a broad yet dry view of the material content.

Decide between the two readings based on your level of interest and curiosity. You may even choose both.

There are lines in small letters within the text. These are commentaries a latere on the main argument.

The reader should understand that the reflections in this text by no means cover the subject of the Amazon and the Twenty-first century.

This text has a specific focus on the water issue that is exposed in the beginning of the text.

In order to discuss the region well, many things must be taken into account. The forest and water should be included in conjunction with people.

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* Armando Dias Mendes is an advanced level University Professor and *Honoris Causa* Doctor at UFPA. He was born in the Amazon and was destined to be an Amazonologue. To his own surprise, he has been the author of books, articles and speeches that are nothing more than variations on the same theme in different tones, keys and rhythms.

Understanding the Amazon and the future of the region would not be possible without taking all of these elements into account.

This Introduction seeks to make it easier to come into contact with the water issue and the subsequent articles and authors.

The main sources of inspiration and information are listed at the end of the introduction.

Water that Sees the Sun: No color, no odor, no flavor (Portuguese Proverb).

The day will come when the rivers will all dry up and water will become a rare thing. The people's sins will turn the world upside down. Everything will be changed. The backlands will become oceans and the oceans will turn into backlands. (Prophecy attributed to Father Cícero Romão Batista, *apud* Marcelo Barros).

If Jesus returned to Kana today, we would ask him to turn wine into water. (Wadih Awawdê, Mayor of the city Kafr Kana, ancient city Kana of Galilea, id.).

We experience almost everything from downstream. (Lord Selborne, President of the Sub-committee for Freshwater Ethics World Commission for Ethics on Scientific and Technologic Knowledge).

Dirty water cannot be washed clean. (East African Proverb, *apud* Lord Selborne).

Water Control is Life Control and Quality of Life Control. (Id.).

In the 70s the owners of the world were the petroleum barons. In twenty years we will be controlled by the water barons. The most powerful of these will be the French multi-nationals like Vivendi, Lyonnaises des Eaux, Nestle, Danone, etc. Observation: Coca-Cola now has its own brand of water: Bona Aqua. (Ricardo Petrella, *apud* Marcelo Barros).

Wars in the Twenty-first century will be linked to water. (Ismail Serageldin, Vice-President of the World Bank on environmental subjects and President of the World Commission on Water, *apud* Marq de Villiers).

This volume inaugurates an NAEA & Associates trilogy on the use of water in and from the Amazon.

This initiative is justified *ex ante* for obvious and evident reasons. The call for this effort is part of a structured, opportune reflection on water that has been taken on by the academic world in (and of) the Amazon where this precious liquid is still found in great quantity. The Amazon is the "Water Planet".

This part of the text is organized into sections that reflect any good Amazon River in its sources and flows and in the mouths of the river as well as the outflows.

This daring effort to fashion the text in the shape of a river was irresistible for the writer and hopefully will be extremely potable for the reader.

The vision presented here in this commencing address proposes and exposes a personal vision and was developed and signed as such.

This vision is not a compromise to anything but itself. This text incorporates and transforms reflections and things that have already been said. Many of these things have already been said and are presented here in a slightly more "purified" form.

1. SOURCES

This trilogy involves three international meeting points. The first of these originates directly from the tap.

There was a type of project meeting (workshop type) that was promoted and carried out by NAEA/UFPA, in June 2002, in Belem. This set the precedent for a series of significant initiatives that flowed from the same proposal. The second meeting is anticipated in March 2003, in Belem again and will commemorate thirty years of NAEA operations. It will reverberate with the issues of the Johannesburg Conference from August 2002. The third meeting will take place in Manaus and is anticipated for the second semester of 2003. This will be a cooperative meeting and is currently under the direct auspices of the Djalma Batista Foundation. It will reverberate with the issues of the III World Water Forum that will take place in March of the same year.

The expected result is that we will all be able to contribute in some way to defining the Amazon framework for the new era.

> If we don't have a framework everything will occur and will be revealed to us as mere defenseless spectators. Our self-esteem will have been knocked out cold. A framework for the Amazon means designing a coherent framework for the Twenty-first Century for the region. This needs to occur in the context of converging actions that will make a regional project happen. This project needs to be not only compatible with the national project, but an important component of the same. Both of these projects are still to be defined.

This framework, for better or worse, undergoes "politicalization" as it flows along. This unique liquid flows without color, odor or flavor. It is potable.

> Politicalization means taking the issue out of the reign of the casual and the random and finally bringing it to the consciousness of the human world in organized society. This process assumes that there are choices to be made, targets to be reached and methods to be employed. This involves political behavior. Humans, as we have been taught *ad infinitum*, are political animals. The truth is that there are good and bad policies.

The Amazon framework carries the obligation to rediscover the spiritualization needs of politics on a local and a global level.

> Spiritualization means creating policies, values and criteria that transcend purely material factors. This means both ecological determinants and economic determinants. The opposite should prevail. Ecumenical requirements should prevail and should be programmed to push far beyond these fatalistic elements. They should be appropriately based on a decent ethical foundation.

The following current of reflection is divided into three parts. They correspond to shaping currents of *mare magnum* we are examining.

> Each part should reflect a wide variety of inter-related elements. Who knows if the contributions these authors offer that are united in this volume will reverberate in their sources. One thing is certain. The final summary has not yet occurred for this

issue. It is as opulent as any third or fourth level Amazon river. Future events and related books should help to compose a more precise and complete development of the material.

At the end there will be a view of the resultant runoff. This view will serve as a type of inventory and will include declared proposals.

Even if this is just a groping and experimental construction of the many contradictory variables the desire here is to unite these variables into a representative patchwork quilt.

2. FLOWS

2.1. The Amazon Framework

It is clear that the Amazon needs a framework that will be applicable to the current times. This framework can only be created if a national intention is made clear.

This means responding with a proposal and a plan of action that have goals, methods and means. There is more to this question in that this process must occur in a way that allows for the bold creation of an alternative future for the Amazon. Reducing the matter to simple extension will dispense with autonomous objectives and this would make results independent from each other. This type of approach would put the matter at the service of those who would use or abuse it.

The Amazon Framework should reflect the characteristics and essencialities of the region itself as well as relationships to the regions that surround it.

The total surroundings mean national and planetary surroundings, physical and human. They also mean economic, social and political surroundings. This approach helps modulate the regional history in order to suffuse it with a sense of belonging and bring it closer to another concept of the future of the Amazon. If this reflection doesn't reflect this inflection, what good will it be? Why create a framework if it will be useless and contradictory and frustrating?

There must be a framework that includes personal and collective promotion. This framework must incorporate the material and spiritual concerns of the people that live in the Amazon. It must incorporate the valorization of the individual and social concerns.

This is the ultimate design for the framework and its principal reason for being. Everything should flow towards this goal and float in that direction. At the same time, however, *et pour cause*, it must be a framework that is not drowsy or dull in regard to protecting the natural heritage of the Amazon. In any case, for translucent reasons, this framework should be founded in the most solid development of Science & Technology that will be applied in all of the changes that occur. Consolidated regional integration must be sought in all cases as well. This should incorporate the intra and the inter, the physical and the "metaphysical" and the material and the non-material. Integration is essential and must take the place of mere insertion or cold inclusion. This is all to say that the Amazon must be respected as a subject and not an object, or even worse as something adjective.

Clearly, this involves internal and external policies that are part of the stream of consequences. This involves relentless depths of geopolitics.

The Kyoto forum will be the III World Water Forum. The two previous meetings were held in Marakesh (1995) and Haia (2000). The second forum was linked to an International Conference on the ministerial level. The final Declaration was voted on separately in the Brazilian delegation. The official text seemed to be weak and seemed to sprout superfluous branches.

2.2. The Waters Become Political

Freshwater consumption has grown rapidly around the world, even more so than the population has. Development is a large water consumer.

It is well known that freshwater represents the tiniest part of all existing water on the planet. Liquid freshwater is an even tinier part of this subtotal. The potable fraction of this quantity is even smaller. On the other hand, the existence of potable liquid freshwater oftentimes does not coincide with the existence of humans. *Per capita* freshwater consumption usually accompanies the degree of socio-economic development of populations. The rich use much more water than the poor do, both individually and collectively. The authors of this collection have been drowning in numbers that illustrate this scenario and refer to them often. The summary of this dramatic scenario is that liquid potable freshwater is no longer abundant or inexhaustible as it was in the past. In practice, water was not susceptible to ownership. It was free of commercialism, like air.

Like air, however, freshwater cannot stop being a vital necessity for humans, plants, and animals.

At the same time, and precisely for this reason, water is also an unalienable, universal right for every living being (with the exception of those creatures that live in salty ocean waters). Water is like air in this respect.

Water, however, has become increasingly scarce and badly distributed, in addition to being badly managed. It has also taken on an economic value.

Economic value has transformed water into something that can be appropriated and has generated a rapidly growing market within countries and between countries. Now, the threat that is on its way is that water has a price and this price is susceptible to quotes on exchanges that are real or virtual. Water is subject to speculation. Water has a price.

Intervention from governments and States is now required. Water has become a political issue.

An immediate issue of internal politics is how to take care of preserving springs and water sources. There are also the issues of fighting water waste and recuperating aquifers. There are also the issues of criteria for use and the prohibition of abuses in a way that will extinguish disputes (Water Codes *et símile*, Agencies, Committees, etc.). This involves taking care of the requirements for quantity and quality of the water supply for agriculture, industry, services and personal consumption. There is another aspect to this that involves external politics when international waters subject to different nationalities are involved and there are different rulings on the status of the greater good of humanity and the regulation of the various uses of water. This is true for common uses and shared uses, like the guarantee of free access to water. This even involves relationships of "free" negotiated trade. Other aspects of this issue are obedience to world codes and obligatory respect of these codes with eternal vigilance in the hands of the powerful. World organizations are not always satisfactorily neutral. These policies impose definitions of basic concepts, rights and duties. They impose conscious decisions made between alternatives that are supported by extra-economic criteria and values. These items are the counterpart to the inevitable regulatory rules of marketing and trafficking. These nouns are used in their etymological and estimable meanings.

One of the exterior signs of making water merchandise is that it has become "petroleumized". Water has taken on the strategic position that was previously filled by petroleum.

As in the case of petroleum, water has become the cause of disputes, conflicts and wars. These are the already announced wars of the Twenty-first century. The petroleum wars do not all need to be listed here. However, there was one in South America in the Twentieth century. That war was the Chaco War (a Hispanic name that is equivalent to the *Luso*-Pantanal swamplands of Brazil and as such is a geographic reality that is really all part of one continuous entity). If you will allow me the leap, I will associate this war with an exploding scenario. The extremely detailed study from Marq de Villiers (especially Parte III) is impressive. There is not a lack of international regulatory agreements. After World War II there have been over 300. This represents an average of five or six a year. This represents a number ten times higher than the number of agreements since the Ninth century (*apud* Lord Selborne). The majority supposedly follow the line of innumerable agreements regarding innumerable objects that are not going to last on this earth.

This is the view from the bridge. The tension on the bridge is already apparent. The bridge is suspended across an Age of Innocence and the new Water Century.

Innocence? Not really. Perhaps this is a prospective analysis.

2.3. Spiritualizing Political Policies

(Bad) political policies, mercantilism and water's being petroleumized have made it difficult to liquidate the problem. In reality, these things have complicated the matter.

Liquidation means putting content on track in order to provide a outcome that is good, on time and in time. In other words liquidation is the guarantee of a quality water supply that is regular and accessible for consumers and that is in line with fair retribution to the suppliers. As long as water is an undeniable comfort on one hand and a commodity on the other, the dilemma won't dissolve.

This calls for challenges to be placed on the framework that are not only of an economic or ecological nature. This calls for the inclusion of challenges of an ethical nature.

In truth, the issue involves (and revolves around) the deepest mysteries of the human soul. Water has a historical sacred presence that goes back a long way. The nature of water and the cultural slopes that it travels in its broad reaching journeys are all part of the scenario that carries the real meaning and ideal symbolism of the waters. There is an overlapping between the sacred and the utilitarian. Water is recognized as a "value of a higher order". It is a value that goes beyond utilitarian advantages that are direct and immediate. This is how water should prevail.

The spirit, especially the primordial spirit, is called on to renew and give things new life and new employment.

Many religious cultures throughout history have looked at the Spirit as the breath of life that comes through the waters. Life hatches from the element of water much more than from the elements of air, earth or fire. This is a classic interpretation. It would not be impertinent to say that in nearly all of the Christian and Moses traditions include water as a life-giving source. Moses means "saved by the waters". Baptism is a dive into the water. There are many other religious traditions that include water in a fundamental position. (see the illuminating explanations of Marcelo Barros, Cap. III) It is only through the spirit that these materialistic, economistic and mercantilistic slopes can be traversed and overcome. These slopes deform hearts and minds as well as bodies.

Recognizing this fact makes the growing complexity of this challenge crystal clear.

Overcoming this challenge does not mean standing by in a servile and inhumane manner and watching globalization happen. It means contributing to the construction of a final unanimous universe (from Teilhard de Chardin). This is a much more demanding task. This project undergoes unifying humanity under the shelter of egalitarian principles. This process involves co-operation for uses and methods and finally, a joint harvest and fair division of the results.

3. THE MOUTHS

Where does all this "news" flow from? What kind of runoff does all this news provide? What are the real or probable scenarios that occur?

These scenarios have to be dealt with if we want to build alternatives for the direction of regional history. These are scenarios that are retroactive and proactive in the region. These scenarios have been altered by the late appearance of the water element on the scene. Curiously, water is the most obvious element in the Amazon, together with the thick, dense forest. The picture that has been revealed in the international forums is the proposal to classify this bold, and to those of us who live in the Amazon, formidable element. Global use of liquid potable freshwater has been appearing as a concept. Sometimes this concept is referred to as "social use" with a slightly euphemistic meaning. Where water exists and who it belongs to is under dispute. Many are fighting over the necessities of everyone. This creates a climate for potential huge and devastating wars. It also creates a climate for huge and corrupt negotiations. The Amazon reserve is isolated on the world map. It is needed and coveted after. The Amazon reserve is where these two impulses meet. They meet, or fail to meet, where the waters meet.

There is a new *mise-en-scène* being recognized. The required abilities for dealing with this new scenario involve many problems. There is an inventory of existing factors that are mutating and of factors that simply do not exist.

Therefore, it is absolutely necessary to incorporate all the three levels: the regional, the national and the global.

3.1. Internal Perceptions of the Region

In the first place, the region (or any region) can be seen as something with no structure. This reduces it to an autistic sort of vision, one that is gratuitous and dull-witted.

> From this point of view, when a region wants or has a "political will" that is part of a plan of action from leadership with clear objectives (who knows, perhaps an organized civil society), then the shackles of underdevelopment are broken and stubborn determination is set free. This quality conquers all necessities for everyone and for always. It is the process of pulling yourself up by your own bootstraps and allows weight to be lifted and levitated. This is how the law of socio-economic gravity can be beaten. This law keeps the region caught up in the quicksand of delays and dependence. Regional development efforts in a not so distant past seem to have inspired a secret assumption that is tarnished. This has occurred in a conscious or unconscious way. I believe that there is a way to use this vision as far as it reaches to provide an overlook.

On the contrary, there is an overflow of behavior (not to say conviction) that we can call National-abstractionist, for lack of a better label.

> The prevailing so-called "national" interest tends to dominate in the abstract. This means that there is no consideration for regional diversity or inequality. The secret (and the not so secret) assumption is that the country is essentially, mysteriously homogeneous. This means that the economic social policies that apply to the Uraricoera Valley apply to the Guaíba Valley as well. It means that the region of the Mouth of Necessities (or the Bottle Mouth) is in synch with Paulista Avenue in metropolitan São Paulo. If we move into the kingdom of the waters this means that the Grão-Pará (with its *pororocas* tidal flows), and the Parnaíba and Paraguai rivers, as well as the Pantanal Swamp and even the Paranoá Lake, are all part of a precious, perennial and perishable patrimony. The things that change are the plants, the crustaceans and the mermaids. The regional issue is dissolved within the national problem. This erases the regional problem and makes it disappear. One of the "basic objectives of the Republic" appears to be as solid as a rock. This objective is to reduce social and regional inequalities (CF, artº 3º, III). This objective, however, seems to vanish in the air.

Lately, the hyper-realistic idea that regions don't perish or disappear has been gaining strength. Now there are only micro or meso-regions.

The macro and mega-regions disappeared from the geographic, demographic, social, political and economic maps. The new or emerging regions are smaller and are more homogenous and uniform by definition. The definition of these regions was based on external or internal migratory movements that took place in directed or spontaneous ways in each macro-region. Based on these movements and the correlating relocation of human and economic boundaries, a distinct ecological-economic zoning formed. This was especially true in agriculture and in the linked investments that flowed from agriculture. These new definitions occurred spontaneously, but it looks like these boundaries are here to stay. The celebrated identifying natural and cultural characteristics of the exonerated macro-region are trampled upon because of this. The original reference point (where it all began) is substituted for other reference points that are imported, or imitated and they become the important ones. The lack of a certain direction makes the region derivative and it takes on an inferior position.

3.2. External Perceptions of the Region

Internal perceptions include external anticipations that are integrated and integrating. These need to be built and fortified.

Based on a current realistic point of view, there is a need to develop a prospectus for the future that will guide activities. This needs to occur not only for the particular details of the Amazon of each country that is part of the rainforest basins and the "rivers' nests". It needs to happen for the Pan-Amazon. This position vibrates with integration possibilities that are much larger than those that exist now. These possibilities are excessively more beautiful than current possibilities. They must be diligently and effectively pursued for the recently emerged Water Century.

Physical integration is the basis for everything right from the start. Everything means circulating people, goods, services, values, transportation, communication, energy...

In synthesis, there is a breaking of the isolation that is imposed by the region's geography, orography and topography up to a certain point. Isolation (allow me to emphasize the banks of the currents of the principal idea with a delicate sense of opportunity) has been dominant for centuries since the historic adventures of Francisco de Orellana and Pedro Teixeira, going up or down the river. This stubborn effort was only possible under the auspices of the Kings Felipes of Spain as well as from Portugal. The entire masterpiece was due to the crazy suicide of d'El Rey D. Sebastião in North Africa. He was the one who said to Fernando Pessoa that a true man would understand: "much more than the healthy savage beast the delayed cadaver that procreates". This is shocking definition however it is revealing of the human condition as a pure natural being. If we continue along these lines we won't stop soon. We'll only stop when we have to return from the location of Grão Pará and its incomparable skies.

If two countries with a single ruler has become anachronistic, a formula to vitalize the Continental Amazon as a whole must be invented.

Geographic politics in the region (I must insist on this emphasis, please excuse the repetition) would benefit from coming from within and not from outside. Don Sebastião fought the moors in Alcácer-Kibir. This operation was not a success and finally the Portuguese and Spanish crowns joined because of premature and literal disappearance without an heir. He became known as "The Hidden", and was eternally waited for. What this unfortunate one allowed to be discovered, to very pragmatic ends, was the unsuspected complacency of the Tordesilha meridian. *Per ende*, the dilation of Portuguese America (at the cost of the contraction of Spanish America) occurred in a precocious March towards the West. This promoted the definitive configuration of the future State of Grão-Pará and its successor, the Amazon. The story goes on from there and geography behaves, politics metabolize and diplomacy consecrates. This should serve as a warning or example. There is pardon for this twisted journey that has continued for so long, but it is an edifying example. The end.

Nevertheless, when all is said and done, there must be desire and nothing less than a certain spiritual integration. This implies an overall effort, an effort *over all.*

Spiritual is discussed here in the sense of what has already been said. It's clear that this cannot be measured, weighed or counted exactly. It is difficult to define and needs to be explained. The foundation is the circulation of ideas. It goes beyond the physical and that is why the term "metaphysical" is used. This can be confused with the "noosphere" Teilhardiana, that is understood literally as something that: "*À la fois realité dejá donné, et valeur à realiser librement*." A distinct biospheric value that is nourished by the biosphere is "*um tout spécifique et organique*". Is this a result of complexification? (Remember? See above) and a tendency for unanimity? (remember again? Id.). Unanimity is nothing less than the universe. In this context, the Amazon can finally find its own place and be recognized for its planetary role, its cosmic role, who knows? It can finally rest in peace, in the best meaning of the phrase.

3.3. External Perceptions of the Region

It's finally time to confront the challenge of the global charade that involves the Amazon: its insertion in the planet.

Insertions or inclusions, as has already been said, are numerous. The best approach is to separate them.

The easiest to identify in terms of being tricky, and therefore the easiest to discard, is simple passive insertion. This is the insertion that comes from "doing what the others do".

Ruled from without, this process is limited to imitation or generated demand or to what is in fashion in the outside world. This could be soybean plantations, energy crops like açai, or forest hotels and clothing made from plant leather. It could also mean aluminum pans. These trends all occur simultaneously and force the region to produce what is not naturally part of the region. When this doesn't happen, the original forces are used. This means the rivers that are involved in the construction of roads that are solely used for transporting products from other national regions in the direction of other global markets. This geographic fatality is what brings consumer markets closer in terms of grain and products of a significant value with random origins. This region is used with an extreme lightness of being that is not beneficial to the region. It is beneficial to those who produce and export and to those who import and consume. It is never favorable for those who sit on the park bench and watch the band go by (or the boat, or the truck). Amazon byways are reduced to runoff. Yet they are necessary in any type of linked regional project. Not in and of themselves.

One variant that is perhaps slightly more "advanced" is made up of what we can call insertion by adhesion.

"What's good for Favônia is good for Amazônia". Don't slogans and sayings like this exist? They are copied, and transplanted. After all, what has been done in Favônia has been showing results. It's as if the same wind patterns that bring favorable results to one reality or latitude would do the same for different ones. Random models are summarily adopted but not necessarily adapted. Sooner or later adjustments need to be made. *Tout s'en va de lui même...* The beatitude of this refrain is found in what are considered to be modern apostles (or post-modern, I don't know anymore). Therefore, they are on the cutting edge for their time and part of the vanguard movement for their place.

The only defendable way to fit the Amazon into the world depends on a clear and unmistakable shape for the Amazon.

The Amazon shape is tied to what is naturally specific – i.e. to *Amazonianess.* Inclusion must occur with the support of all of the inherent characteristics of the soil and the underground layers of the soil. It must also include the flora and fauna and the natural flows (air, water, natural gas, oil...). It must also include folklore, training, forms, creations and regional facets. All of these concrete and ephemeral Amazon qualities and the physical and spiritual elements as well must be considered. Insertion must take place as something that happens from within and moves outwards. It can't be roughly carved out by established demands. The impulse for this inclusion must come from innovative opportunities that are inherent. When put to the test, these scenarios have to have universal appeal and must include enthusiastic alliances. There is no need to show this reality that is so apparent to the naked eye. The priorities jump out at us. There are pupunha, hearts of palm, fruit pulp, dust duck in tucupi sauce ("dust duck on tucupi sauce")... Açaí fruit, guarana, ices, jellies and jams, sweets in general. There are also music, dances, ceramics and folk art. There are also teas, roots, leaves and traditional medicine and much more. Long live Jean-Baptiste Say! He never got to the Amazon but he realized that someplace, sometime, somehow that there would be supply that would create its own demand. He deserves a few statues revealed to the sound of discordant Rap music and the fervent Marujada dance in all of the federations of employees and employers in the region. All of them should always be grateful.

4. OUTFLOWS

This is where we finally end up? Here in this torrential flow that threatens to drown us? Are there other still unknown consequences from these outflows?

There are two types, according to what is considered to be the intra-regional field and the international field (evidently going through the inter-regional). Concern for one type does not cancel out concern with the other type. They interact.

Internally, engage the basic hopes of the populations through reducing the quality and quantity of the fountainheads.

This is how the fountainheads run dry or become irreversibly polluted or somehow compromised. If this happens, there is no appropriate and unequivocal answer for the habitual requisitions like electricity, industry, navigation and agriculture (cultivation and animal breeding). There is no answer for irrigation, fishing, and tourism, sports, health and sanitation, food or climate regulation... Hydroelectric dams take on the equivocal status of Dr. Jekyl and Mr. Hyde. The same is true for irrigation or animal breeding. It's important to emphasize once more that all of us live downstream from this disaster. If this possibility seems alarmist given the dimensions of the region and the aquifers, the studies here show that these threats may become realities in sub-regions and localized areas. The water cycle can be affected. These seem to be current problems, but the tendency is for them to spread if they are not faced in time. These problems will affect growing populations.

Externally, this threat will turn into a fact for the whole world and the current flow of the River-Sea will be the world's number one provider of freshwater.

This means that this hypothesis could perfectly well become a reality and the huge Amazon Grand River could be declared the common property of humanity. This would bring on management from a multi-national or international distributor. Hasn't this scenario already been hinted at, even rehearsed for the humid tropical forest of the region and the biodiversity that lives within it? The water issue is the most urgent and the most worrisome. Would we get dizzy if we put the two questions together imagining an attempt to convert the region into a protected confined area overseen by an *ad hoc* organization that would be composed of the powerful people in the world? This would all take place in the sacred name of humanity. Biological diversity can be freely exploited. This exuberant source may become exhausted for those who live in the Amazon. This would involve damage to the priority of their necessities. Or, some type of "compensation" may be promised. This is in line with what is offered towards the preservation of forest areas where the largest polluters in the world keep polluting without being punished (the very rich may even acquire lakes with the alleged intention of providing their grandchildren with water – what concerned grandparents! — *apud* Villiers). It is always a good thing to remember that saving the huge quantity of freshwater in the Amazon basin doesn't involve only the regional population's needs. It has already been estimated that transferring 20.0% of this liquid accumulation for, let's say fertilizing the Sahara desert, would end a reservoir of biomass and the Amazon basin. The repercussions would be felt around the world and would greatly damage the regulation of the planet's climate. (*apud* Marq de Villiers)

An alternative: Allied Amazon countries and other large suppliers make up a pool (an appropriate nickname) in the style of OPEC.

In this way we (the countries that make up the Amazon condominium) would associate with the United States and Canada (maybe Russia, China and India too). This would be a new and promising global cartel. Agreements could be reached. I don't think this would be easy given the weight and texture of the partners. However, we could establish criteria, quantities and common water prices for water sold to the thirsty countries. This is how OPEC works and has worked for a long time with petroleum. This is almost how Canada has been working in negotiations for tens of billions of liters of water per year with China. This might even promote a lively scale of water for petroleum. This seems to be happening on an experimental level on the frontiers of the Middle East. Who knows? Water is part of a good beer and this could cause a certain allure to appear between Canada and France. This scale could be used for water and wine as well (the opposite of the first miracle of Christ in Kana). The disheartened mayor of Kana has suggested this 2000 years after the miracle. Is there enough to be discussed – or enough water for everyone who is thirsty?

In the end and in practice, how can we end this saga? What kind of attitude should we take on? What kind of framework should we vote on? What kind of framework should we execute? What kind of idea about the Amazon should be pursued?

This is what is being said in the final analysis. Pursuing a prospectus, a proposal, and a purpose. To sum it up: pursuing an Amazon Project. This is a sufficient task internally for the ADAs or SUDAMs that are the current or eventual re-dividers. It is a challenging task externally for the OTCAs (definitively blessed on November 22, 2002 in Santa Cruz de la Sierra). These are the "owners". There will be a certain confrontation that ALCAS (expected birth date 2005) and the planet's OMCs. These last are still infants, but they have shown that they are on their way. The task, in reality, is common for the existing Amazon entities and for new entities that may appear. The task needs to be developed with everyone involved in an intimate partnership. This is what is usually said these days.

The storehouse of information and reflection that is collected here will be complete with the culmination of the announced trilogy. This is an important aid for dealing with theanxiety.

> I tried to spare the reader from excessive data that is presented in different formats. This was especially true concerning the inevitable mining of numbers, statistics, indices and rates. This digression was done extremely consciously and reflected its own more fluid current. However, the organic material that is captured is the same.

I will be happy if I have helped the reader become interested in the reading. I hope I have encouraged the reader to want to jump in to these warm waters.

> Better yet, to sum it up: my purpose here is nothing but to waken the readers' desire to quench their thirst in sweet, fresh, liquid, clean water. This is how all good potable water should be.

No color, no odor, no flavor — it's healthy. Water that sees the sun.

SOURCES

The scarce sources referred to in this introduction come from a selection of three publications that have just been released in Brazil. They represent different angles of the issue. 1. Marq de Villiers book ***Água (Como o uso deste precioso recurso natural poderá acarretar a mais séria crise do século XXI) (Water – How the Use of this Precious Natural Resource may become the Most Serious Crisis of the Twenty-First Century)*** *– Rio de Janeiro. Ediouro, 2002. This book is a previous repository of information on the subject and on the ongoing conflicts and disputes that are provoked or aggravated by the water issue; 2. UNESCO Notebooks* ***BRASIL****, Environment and Development Series, Vol. 3, Lord Selborne* ***Ethics in the Use of Freshwater: a study*** *– Brasília. UNESCO, 2002. This volume summarizes current global discussion of ethical foundations to be constructed for the solution of these disputes; 3. Benedictine Monk Marcelo Barros' book* ***O Espírito vem pelas Águas (The Spirit comes through the Waters)*** *– Goiás/GO. Editora Rede, 2002. This book approaches the question through the point of view of spirituality and the change in the focus of suggested solutions. Naturally, some* *of the basic information about the amount of ocean and freshwater, consumption, environmental disasters, necessities and involved interests are repeated in these three publications. I was greatly excited by the subject in* ***Amazônia: modos de (o)usar (The Amazon – Bold Use and Methods)*** *– Manaus. Valer, 2001. Of particular interest is the final liquidation on THE WATER CENTURY. Teilhard de Chardin is unique: the concepts used are taken from small texts in* ***Léxique Teilhard de Chardin*** *– Paris. Éditions du Seuil, 1963. Poems, films, novels, songs and other forms of text are absorbed without needing baptism certificates or official statements and diplomas. The reader that is interested in deep exploration of specific elements of the water issue in the world and in the Amazon should clearly consider bibliographic suggestions from other sources contained in the collected texts here. This is the issue for today and for this century. Q.E.D.*

3. EVALUATION OF THE ANTHROPOGENIC IMPACTS ON THE WATER CYCLE IN AMAZONIA

José Ricardo Santos de Souza
Edson José Paulino da Rocha
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1. INTRODUCTION: THE GLOBAL WATER CYCLE

The masses of the Earth and Sun, the orbital distances between them, and the resulting gravitational force have determined the physical evolution of this small planet, of a star of fifth magnitude in emitted radiation.

It is generally accepted that, as the Earth condensed, its heat loss to the space created a solid crust, with water over its surface. Water was emitted through the crust's interstices and, together with other gases, by volcanic eruptions. These gases, including the water vapor, constituted a primitive atmosphere, which evolved in its turn, to ever more complex substances, while water was deposited in liquid and solid form on the Earth's surface.

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The incident solar radiation flux and the atmosphere's thermodynamic properties established a negative temperature gradient with height, from the surface up to around 20 km of altitude. This defined an extremely thin atmospheric layer, called the troposphere. A sign inversion of the temperature gradient that occurs between this layer and the stratosphere inhibits the process of air and water vapor convection. This prevents rapid loss of water vapor, which would otherwise be able to escape the Earth's gravitational attraction. Even before reaching this temperature inversion level (called the tropopause), a humid air parcel may reach the temperature and vapor pressure necessary for condensation or sublimation on special aerosols called nuclei. The formation of water droplets and ice crystals (that is, hydrometeors) in high volumetric concentrations results in visible clouds. Some clouds allow for the hydrometeor growth and eventual precipitation, bringing the water previously evaporated back to the surface in the form of rain, snow, or hail. This water can accumulate in the oceans and seas, polar caps, icebergs, rivers, lakes, and subterranean waters.

The water is set in motion by solar energy and moves between the Earth's surface, the seas, and the atmosphere in a hydrologic cycle. The velocity of this cycle depends on, and is significantly determined by, the climate and vice-versa. The water sources that contribute to this hydrologic cycle make up the hydrosphere. Considering the fact that DNA is only reproduced in a watery solution, the existence of this hydrosphere in a relatively balanced state for millions of years is what has allowed life on Earth to occur, and it is necessary to its maintenance. Living beings and their remains are made up primarily of water. This is what represents the Earth's biosphere. It is worth noting that biological diversity is greater in regions where the climate includes a larger concentration of water and a higher velocity in the water cycle.

Disregarding the crystallization of water in lithospheric rocks and the existing water in the terrestrial magma, the hydrosphere contains approximately 1.39×10^{18} m^3 of water. In terms of percentages of this total, 97.5% is in salty water in oceans and seas. The remaining 2.5% of fresh water is distributed as follows: 1.8% frozen in polar caps and icebergs; 0.6% in subterranean waters in medium and deep aquifers; 0.014% in lakes and rivers; 0.005% in the soils; and 0.0001% in the atmosphere. Water in the biosphere is estimated as only 40% of that in the atmosphere.

Even though the aerial part of the water cycle involves such a small fraction of the hydrosphere, it plays a fundamental role in the fast water vapor transportation from one region to the other of the Earth, in the global balance of thermal energy, and consequently in the hydrological cycle (Houghton, 2002). In fact, water stored in ice caps and underground sources may not participate in the hydrological cycle for millenia, while on a global average, the water evaporated from liquid surfaces and soils and that transpired by living beings is totally recycled at intervals of about nine days (Peixoto and Oort, 1990). The water contained in the atmosphere is returned to the surface by way of precipitation. This occurs in shorter cycles in the Earth's tropical regions, such as the Amazon.

The water vapor in the atmosphere regulates the Earth's temperature by a natural greenhouse effect. The temperature near the surface is around 30° beyond what would be expected purely from radiative effects of solar energy on Earth without the humidity of the troposphere. Consequently, the interactions among hydrology, meteorology, and biology must be examined in order to understand the Earth's hydrologic cycle. This cycle incorporates energy exchange, the transportation of water vapor, precipitation, drainage, infiltration, and a variety of water storage mechanisms. These elements all depend on weather, ecosystems and other biospheric factors.

There are tremendous climatic variations and unequal distribution of water on the Earth. In general, there are three latitudinal high precipitation belts. One of these is located in the equatorial region and corresponds to the latitudinal belt covered by the Inter Tropical Convergence Zone (ITCZ) (Melo et al. 2002). The other two are in positions that are practically symmetrical and are located in middle latitudes in the two hemispheres. In these zones, vapor produced in neighboring zones converges at low levels and rises, producing widespread cloud coverage, and a predominance of precipitation over evaporation. In contrast, in some subtropical and polar zones, evaporation exceeds precipitation and generally coincide with the desert regions around the globe.

Mountain topography interferes substantially in the longitudinal distribution of water. The Andes mountain range, for example, blocks the transportation of humid air from the Atlantic Ocean and produces high precipitation rates on its east side. Desert regions are found west of the range, however.

The water content of the atmosphere falls exponentially with altitude. This means that 90% of precipitable water is found in altitudes of less than 5600 meters. Total atmospheric water mass is around 13.1×10^{15} kg. This is equivalent to a layer of uniform liquid water of 2.5 cm depth covering the entire planet's surface. Assuming an average value of one meter of annual precipitation for the entire planet, it is possible to estimate that the content of water in the atmosphere is recycled every nine days. This means approximately 40 complete cycles per year. In the tropics, particularly in the zones near the equator where the Amazon is located, the average estimated annual precipitation is between 2,300 and 2,500 mm. This means that water is recycled between the surface and the atmosphere about 2.5 times faster in this area. Therefore, approximately 100 complete cycles of evaporation and precipitation, involving all of the water in the atmosphere are completed annually.

The amount of humidity in the air in the Amazon reaches 25 grams of water vapor for each cubic meter of air. In the Polar Regions the absolute humidity is around 10% of this value. The seasonal variation for humidity in the air is about 2 times higher in the Northern Hemisphere than in the Southern Hemisphere. This is due to the larger ratio between the oceanic and continental surfaces in the Southern Hemisphere.

This brief introduction is an effort to clarify the origin of water on our planet. It is an attempt to describe the current main water reserves and the reasons for unequal water distribution that is caused by atmospheric circulation. The importance of weather, temperature and precipitation are clearly important to understand the interactions that occur between the oceans, the atmosphere, and the biosphere. These interactions determine the availability of fresh water in rivers, lakes, and subterranean reservoirs. The following discussion of the water cycle in the Amazon region seeks to analyze the current situation in that area and possible future scenarios of human impact on land uses, climate, weather, and associated surface waters.

2. WATER IN THE AMAZON BASIN

The amount of water held in the Amazon Basin has changed, as has much of its surface vegetation coverage, due to long-term geophysical factors. As an example we can mention the glacial periods of about 20,000-years recurrence and other factors of smaller time scale, such as the ENSO oscillation. However, when focusing on possible human impacts in this region, the Amazon water cycle over the last few centuries can be considered to have been in balance from a bio-geophysical point of view. In order to evaluate the determining factors in this cycle, beyond the global relationships that have already been discussed in the introduction, it is necessary to know on the regional scale, the distribution of the incident solar radiation and its balance on the surface (albedo, absorption, sensible and latent heat fluxes, evaporation and wind speeds). Therefore knowledge of the spatial distribution of: vegetation types, liquid surfaces, soil moisture contents, seepage rates, surface runoff, subterranean water flows, air humidity and temperature, precipitation, other gas fluxes to the atmosphere etc., are fundamental to understanding how local hydrologic resources are maintained or changed. Lack of data on a regional level has led Brazil and the international scientific community to carry out a huge research program during the last 5 years that has become the Large Scale Biosphere-Atmosphere Experiment in the Amazon (LBA). The three authors of this chapter have participated in this program, along with over two hundred researchers and students from Brazil and around the world.

The Amazon Water Basin drains into the Atlantic Ocean at a fluctuating rate that can exceed 300,000 m^3/second of water. This represents 20% of the world's surface fresh water flow. Where does this water come from if this system seems to be balanced? In a generic fashion, we know that the atmosphere brings water vapor primarily from the Atlantic Ocean, and also from the Pacific Ocean (this source mainly affects Colombia). Successive precipitation supplies and redistributes this water over the entire Amazon. The region acts like a sink for the water vapor in the same way that the resulting liquid water supplies the rivers and other water sources. Observational studies have demonstrated that the flow of humidity for the Amazon is mainly intensified in the eastern zone by high sea surface temperatures (SST) in the Atlantic. This higher SST zone coincides and determines the seasonal motions of the ITCZ (Marques, 1978; Marques et. al. 1979a; 1979b; Rocha (1991); Souza (1991). The annual average specific humidity in the Amazon varies between 16 and 19 g/kg (grams of water per kilogram of air) on the surface. The lowest average values of this variable are found in the southeastern part of the region and are around 14 g/kg. This humidity from the Atlantic penetrates the continent in successive evaporation and precipitation cycles (Marengo, 1992; Wagner, 1996; Nobre and Shukla, 1997), reaching the Andes within approximately 10 days. There, the vapor flow speed diminishes and the stream splits into two branches. One proceeds to the northwest of Amazonia and Central America and the other flows to the southeast direction, transporting humidity to the southern portion of the region.

This humid air forms convective clouds and precipitation with enormous spatial and climatic variability in some sub-regions (Ribeiro et al., 1996). The maximum regional precipitation occurs in the northwestern part of the Amazon. There is no dry season there, and monthly totals of above 200 mm occur during most months. Some authors (Salati and Vose, 1984; Figueroa and Nobre, 1990; and Marengo, 1992) suggest that this maximum might be associated with the concave shape of the Andes mountain range, which produces a convergence of humidity at low levels in that region. Although it is much lower, another precipitation maximum occurs on the Atlantic Coast of the Amazon. There are two major differences in seasons in this area, however. There is a dry spell from September to November when precipitation averages about 50 mm/month. Precipitation during the rainy season from February to May averages over 250 mm/month. This is caused by the ITCZ penetration that exceeds the squall lines, the westerly waves, mesoscale and local convection systems, as well as other factors that contribute to year-round precipitation in this sub-region (Cohen, 1996; Obregon and Nobre, 1990; Cohen et. al. 1995).

In the sub-areas located in the southeast and south of the Amazon, the dry season is more extreme during winter in the Southern Hemisphere. The rainy season is caused by the frequent presence of convective systems associated with frontal systems produced by the humidity that originates from the South Atlantic Convergence Zone and penetrates into the continent,. The heat and humidity collected in the Amazon are also transported to higher latitudes by the Hadley circulation and to other longitudes by Walker circulations.

The positive balance of this precipitation minus evaporation should take into account that the source of half of regional precipitation is found in its own evapotranspiration (Molion, 1975; Marques, 1978; Ferreira, 1987 and Souza, 1991). This balance supplies water to the soils and to the water streams of the largest humid tropical forest on the planet. This forest covers practically 8 million km^2, and represents 56% of the Earth's tropical forests. The three main water basins of this forest are the Amazonas, Tocantins and Orinoco rivers and their tributaries. The Amazon Water Basin drains in 80% of this forest area. This is approximately 5.688.000 km^2 (Nishizawa and Koike, 1992). Nine South American countries share this basin, although almost 5 million km^2 are found in Brazil. This water basin contains 10.5% to 12% of the world's total fresh water supply, representing about 70% of the Brazilian superficial water storage.

Why should we worry about preserving water now, when these abundant water resources exist in Brazil, especially in the Amazon? This question deserves special attention when one considers the speed with which human beings have affected these local water resources over the last three decades. Additional repercussions in other regions in Brazil and the world should also be considered since the domains of weather and climate are all connected, as evidenced by El-Niño and La-Niña phenomena and other fluctuations in oceanic surface and atmospheric temperatures. Analogous effects may result in changes in the Earth's atmospheric temperatures. Considering the area of the Amazon Region, it is expected that land use changes may alter local water availability and produce significant effects on the weather and water cycles of other parts of the planet.

3. HUMAN ACTIVITIES IMPACT ON WATER RESOURCES IN THE AMAZON

The indigenous population of the Amazon practiced subsistence harvesting for centuries without significant impact on its ecosystems. European colonizers and mixed-race populations represented only 90,000 inhabitants in this immense region in 1800. The population in the Amazon grew gradually, with a notable migration surge that occurred during the rubber boom (1850-1910). At the end of this period the region held 1,210,024 inhabitants (Bunker, 1980). A number of roads were built in the region from the second half of the 1950s to 1975. The largest were the Belém-Brasília and the Transamazônica highways. The population of the Amazon doubled from 1940 to 1970 and went from 1,462,000 to 3,604,000 inhabitants. However, the last thirty years of the twentieth century have seen a huge migration of population into the Brazilian Amazon. During this period, the population quintupled and is estimated today at around 17 million. It is worth mentioning in comparison, that the Brazilian total population did not double during this period, going from 90 million to 176 million, according to data from the Brazilian Institute of Geography and Statistics.

This population growth was facilitated by the opening of roads that were built to integrate the Amazon with the rest of Brazil. This allowed for large projects in mining (Carajás, Trombetas etc.), agriculture (Volkswagen, Jari Florestal, Swift Ranch), and energy (Tucuruí, Urucum and Belo Monte). Unregulated wood exploitation occurred, and the Brazilian government supported a policy of occupation and land use financing . This policy generated enormous devastation along the main roads in Southeast Pará and Rondônia, and in Northern Mato Grosso as the native forest was slashed and burned. A similar process had already taken place on a smaller scale in the Bragantina zone, eastward of Belém, in the beginning of the twentieth century after the construction of the Belém-Bragança railway.

Although scientific data are still lacking, we will try to produce a summary of the studies available in order to evaluate the current impact of this population on the water cycle in the Amazon. This will include changes in the energy balance at the surface, soil and air humidity, and the quantity of aerosols, as well as cloud coverage and precipitation in the sub-regions. This will also include evidence of disturbances in river flow, mangrove marsh waters, silt deposition, and deterioration in soil quality and in biodiversity. An effort will be made to correlate these elements with activities related to the construction of highways, railroads, and hydroelectric dams, as well as to wood logging and slash-and-burn activities. Other activities include agriculture, animal raising, mining, urbanization, and industrialization in the region.

3.1. Deforestation / Slashing and Burning

Deforestation consists of cutting down the native forest followed by burning the biomass. This has been a common practice that is extremely damaging to the water cycle, especially locally. It still takes place in the beginning of this century in the Amazon. This process is associated in one way or another with all of the other human activities mentioned above. Depending on the spatial scale of its execution, deforestation may result in irreversible damage to the water cycle. This damage includes climatic changes, locally and in areas far from the Amazon. Some estimates suggest that 7% to 10% of the forests in the Amazon had been destroyed by 1990 (World Resources, 1990), and that deforestation would continue at an annual rate of 1.7 million hectares.

The removal of the forest reduces the retention of humidity in the soil's top layer down to one meter in depth. It facilitates the sudden evaporation of water previously retained in the forest canopy and produces a new balance in surface radiation. This brings about an increase in albedo (reflectiveness) and in temperature (Salati, 1985). A study by Cutrim et. al. (1995) using satellite observations of the huge deforested area in Rondônia demonstrated the occurrence of widespread convection in the deforested area with the formation of shallow cumulus clouds that usually do not evolve into nimbus clouds and thus may not produce rain.

Forests are large natural producers of hygroscopic salts and organic fibers, which are expelled together with water vapor from the leaves' stoma during the transpiration process. These aerosol particles are transported by the air and, at higher elevations, will act as water vapor condensation nuclei. This process causes the formation of abundant clouds and represents almost 50% of recycled rainfall. These are the rains that result from evaporation in the Amazon region and that are not the result of direct transportation of ocean water vapor (Salati et al 1979; Eltahir and Bras, 1994). On a medium and long-term basis, removing the forest results in a decrease in the humidity in both the soil and in the air. It also results in a decrease in the concentration of condensation nuclei and in the cumulonimbus clouds that the region's water cycle so depends on.

The slashing and burning process suddenly increases the concentration of aerosols from 200 cm^{-3} to 20,000 cm^{-3}; that is, there are ten times more aerosols per cubic centimeter in the air during biomass burning. A huge amount of evaporation and convection of the humid air mass occurs from the surface heated by fire. This means that, on a short-term basis when the burning is occurring, this procedure causes more potential cloud coverage and precipitation. The harmful consequences for precipitation and the water cycle immediately follow the fire.

The bare soil loses its porosity through compaction and the rains may cause faster rainfall drainage, erosion and silting of the rivers and lakes. Even when the soil is recovered by small bushes or grass (Gash et. al. 1996; Hodnett et al., 1995; Rocha et al. 1996), there are significant micro-climatic changes on the surface. Comparative studies were performed between pairs of sites in the Southwestern (Ji-Paraná-Rondônia), Central (Manaus-Amazonas) and Eastern (Marabá-Pará) regions of Amazonia. These studies were part of an Anglo-Brazilian co-operation project called the Anglo-Brazilian Amazonian Climate Study(ABRACOS). As part of these studies, Gash and Nobre (1997) pointed out the following differences among the pairs: a) the forests absorbed 11% more solar radiation than the pasture areas did; b) the average albedo found in the Amazon forest was 13.4%, while the corresponding number for the pastures was 18%; c) the average temperatures of the forest soil were around 24.1°C, while those in the pastures reached 33°C during the day; d) the daily temperature variation for the forest soils at 20-cm depth did not exceed 2.8°C but was 8°C under the pastures, at the same depth (Souza et. al. 2002a,b); and e) the volumetric moisture contents within the upper first meter beneath pasture sites were generally 15% smaller than under nearby forests at the same depth interval (Souza et al., 1996). At about 2 m, the soil moisture beneath the pastures may exceed the corresponding values of 0.36 m^3/m^3 found under the forests. Down to the 4-m depth, the forest's root and leaf systems are always more effective in pumping water to supply the vegetation transpiration needs than the pastures. This indicates that removing the forest results in lower (20% to 30%) humidity in the air above the surface. The large-scale result would reduce precipitation by between 5 to 20%, according to the estimates of Nobre et. al., 1991. The results of numeric models put out by Lean and Warrilow, 1989; Henderson et. al, 1993; Manzi, 1993; Lean and Rountree, 1993; and Lean et. al, 1996 suggest that large-scale deforestation in the Amazon diminishes superficial drainage between 10 and 20% and increases the temperature of the air near the surface between 0.6 and 2.0°C. It would also prolong the periods of drought in the region. A near-surface air temperature change of the magnitude estimated by the numerical models for the continental scale of the Amazon could cause huge changes in the regional water cycle. This could also be inferred by analogy with the precipitation changes observed as a result of temperature anomalies of the same amplitude that periodically occur over the Atlantic and Pacific oceans. Moura and Shukla (1981) showed that when the SST are above average in the North Atlantic and below average in the South Atlantic at the same time that the ITCZ is found north of its climatic average position, the sinking branch of the Walker cell intensifies the subsidence in Central and East Amazon. This substantially reduces precipitation in these areas.

The studies of Nobre and Rennó, 1985; Kayano and Moura, 1986; Richey et al. 1989; Marengo, 1992, 1995; Marengo and Hastenrath, 1993; Montroy, 1997; Marengo et. al. 1998; and Souza et. al. 2000 corroborate the fact that positive anomalies of SST in the Equatorial Pacific (El-Niño) produce droughts in Central, Northern, and Eastern Amazon. This also occurs in the northern part of Northeastern Brazil. Corresponding negative anomalies (La Niña) produce abundant rains in the above-mentioned sub-regions.

The question immediately facing us is how to quantify the effect of these similarly predicted continental thermal anomalies. They may become larger and even permanent and represent a different type of phenomenon than those that periodically occur in the oceans, affecting the water cycle in the Amazon. With the impossibility of performing a large-scale deforestation experiment, the approach at this time is to make estimates through numerical models as were done in the previously cited works. Conclusions from these studies are still being discussed (for instance, by Rocha, 2001 and Gandú and Cohen, 2002) in terms of the magnitude of the effects, but not regarding the impact itself, which certainly is expected and will be important.

The cumulative effect of slash-abd-burn deforestation has already produced mesoscale effects of destruction in the eastern part of Amapá, the east and southeast of Pará, the northeastern part of Mato Grosso, and central Rondônia (Fisch et al. 1997). The total numbers of devastated forest are estimated to be between 250,000 and 500,000 km^2. This represents between 7 and 14% of the Brazilian part of the forest. The highest rates for slashing and burning occurred in 1987. The Brazilian government has corrected earlier policies for occupation and land prices in order to discourage the devastation of the Amazon Forest. Nonetheless, at the end of August 2002, the NOAA-12 Satellite , detected around 10,300 fire sites (or heat spots) monthly in the region. The State of Mato Grosso was the annual leader with 26,400 registered fire spots in the first 8 months of the year. Each heat spot represents 1 hectare on the satellite image. Each hectare of forest contains over 100 m^3 of biomass of 300 kg/m^3. It can be estimated that 900,000 tons of aerosols and gases are sent into the atmosphere annually in the Mato Grosso region alone. The fact that perhaps the majority of these burnings are taking place in previously deforested areas should be taken into account. These areas are currently used for agricultural and animal raising purposes. However, this does not diminish the concern with the continuation of native forest destruction that is estimated to have grown 10% between 2001 and 2002. These estimates are based on the number of fire spots that were detected.

The release of carbon monoxide and dioxide and other gases into the atmosphere could eventually increase the greenhouse effect, causing heat retention near the surface and an increase in air temperature. Long-term studies of CO_2 exchanges between the Amazon forest and the atmosphere indicate that the absorption of this gas during photosynthesis exceeds its emission through plant respiration at a rate of around 1 to 9 tons of carbon per hectare, per year.

It has not yet been possible to establish a balance between the absorption of carbon and the consequent increase of biomass versus the loss caused by burning. What is known is that the signal of possible CO_2 emissions from the Amazon to other parts of the planet is practically non-existent. This means that there is no evidence that the region is a source of CO_2 in global terms. This could mean that the forest reabsorbs practically all of the CO_2 that is produced by the burnings through acceleration of growth and retention in biomass of other sub-areas of the region. This atmospheric "fertilization", followed by higher rates of carbon incorporation, is possible but has biophysical limits however, and there is no guarantee that this balance will be maintained in the future. As we have mentioned, if the greenhouse effect increases the surface temperature of the forest, the consequences could be disastrous for the water cycle.

3.2. Local water impacts

The water cycle in the Amazon has been disturbed, as has occurred in other parts of the world as well, by the construction of railroads and highways, agriculture, animal raising, mining, urbanization, and industrialization. There is not much data available in the scientific literature on the small-scale effects on local water resources and even less is available on the cumulative effects of these human activities on regional water resources. Nevertheless, it is important to emphasize these actions as vectors of native forest destruction and evident qualitative changes in the local distribution of water resources.

3.2.1. Roads and highways

The 500% growth in the Amazonian population that has been verified over the past 30 years did not take place mostly along the rivers as in the past. Regional access and transportation routes were increased by a network of roads and highways that were built to allow for migration and colonization. This occurred as a way to assure Brazilian sovereignty over its geo-political frontiers. Thus huge highways were built, such as the Belém-Brasília, Transamazônica, Belém-Marabá, Santarém-Cuiabá, Manaus-Boa Vista and Rio Branco-Perú routes. In addition, a network of secondary roads in Rondônia and the Carajás-São Luís railroad naturally brought about increases in economic activities. At the same time, they facilitated enormous destruction of the forest alongside the roads.

The roads frequently block the normal flow of surface waters in small streams. This often causes flooding on one side of the roads and environmental degradation along the borders. Precarious bridges are constructed below the high water levels of the rivers they cross, and they frequently create obstacles to the drainage capacity of the rivers. At times the currents destroy the bridges. Sometimes, as in the case of the Bragança-Ajuruteua route in Pará, access to the beach was made possible through a mangrove marsh. The marsh had 150 hectares damaged by the landfill damming of waters that occurred because of the road. This is just an example of using cheaper civil engineering methods for road construction, with serious damage to the environment in this Region.

3.2.2. Agriculture and animal raising

Selective wood extraction causes species losses but apparently does little damage to regional water resources. On the other hand, the devastation of the forest that has occurred for agriculture and raising animals has had significant damaging effects on the forest since the beginning of the last century after the construction of the Belém-Bragança railway. Part of the microclimatic changes that were produced have been partially quantified by the previously mentioned ABRACOS and LBA projects. These changes are related to losses in biomass, changes of water, temperature and soil fertility, as well as in balances in surface energy, humidity, and precipitation. Other changes have been surveyed in relation to climatic implications in CO_2 recycling.

The introduction of machines in soybean cultivation in Southeast Pará has been extremely worrying. This is true primarily in terms of the compacting and loss of porosity that may occur in regional clayey loam soils. This is an almost certain consequence of this type of cultivation, as Bruijnzeel (1996) pointed out

Pollution in the water routes, caused by the use of agricultural pesticides and fertilizer products. Raising animals in open pasture fields may cause soil erosion and silting of the rivers. These effects need to be studied further in order to provide a better evaluation of their impact on water resources.

The destruction of the forests to plant grass to feed cattle should be condemned from an economic point of view and even more so from an environmental, biological, and climatic point of view.

3.2.3. Mining and industrialization

There is a high environmental price paid for the large-scale mining that occurs in the Carajás Mountains. The cost is lower than the cost of agricultural and raising animals, however. Beyond the problem of vegetation destruction, there is the problem of the waste disposal from the mining purification processes of iron, copper, and other ore metals abundant in this area, which is one of the largest mineral provinces on Earth.

One should be concerned with the decisions to introduce coal into the region's pig iron production, considering its dangerous consequences. This process has a potential to consume an enormous quantity of the nearby forests' wood and may significantly alter the local water cycle.

The exploitation of bauxite in Oriximiná, Pará, has already damaged the Trombetas River basin. This exploitation almost destroyed the Batata Lake because of extensive silting. There was no legal punishment for the mining company responsible.

Even gold extraction processes and tin mining processes that are practiced by miners in the region have caused appreciable destruction. This has occurred in the Serra Pelada gold mine and other places contaminated with mercury, such as the Tapajós River and numerous other areas in the Amazon Region.

Recently, PETROBRAS began extracting natural petroleum gas in the Urucum River in the State of Amazonas. Although the impact of this decision may seem small in regional terms, it is important to monitor and prevent possible contamination of the air and rivers that may occur as effects of the industrial processes. Transportation accidents can also contaminate the waters. This type of pollution is potentially disastrous for the regional flora and fauna.

Large industries are still not very numerous in the Amazon. However, precautions must be taken in the aluminum industry processes of ALUNORTE and ALBRÁS in Barcarena – Pará to ensure that solid and liquid residues do not accidentally contaminate the water flows, as well as the subterranean water in that location. Gases are produced in the electrolyte cubes, and carbon fumes are emitted in anode production. These are released in the atmosphere of Barcarena, bringing about the possibility of acid rain.

It is worth noting that the rain in the Amazon is generally acidic. There are many areas in the region where the soil and water have a PH lower than 7. Rainwater analyses have been performed at different stages of single precipitation events and in different events during one year. The rainwater samples taken in Belém (Santos and Souza, 1988) indicated PH varying between 2.8 to 5.6, with an average of around 4.2. Meanwhile, chemical analyses were not detailed enough to verify if this acidity was due to natural carbonic acids or if it was caused by nitrous and sulfuric acids. These last acids are generally associated with deforestation and the burning of fossil fuels, respectively (Johnson et. al. 1984).

Due to the high relative humidity (nearly 80% on average) and the high rate of water recycling in the Amazon, air pollutants are not transported for long distances. Precipitation generally cleans the atmosphere and returns the pollutants to the surface a few kilometers away from their primary sources.

3.2.4. Urbanization

Urbanization is a process associated with the huge population increase of the last three decades in the Amazon. The largest capitals in this area are Belém and Manaus. In addition, other urban centers have emerged and expanded during this period. This has caused the soils to become impermeable, causing industrial and sewage water to drain into open air channels and into the region's rivers. The consequent contamination of surface waters has already affected the use of underground water supplied to individual buildings, industries, and even for the public use.

The cities have become heat islands, subject to floods and the frequent occurrences of cloud-to-ground lightning at observed rates of 7 events per km^2 per year as compared to 2 events per km^2 over nearby forested areas (Souza and Rocha, 1999). In addition to the general deforestation that occurs in the region, the cities generally lack trees. They are sometimes hot and uncomfortable places with diseases (such as malaria and dengue) that are carried by water or by mosquitoes that use water in their reproductive cycle.

3.2.5. Dams and hydroelectric plants

The use of dams in generating electric energy is last, but certainly not least, in terms of local impacts on the water cycle. With high population growth and development efforts in the Amazon, the Brazilian government started in 1970 to invest in constructing hydroelectric plants in Tucuruí on the Tocantins River, Curuá Una on the Curuá Una River, Balbina on the Uatumã River, and Samuel on the Jamari River. ,The Belo Monte project on the Xingu River is currently under environmental impact studies.

In reality, the Amazon has enormous hydroelectric potential, and the pluviometric regime shows small fluctuations when compared to other regions in Brazil. In a search for "clean", low-cost energy, Brazil has constructed an energy matrix that is dependent on hydroelectric plants for over 80% of its electric power. The Amazon is the Brazil's last considerable potential reserve. However, this use does not occur without damage to the environment and changes in the water cycle.

We will use the Tucuruí reservoir as an example. This reservoir corresponds to an artificial lake of 2,430 km^2 (Fisch et al, 1997) to generate 8,370 MW of energy by 2006. Through the decomposition of submersed organic material (Santos et al., 2002), the creation of this lake generated greenhouse gases, CO_2, CH_4, and others that have not yet been specifically quantified. Evaporation of this huge water layer, according to Sanches, 2002 and Sanches and Fisch, 2002, brought on the rainy periods a month earlier. This shortened the period of drought and significantly increased precipitation in that location. It is worth mentioning that flooding of the Tucuruí dam during the El-Niño period in 1983 provoked an increase of water salinity in Guajará Bay, in Belém. This bay is around 80 km from the Atlantic Ocean.

4. CONCLUSIONS AND RECOMMENDATIONS

There is an unfortunate lack of conclusive studies about the various impacts humans have on the water cycle in the Amazon. In addition to the LBA projects and the subsequent

Millennium project, the Brazilian and international scientific communities must make a continuous effort in order to quantify local and regional alterations in water resources. It is essential to determine if the variations in the discharges in the Amazonas and/or its tributaries are a consequence of human damage to the environment or if they are due to climatic variables (Richey et. al., 1989; Duarte et al., 2002) that are common on a global scale.

Economic and ecological zoning must occur in the Amazon. This needs to focus on development that will be sustainable while minimizing the impact on Amazonian ecosystems.

The expansion of access routes to the region needs to be limited. There needs to be a return to using rivers as transportation routes. It is unjustifiable to construct dams like Tucuruí and then 20 years later still not have completed the locks that would allow for full navigation and fauna access migration to the headwaters on the Tocantins River.

High priority must be given to physically determine the limits of the reserves designated to indigenous tribes that have already been contacted and that will potentially be contacted.

Extraction reserves should be created with plantations of high economic value species that will be introduced and managed in a sustainable fashion. Totally preserved national forests (FLONAS) should be created, and forest reserves that already exist, like Caxiuanã, should be increased in numbers.

There should be legal constraints and penalties for arbitrary deforestation and burning. Incentives for reforestation should be created on federal and state levels for native or threatened tree species like mahogany, cedar, acapu, sucupira, pau amarelo, rosewood, macacauba, and other species of high economic value that are also important in the region's water cycle.

A "green label" should be created and conferred by IBAMA (Brazilian Environmental Institute) to forest products obtained through means that sustain the species.

A program for reclaiming the areas that have been degraded by agriculture, animal raising, and deforestation should be created and should include fiscal incentives when necessary.

The State Secretariats of the Environment in the Amazon should be equipped to monitor and analyze reports on environmental impact.

Finally, SIPAM (Amazonian Protection Monitoring System) has an important role to play in monitoring water resources through its initial 200 platforms for hydrologic data collection and precipitation estimates via radar, lightning detectors, and satellite images analysis.

IBAMA and the National Water Agency should be equipped to improve the efficiency of their monitoring processes and should improve co-operation with the Federal Police in order to effectively punish those who disobey environmental laws and pollute water resources.

Brazil should also have access to data from the LANDSAT series, MODIS, TERRA, GOES, NOAA-12 and TRMM (Mota and Zipser, 2002) satellites and from the Brazilian AQUA (Veissid, 2002) satellite now in space. Brazil should also have teams to interpret this data. These teams should work toward guiding the planning efforts and surface teams in monitoring surface reflection, vegetation growth, soil uses and soil degradation, and aerosol content in the atmosphere. This examination should also include air temperature profiles, cloud studies (dimension, droplet size), earth and ocean surface temperature, and other important biophysical factors that influence the water cycle in the Amazon.

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4. POLLUTION OF NATURAL WATER RESOURCES IN AMAZONIA: SOURCES, RISKS AND CONSEQUENCES

Norbert Fenzl *
Armin Mathis **

1. POLLUTION IN AMAZONIAN RIVERS – GENERAL ASPECTS

It seems somehow contradictory to talk about pollution of Amazonian Rivers if we simply compare the geographical dimension of this immense "water planet" and the low density of its population.

However, we will see that the antropic impacts are largely amplified in such a sensitive ensemble of complex ecosystems like Amazonia.

The Amazon River Basin, the largest in the whole world, covers an area of 6,925,000 km^2, from the Andes to the Atlantic Ocean, north of Brazil. The basin spreads throughout the following seven South-American countries:

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Countries	Area (km²)	Participation in the Basin (%)
Bolivia	954,340	15.61
Brazil (*)	4,718,067	63.88
Colombia	986,600	16.14
Ecuador	141,000	2.31
Guyana	82,250	1.35
Peru	36,980	0.60
Venezuela	6,437	0.11

Source: MMA, 2003

(*) Including the Tocantins River Basin with 813,674 km^2.

The largest part of this extensive hydrographic basin (63.88%) is located within Brazilian territory, including seven local States:

States	Area (km²)	(%) of the Basin	(%) of the State
Acre	153,149.9	3.92	100.0
Amapá	44,870.2	1.15	31.3
Amazonas	1,577,820.2	40.41	100.0
Pará	1,049,903.5	26.89	83.8
Rondônia	238,512.8	6.11	100.0
Roraima	225,116.1	5.77	100.0
Mato Grosso	615,020.1	15.75	67.8

Source: IBGE, 1994.

The Amazon River Basin has a tropical humid climate and an average discharge of 209,000 m^3/s (MMA, 2003).

With an extension of 6,600 km, and a depth reaching 100m in some areas, the Amazon River, carries around 15% of the average worldwide superficial water flow, which is 992,6°mm/year.

The whole Basin has two types of rivers: the plain rivers, such as the Amazon itself, the Madeira, Içа-Putumaio, Purús, Juruá, and Negro rivers; and the highland rivers, such as the Xingú, Tapajós, Trombetas, and Jari rivers.

The resident population is of approximately 6,700,000 inhabitants (IBGE, 1996), roughly corresponding to 4.3% of the Brazilian population. So far, the demographic density is very low, counting 1,7 inhabitants for 1 (one) km^2, much lower than the average Brazilian population density, which is 18.4 inhab/km^2 (IBGE, 1996). Therefore, the population occupancy rate – and the subsequent antropic activity rate – is very reduced in the Amazon River Basin, when compared to other basins within the Brazilian territory.

Due to the high amount of water availability and the low population occupancy rate, the Amazon River Basin, when compared to other Brazilian basins, has the highest annual rate of water availability per capita: 984,000 m^3 for each inhabitant per year.

Under such circumstances the former question, how we can explain that in such huge territory with such a low density of inhabitants, very few industry compared to the area, we can observe considerable problems of environmental pollution?

As we know until now, there are two basic groups of activities responsible for the pollution of the aquatic environment: mining on industrial and small scale (gold mining) and forest burning.

Still less important and less investigated, the uncontrolled use of pesticides, especially in agro industrial activities, probably is one of the most serious environmental problems Amazonia will have to face in the future.

Actually, the pollution of the natural water resources of Amazonia is largely focused on Mercury and Arsenic. Both pollutants are relatively well studied and its different environmental effects are known. In the case of Mercury it is important to note that, recent investigations are able to show that forest burning causes an important Mercury input into the aquatic ecosystems of Amazonia.

2. MERCURY

2.1. Introduction

Mercury is a significant toxic metal occurring naturally at low concentrations in the earth's crust (soil, rocks, coal and copper ore, etc.). The problem is that Hg is very toxic in even low concentrations, so, small increases of the metal in the environment, can have serious impacts on human health. While trace amounts of mercury have always been present in the environment, its concentrations have been increasing to dangerous levels due to human activities such as coal burning and large forest fires, as in the case of Amazonia.

When coal or forests are burned, mercury is released in the air and can be carried by winds over large areas, far from its source before being deposited on soil and bodies of water. Actually the largest source of mercury in the atmosphere is the combustion of fossil fuels and waste. In the USA, combustion accounts for approximately 84.9% of all atmospheric emissions of mercury, 30% of which is emitted by medical waste incinerators[1].

The absorption of Hg by bio-organisms is called bioaccumulation. The most toxic form of Hg, methyl mercury, is produced by bacteria activity or chemical reactions in rivers or lakes and absorbed by aquatic micro-organisms, which are consumed as fish food, at the beginning of the food chain. So, Mercury is stored in increasing quantity in all members of the food chain, until it reaches the human organism at the top of the chain through fish consumption.

In small concentrations, Mercury is a neurotoxin, affecting the nervous system with varied health effects ranging from mental retardation to death. Special care has to be taken by pregnant women because the placenta is extremely sensitive to Hg accumulation and causes direct exposure to the developing fetus.

The worldwide most famous incidents of human Hg exposure are Iraq and Japan. In 1972, 6,500 Iraqi adults and children developed neurological problems and 459 people died after eating fungicide contaminated grain containing methyl mercury. In Minamata, Japan, 700 people died, 9,000 individuals suffered different degrees of paralysis and brain damage, and 50,000 individuals experienced at least mild symptoms after being exposed to methyl mercury in seafood they consumed. During the last decade, increasing concern about Mercury (Hg) pollution in the Amazonian ecosystems encouraged numerous research groups to study the causes, the real extension and the social consequences of the problem. Despite the great volume of data and information collected during the last years, the biogeochemical cycle of mercury is still poorly understood.

Earlier research groups concentrated their attention primarily on gold-mining areas, because it was thought that they are the main responsible for the Hg contamination of aquatic ecosystems (Malm et al., 1990; Nriagu et al., 1992, Pfeiffer et al., 1993; Malm et al., 1995; Fenzl, N., et al., 1997; Nascimento, F. et al., 1997; Fenzl, N. et al., 1998; Silva Maurice-Bourgoin et al., 1999).

More recently, studies showed that Hg dissemination and contamination are not only related to gold mining activities, but are probably a combination of soil erosion,

[1] Guy Williams: Mercury Pollution Prevention in Healthcare, www.great-lakes.net/lists/enviro-mich/ 1997-07/msg00107.html, 1997

gold mining, and forest fires. Evidences of such affirmation resulted from high non-anthropic mercury concentrations found in superficial mineral horizons of forested oxisols (Roulet and Lucotte, 1995). For example Roulet et al. (1999) sustain that more than 97% of the Hg accumulated in soils of the Tapajós basin are due to natural sources. This explains the exceptionally high mercury levels (44 - 212 ng/g) detected in soils of the Negro River basin with little gold-mining activity (Silva-Forsberg et al., 1999).

An interesting result was also announced by Hans Friedli and Larry Radke, who investigated biomass burning as a potential source of atmospheric mercury, when the high levels of mercury threatening Arctic Inuit communities called their attention[2].

They collected samples from seven forests across the continental United States and had them burned at the U.S. Forest Service Fire Science Laboratory of Montana. All the coniferous and deciduous samples contained mercury at levels ranging from 14 to 71 nano-grams per gram of fuel. Ground litter had the highest concentrations, reflecting accumulation during annual or biannual cycles before the leaves or needles were shed. An important result was the fact that, the samples released 94 to 99 percent of all the mercury they had stored.

The authors extrapolated their findings to global biomass burning and estimated the contribution at up to 800 tons (730 metric tons) per year, or 25% of all anthropogenic sources.

These results are an important contribution for understanding the dynamics of Hg pollution in Amazonia.

Actually, it seems to be a consensus that two main sources are responsible for Hg dissemination in the Amazonian basin: historical atmospheric inputs from natural processes (p.ex. volcanism), described especially in the Madeira River basin, and anthropogenic inputs from colonial (1550-1880) and modern gold-mining activities.

The process of Hg dissemination is closely related to the transformation from inorganic to organic mercury (mostly– methyl mercury, MeHg) and its bioaccumulation in the aquatic food chain, where fish seems to be the main source of human contamination (IPCS, 1990).

Since fish is a basic item in the diet of a great number of Amazonian communities, the relationship between fish consumption and Hg exposure has been demonstrated in several publications.

MeHg concentration in hair is the most useful indicator for contamination, because hair binds MeHg proportionally to its concentration in blood and its concentration remains constant. So far, MeHg measurement in hair is also useful to get information about the

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2 Hans Friedli and Larry Radke, Wildfires and mercury pollution: A smoking gun? - www.ucar.edu/communications/staffnotes/ 0107/mercury.html, July 2001

history of MeHg exposure over the recent past, Goulding (1980), Moran (1990), (1988) Boischio & Henshel, (1996).

In general, clinical symptoms of intoxication can be noticed only above a certain critical MeHg concentration in hair and the intensity of such symptoms is different for adult and prenatal life. Children with highly intoxicated mothers may present different types of neurological disorders like cerebral palsy, including microcephaly, hyperreflexia, and gross motor and mental impairments. Serious symptoms of MeHg intoxication like troubles of speech and hearing and even death were observed at hair Hg concentrations in the range of 200 to 1,500 ppm (Clarkson, 1997).

2.2. Hg Exposure and Fish consumption in Amazonia

Several studies in the Amazonian Basin have shown that riverine populations are exposed to methyl-mercury through fish consumption. Dolbec, J., Mergler, D., Larribe, F., Roulet, M., Lebel, J., Lucotte, M. (2001)[3] investigated the relationship between fish-eating practices and seasonal variation in mercury exposure in 36 women from a village located on the banks of the Tapajós River, a major tributary of the Amazon. The results showed a clear Methyl Hg contamination of the investigated population with higher hair mercury levels in the dry season compared to the rainy season. So, the research proved the relationship between mercury exposure of riverine population and the type of consumed fish species.

2.3. Methyl Hg concentrations of different sediments and soils

Roulet M., Guimarães J.R.D., Lucotte M. (2001)[4] investigated the spatial and seasonal variations of Methyl Hg concentrations in different sediments and soils of the Tapajós River floodplain, a typical Amazonian floodplain ecosystem. The results confirmed previous observations, in the same study area, of net 203Hg methylation potentials and the fact that fresh and labile organic matter in the litter of these floodplains are the most important factor leading to significant enrichment of MeHg in these particular environments.

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3 Dolbec, J., Mergler, D., Larribe, F., Roulet, M., Lebel, J., Lucotte, M. Mercury contamination and fish diet of an Amazonian population (Brazil). In: The Science of the Total Environment, 271 (1-3): 87-97

4 Roulet, M., Guimarães, J.R.D., Lucotte, M. Methyl mercury production and accumulation in sediments and soils of an Amazonian floodplain - effect of seasonal inundation. In: Water, Air and Soil Pollution, 128 (1/2): 41-61.

2.4. Hg in waters of the Tapajós and Amazon rivers, Brazil

Roulet M. et al. (2001)[5] investigated the mercury (Hg) concentrations in the surface waters from the Tapajós River, the Arapiuns River, its principal tributary, and the Amazon River at its confluence with the Tapajós. Normally Hg concentrations in Amazonian rivers are governed by the concentration of suspended particles. Hg concentrations in the filtered water showed to be lower than 2,8 ng/L in all samples. On the other hand, concentrations of fine particulate Hg reached values up to 29,7 ng/L. The study shows that the dominant stock of Hg in the aquatic ecosystems of this region originates from erosion of natural soils in the catchments rather than from anthropogenic pollution. The authors sustain that the input of natural Hg coming from soils into the aquatic ecosystems may have increased over historical levels in the region and could be responsible for high methyl mercury levels recently reported in fish and human beings.

2.5. Mercury concentrations in waters, fishes and human mercury exposure of the Upper Madeira Rivers, Bolivia

Investigations of mercury concentrations (in river water, suspended particles, fish and human) were conducted in the upper Madeira Rivers of the Bolivian Amazon basin (Maurice Bourgoin, L., Quiroga, I., Chincherros, J., and Courau, P., 2000)[6].

The total mercury concentrations measured in surface waters of the upper Beni basin varied during the dry season, from 2.24 - 2.57 ng/L (Zongo river) to 7.00 ng/L (Madeira River, Porto Velho) and 9.49-10.86 ng /L at its confluence with the Amazon.

The results obtained from fish indicated surprisingly high Hg concentrations in 86% of the piscivorous fishes collected in the Beni River, exceeding almost four times the WHO (1976) safety limit. Beni River omnivorous and mud-feeding fish samples showed Hg concentrations from 0.02 to 0.19 µg/g (wet wt.), while piscivorous fish Hg concentrations reached values up to 2.30 µg/g (wet wt.).

The results of human mercury exposure were based on samples form 80 individuals spread over the entire Bolivian Amazonian basin. Indigenous people living on the banks of the Beni River showed high average levels of mercury (9.81 µg/g) and increasing contamination in young breast-fed children, confirming that hair mercury concentration in babies was significantly affected by maternal mercury contamination during pregnancy. These results show that the major health impacts caused by mercury are basically due to a regular fish diet, instead of gold mining activity.

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5 Roulet, M., Lucotte, M., Canuel, R., Farella, N., Goch, Y.G. F., Peleja, J.R.P., Guimarães J.R.J., Mergler D., Amorim M. (2001) Spatio-temporal geochemistry of Hg in waters of the Tapajós and Amazon rivers. Brazil. Limnology and Oceanography, 46 (5): 1141-1157

6 Maurice Bourgoin, L., Quiroga, I., Chincherros, J., and Courau, P., (2000) Mercury distribution in waters and fishes of the Upper Madeira rivers and mercury exposure in riparian Amazonian populations. The Science of the Total Environment, 260 (1-3): 73-86

2.6. Human Hg contamination along the Upper Madeira Basin, Brazil

Mercury exposure of riverine people living along the Upper Madeira Basin, in the Brazilian Amazonia, considered as heavy fish eaters, has been investigated by Boischio, Cernichiari and Henshel (2000). [7] Ten members of a single family with a similar diet showed a very wide range of Hg hair concentrations (from 8 to 339 ppm), but the interesting result was, that even the same person showed a wide range of 136 to 274 ppm Hg hair concentration over time. The research confirms other investigations pointing out the fact that Hg exposure is directly related to the type of fish and the period of consumption.

3. PESTICIDES

Pesticides, considered as potentially harmful, are widely used in the Brazilian Amazonia, but scientific information about environmental and human pesticide contamination is still relatively difficult to obtain.

As an example of a specific case study we can mention Roulet M. and Lucotte M. (2001)[8] who investigated pesticide contamination in the county of Santarém (State of Pará, Brazil), during the years 1997 and 1998. The results revealed the use of several organophosphates, synthetic pyrethroids, carbamates insecticides and different types of herbicides and fungicides for agriculture, domestic, and sanitary purposes. The research provides also an idea about the quantities of the most commonly used insecticides in agriculture, like *Chlorpyrifos, Malathion, Metamidophos,* and *Methyl parathion.*

The investigation concludes that the estimated annual consumption for these four compounds is about 1,910 kg, which seems to be lower than the Brazilian average in terms of "per capita" and "per agricultural area". Nevertheless, if we consider the fact that relatively high concentrations of toxic organic substances have been detected in such sensitive environments, we must assume that pesticide pollution in Amazonia is already a problem to be faced and requires much deeper investigations. Very similar results were reported in the large cotton plantations along the Pacific coast of Nicaragua (Fenzl, N., Castillo, J.A, Guillén, S., Nascimento, F., 2000)

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7 Ana Amélia Peixoto Boischio, Elsa Cernichiari, Diane Henshel: Segmental hair mercury evaluation of a single family along the Upper Madeira Basin, Brazilian Amazon. Cad. Saúde Pública, Rio de Janeiro, 16(3):681-686, jul-set, 2000.

8 Roulet, M. and Lucotte, M. Characterization of pesticide consumption of the municipality of Santarém, Brazilian Amazon. In: Acta Amazônica, 30 (4): 615-628.

4. TRACE ELEMENTS

In Amazonia, most of environmental research and health concern are focused on Mercury and Arsenic pollution in water and sediments. But there are other trace elements catching increasing attention.

For example, the distribution of several trace elements (Ba, Cd, Co, Cs, Cu, Mn, Mo, Ni, Pb, Sr, U, V and Zn) was investigated in dissolved and suspended matter of surface waters in the Mamore and Beni rivers, in the Bolivian part of the Amazon basin.[9]

The authors of the investigation pointed out important differences between the hydro geochemical Mamore and Beni basins.

The Andean tributaries of the Mamore River are characterized by high concentrations of Mn, Sr, Mo, Ba and U. On the other hand, the tributaries of the Beni River are characterized by high concentrations of As, Zn, Cd and Cs.

The majority of trace elements, even in higher concentrations, are of geological origin, except the high Zn, As, and Cd concentrations measured in the Taquesi River, which can be explained by important mining activities.

5. ARSENIC

5.1. Introduction

Arsenic is a metal that is widely distributed around the earth's crust. It comes into water as a result of the dissolution of minerals and ores, other sources are industrial **waste** or the combustion of fossil fuels. In water, arsenic is found mostly as trivalent arsenic (As (III)) or pentavalent arsenate (As (V)). Organic arsenic is less harmful to health.

The world production of arsenic trioxide is about 35,500 tons. The greatest producers are China (16,000 t) and Chile (8,000 t). Arsenic trioxide is used for the production of wood preservatives and some herbicides. Arsenic metal is employed to improve corrosion resistance and tensile strength in copper alloys (Reese Jr. 2001).

5.2. Arsenic and health

The toxic effects of arsenic are long known. Concentrations of more than 60 ppm of arsenic in drinking water are lethal (Wilson 2002). The absorption of arsenic by skin is

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9 L. Maurice-Bourgoin, F. Gasc, P. Seyler, F. Elbaz Poulichet, Trace elements distribution in the Andean sub-basins of the Madeira river: role of the weathering processes in the freshwaters geochemistry. In: *Manaus'99 – Hydrological and Geochemical Processes in Large Scale River Basins.*

no source of risk. Chronic arsenic poisoning, as a result of a long-term exposure through drinking water, has different symptoms when compared to acute poisoning. Acute poisoning can be identified by vomiting, esophageal and abdominal pain (WHO 2001). The symptoms and signs caused by arsenic are different from individual to individual, population group, and geographic area. "Long-term exposure to arsenic via drinking-water causes cancer of the skin, lungs, urinary bladder, and kidney, as well as other skin changes such as pigmentation changes and thickening (hyperkeratosis)" (WHO 2001). In addition, there is the possibility of increased risk of lung and bladder cancer.

The guideline values for allowable concentration of arsenic in drinking water were constantly reduced since 1958, when the WHO established 0.20 mg/L as maximum. In 1993, the World Health Organization established as a provisional guideline value for arsenic 0.01 mg/L for drinking water. Brazil adopted this value in 2000.

Cases of chronic arsenic poisoning were reported in several countries around the world: In some cases, as a result of leaching from mine tailings (for example Canada, Australia, Japan, Mexico, Thailand, United Kingdom and United States); in other cases as a result of arsenic in natural aquifers used for water supply (for example Argentina, Bangladesh, Chile, China, Ghana) (Wilson 2002). In Bangladesh, about 29 million people are exposed to arsenic contamination of groundwater by geological originated arsenic. The drinking water they consume comes from tube wells that show a level above 0.05 mg/L). [10]

5.3. Arsenic pollution as result of mining activity in the Amazon

Until the late 90's, mercury was the unique trace metal of anthropogenic origin that scared the public opinion. This changed in 1997, when soil and groundwater Arsenic contamination was discovered in the area of ICOMI in Santana – AP. Between 1957 and 1997, ICOMI, a Brazilian company, explored manganese at the Serra do Navio, distant about 200 km from the city of Santana. During its operational period, the mining company explored and exported around 34 billon tons of mineral (Scarpeli 2002). In 1973, ICOMI started to produce pellets from the fine grain mineral, that could not be sold *in natura*. The unit worked until 1983 when a market for fine grain mineral was established. From 1989 to 1996, the same unit produced sinter. The tailings from the pellets and sinter production and the malformed pellets and sinter, about 75000 tons, were stocked near the unit in an open pit-tailing dam that in its deeper parts reached the groundwater level. The heating of the fine mineral during the formation of pellets (900° to 1000° C) and sinter (700° C) transformed the chemical structure of the manganese mineral, allowing the

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10 For details about the arsenic contamination in Bangladesh see Ahmed (2002), Fazal, A. / Kawachi, T. / Ichion, E.(2001), Watanabe, C. / Miyazaki, K. / Ohtsuka, R. / Inaoka, T. (2001), Rashid, H. / Mridha, A.M (1998), Hug, S. / Weglin, M. / Gechter, D. / Canonica, L (2000).

releasing of parts of the arsenic contained in the ore. By lixiviation, this arsenic infiltrated the groundwater near the tailing dam and the area nearby ICOMI industry. In 1998, the company removed the material from the tailing dam to a higher area above the groundwater level. Since that time, ICOMI and the regional state government discuss the gravity of the contamination and the final destination of the tailings. The local press accompanied the dispute and most of the habitants of the areas nearby ICOMI were scared about possible health risks in consequence of the arsenic contamination.

In the Amazon, the pollution of groundwater by ICOMI is the first known case of arsenic contamination in consequence of mining activities. A first analysis of the groundwater nearby the tailing basin, made in 1997, indicates that the water of five wells has arsenic concentration of more than 0.05 mg/L; 30 points of sampling show values under 0.05 mg/L. In April 2002, only one of the wells continued with values of more than 0.01 mg/L. All the wells opened by the population in the neighborhood to supply drinking water, indicate less then 0.003 mg/L of arsenic in the water. The two water streams, which drain the industrial area of ICOMI, were also analyzed; they were sampled at seven different points. In 1997, three samples reported values higher than 0.05 mg/L, and in 2002, two of the sampling points continued with values above 0.05 mg/L, three of them had concentrations between 0.05 mg/L and 0.01 mg/L and two of them showed As concentration of less than 0.01 mg/L.

Based on the fact that the population who lives nearby the industrial area of ICOMI consumed the water of the water streams, the state government of Amapá contracted the Federal University of Pará to assess a possible contamination of those people. LAQUAM, which carried out the research, concluded, based on the hair samples of 100 individuals (10% of the population of the area), that 61 % of the tested group shows a tendency of arsenic contamination, 15% a tendency of chronic contamination, and 22% a tendency of acute contamination. Presently, the Instituto Evandro Chagas is running a broad sampling campaign to verify the degree of arsenic contamination of the affected population.

Besides the ICOMI case, there is little data available to estimate the degree of pollution of the Amazon River system by arsenic.

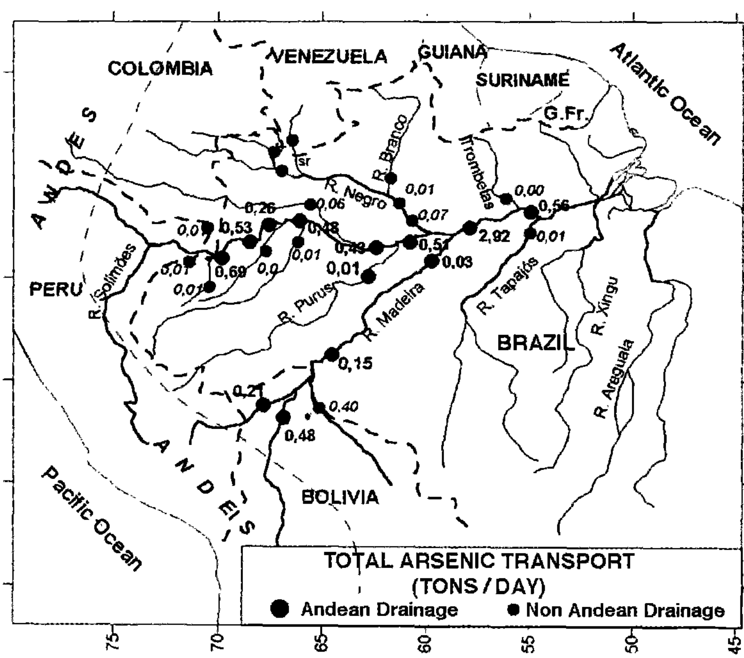
5.4. Arsenic in the Amazon River system

Available data identify two main sources of arsenic input in the Amazon river system: Geologically originated arsenic form the Andes, and arsenic from anthropogenic activities, like forest burning, etc.. Seyler and Boaventura (1999) estimate the atmospheric emissions of arsenic from anthropogenic sources in the Amazon Basin. They calculate that about 250 tons of arsenic per year could be launched to the atmosphere[11]. Based on data presented by Seyler and Boaventura, Scarpelli (2002) calculates the charge of

[11] Their calculation was based on the following data: Quantity of forest biomass consumed by fire 250t / ha, deforestation rate (1983-1993) 40,000 ha/year.

dissolved arsenic and of arsenic as particle for different points along the Amazon River system. In Óbidos, 800 km away from the Amazon delta, the concentration of arsenic in the waters of the Amazon River, is 0.8 mg/m³ with 0.7 mg/m³ in dissolved form and 0.1 mg/m³ in particles in the suspension material. The rivers that drain from the Andes are showing values significantly higher than the clear water river from the Brazilian shield. The Solimoes River presents 1.5 mg/m³ of dissolved arsenic and in the Madeira River samples show 18.6 mg/m³ of particulate arsenic. Such data indicate that the Amazon River transports at Obidos 0.56 tons of arsenic per day or about 200 tons a year. One may suspect that most of this material will be deposited at the mouth of the Amazon (see map 1).

This assumption is enforced by a study of LAQUANAM (2000), who took samples of water in the Amazon delta. The average value of the samples was 8.01 mg/m³, with a maximum of 16.08 mg/m³ and a minimum of 3.1 mg/m³. A control sampling of water from a river that does not belong to the Amazon delta shows concentrations of less than 0.8 mg/m³.



6. CONCLUSIONS

The ecosystems of the Amazonia River Basin are very sensitive to antropic impacts, but there are interesting results pointing at the fact, that natural background concentrations of several types of heavy metals (like Hg) can turn out to be important sources of pollution in some cases.

One of the most important aspects of human occupation politics of the Amazon River Basin is that we have to take into account that modern society steps into a very rich, but also very fragile system, where nearly all environmental impacts are somehow related to the natural water resources. On the other hand it is important to understand that great part of the Amazonian population lives directly and indirectly *on, with* and *from* the rivers. So far it is easy to understand that Amazonia needs to pay special attention to the quality of its rivers.

These facts lead us to already widely discussed recommendations.

1. Amazonia needs a coherent legislation regarding its water resources, to avoid destructive conflicts of interests.
2. Special attention has to be paid to human activities in the so called *varzea* and all the regions with periodic flooding.
3. Amazonia needs a water monitoring network to register at least several important basic physical and chemical quality data of the different Amazonian river basins. This is important, partly because outside the urban centers the rivers are the most important source of drinking water, which is consumed without any treatment.
4. It is necessary to analyze how far energy needs and water protection can be combined without causing mayor constraints to the local population.
5. Amazonian cities, nearly all localized directly at the border of important rivers, need urgently effective waste water treatment systems.
6. Forest burning must be controlled.
7. Special attention should be given to the monitoring of the industrial zone in Manaus and the industrial complex in Barcarena due to the fact, that some production processes release highly toxic materials.
8. Last but not least, it is absolutely necessary to control mining activities and especially low tech gold mining, where the use of mercury is largely uncontrolled.

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5. THE IMPORTANCE OF RIVERS FOR THE TRANSPORTATION SYSTEM OF THE AMAZON

Camilo Domínguez *

1. GENERAL CHARACTERISTICS OF WATER BASINS IN THE AMAZON

The tropical and, for the most part, equatorial climate in the Amazon, averages monthly temperatures above 20° C, and produces intense evaporation. This is true both for the Atlantic Ocean and for the continent. This evaporation is constantly being recycled horizontally and vertically. Atlantic evaporation moves in the form of clouds that produce rain from the east to the west. By the time they reach the Andes, the clouds have unloaded all of the rain. Nevertheless, much of this rain reevaporates, or it is transpired in the form of gas through plants and animals and soon replenishes the clouds that move into the continent. A water column is formed by the humidity that rises and the rain that falls. This column rises thousands of meters from the ground (Salati; Marques 1984: 85-125). However, not all water reevaporates, some of it remains in the ground and drains away in the form of millions of small underground springs that flow into the Amazonas River. Due to that fact, the soil in the forest is always damp, and there are flooded palm forests. They are called *aguajes*, *cananguchales* or *miritizais* and are found in plain areas. This great amount of

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water gathers in the form of sub-basins and basins. They take the opposite way in relation to cloud masses and drain away towards the east, seeking the Atlantic Ocean to renew the cycle.

As expected in the case of such a large water basin, the main tributaries have enough space to take in water from hundreds of thousands of square kilometers. Each one of them is by far longer and greater than many of the biggest rivers in the world. That is the case with the Negro River, the Madeira River, the Xingú River and the Tapajós River. The Amazon basin can offer a total of 50,000 kilometers of navigable rivers to boats weighing up to 1,000 tons. About 10,000 kilometers are navigable to ships weighing 1,000 tons or more. It is impressive to watch ships from Europe or from the United States drop anchor at Leticia, an Amazon port in Colombia, over 3,000 kilometers away from the sea. It is also amazing to see gunboats as they go up the Putumayo River to Puerto Leguízamo, which is very close to the Andes.

1.1 Amazonas-Orinoco-Guyanas.

The Amazon Basin covers an area of 6,879,761 Km2. It includes the territories of six countries, but most of it is located in Brazil. The characteristics of the Amazonian landscape extend over almost one million, five hundred thousand kilometers to the east and to the north, including the Guyanas and the Orinoco River basin. The humid tropical jungle forms a continuous carpet of green that reaches the basins of rivers in Guyana, Suriname and the French Guyana, as it does most of the Orinoco Basin. There is also intense vertical and horizontal humidity transport as well as diverse biota that is typical of the Amazonian region.

The Orinoco Basin has an area of 1,032,524 Km^2. It includes huge rivers, most of which are navigable. The Guaviare is 1,354 kilometers long, and 620 kilometers of this river are navigated by vessels. The Meta is 1,000 kilometers long, 750 kilometers of it being navigable. The Arauca is 950 kilometers long and 650 kilometers can be used for navigation. In Venezuela, there is the Apure. It is a huge river which is navigable for 800 of its total 1,110 kilometers. In addition, the navigable portion of the Orinoco itself reaches 1,700 of its total 2,500 kilometers. Eight hundred and eighty kilometers located in the lower part of this river are especially important due to the fact that vessels with increased cargo-carrying capacity, including transatlantic ships, get to Ciudad Bolivar in Venezuela using a stretch of the river that is 360 kilometers long.

The basins found in the Guyanas are not dependent on the Amazonas River or on the Orinoco River. They flow directly into the Atlantic Ocean. All of the rivers located in the French Guyana, Suriname, Guyana and in the Cuyuní Basin in Venezuela, which is a tributary of the Essequibo River, belong to this region. In the case of the Oiapoque River, it must be taken into consideration that the State of Amapá is partially Guyanese. If we do not consider the Brazilian Oiapoque, the Guyanese Basin covers a total area of 356,396 Km^2. The main rivers in the Guyanas are the Essequibo-Cuyuní, the Corentyne, the Maroni and the Oiapoque. Navigation in these rivers is rather precarious due to the fact that most of their courses run through the hard rock formations of the Guyana Shield. This means that there are waterfalls and rapids that can only be crossed in canoes and small motorboats (Domínguez 1998: 130-135).

TABLE 1 - SUBREGIONS OF THE GREAT BASIN
(Distribution in square kilometers)

AMAZON BASIN	
Brazil	4,989,361
Peru	762,400
Bolivia	600,000
Colombia	336,000
Ecuador	130,000
Venezuela	61,000
Total	**6,878,761**
ORINOCO BASIN	
Venezuela	644.423
Colombia	388.101
Total	**1,032,524**
GUYANAS	
Guyana	136,784
Suriname	110,612
French Guyana	81,000
Venezuela (Cuyuní)	28,000
Total	**356,396**
Grand Total	**8,267,681 Km^2.**

1.2 The Upper Amazon and the Lower Amazon

The concepts of Upper Amazon and Lower Amazon are constantly used. However, there is not an exact definition for these terms. This is so because they result from a combination of morphologic, economic and social factors. In fact, they involve the characteristics of rivers, their navigability, the population density and the geopolitical relationships between the several countries where the basin is located.

In general, the Brazilian concept has prevailed. It takes the spot where the Negro River flows into the Amazons River as the border between the Lower and the Upper Amazon. Only the lower portion of the Amazonas River, however, goes by that name, until it reaches Manaus. From there on to the north, it is called Solimões, and this is the name by which it goes until it reaches the border between Brazil, Peru and Colombia.

Andean-Amazonian countries do not use the name Solimões and prefer the term mid-Amazonas to refer to the stretch of the river that goes from the mouth of the Negro River to the mouth of the Yavarí and from the upper Amazonas to the section between the Brazilian border and the source of the Ucayali River. The most important aspect is the possibility for continuous ship navigation from east to west, although in reality it only reaches the Iquitos port.

As we can see, the names for the navigable stretch of the main riverbed of the Amazonas vary from Panamazonian country to Panamazonian country. Nevertheless, in regards to the rest of the basin, it is generally accepted that the lower Negro River, to the north, and the lower Madeira, to the south, clearly display the differences between the lower Amazon and the upper Amazon. From there on, the influences of the Andes begin to be seen in the morphology, landscape, population, economy and cultures. Between the Portuguese-Brazilian world of the lower Amazonas and the Spanish-American world of the upper Amazonas there is a transitional area that is the result of historical factors.

2. EASY AND DIFFICULT ASPECTS OF NAVIGATION IN THE BASINS

2.1 Navigation on the Sea River

If we consider the Ucayali River as the former of the Amazonas, the total length of the Sea River will be 6,518 kilometers from its source in Mount Huagra (Peru), where it is called Apurímac, to the place where it flows into the Atlantic Ocean. At first, the river goes down the eastern Andean slope for 1,433 kilometers until it reaches the plain, where it is navigable. This is at a distance of 5,085 kilometers from the ocean. From there to Pucallpa, 530 kilometers away, small motorboats with a draft of no more than 3 feet can navigate all year round. From Pucallpa on, the river is deep enough for larger motorboats and tugboats. They can have a 7-foot draft and a carrying capacity of 100 or 200 tons. These vessels navigate 890 kilometers to the place where the river meets the Marañón River, and 125 kilometers more to reach the Iquitos port. From its source to Iquitos, the Amazonas is 2,978 kilometers long, of which are navigable 1,545 kilometers.

From Iquitos to Belém do Pará, 3,540 kilometers of the Amazonas River are navigable. The flow rate increases a great deal due to the fact that the Marañón, the Huallaga, the Ucayali and, a few kilometers downstream, the Napo, a gigantic river, meet. This increase in the amount of water makes it possible for ships with a draft of up to 15 feet to go upstream to the Iquitos port. However, the increasing number of sandbanks and the lack of returning cargo have made it preferable to use the Tabatinga and the Leticia ports for the transportation of cargo on barges and tugboats 440 kilometers upstream.

When it reaches the Brazilian Amazon, the Amazonas has already covered more than half of its total course. From Tabatinga to Manaus 1,600 kilometers are permanently navigable for ships that can carry up to 25,000 tons. The flow rate of the river increases through its large navigable tributaries, like the Içá-Putumayo, the Juruá, the Purus and the Japurá-Caquetá.

From the place where the Negro River, the largest tributary of the basin in terms of flow rate, meets the Amazonas, the river takes on maritime navigation characteristics. From Manaus to the ports of Santarém, Santana and Belém do Pará there is intense river traffic. This is due to the fact that Manaus is in a privileged situation because it serves as the link between the upper Amazon and the lower Amazon. The city also absorbs a huge quantity of passengers and a great amount of cargo, providing transportation services to its millions of inhabitants. Due to this, 50% of all river traffic in the basin takes place along the 1,500 kilometers from Manaus to the mouth of the Amazonas.

The navigation of the upper Amazonas and the lower Amazonas adds up to a total of 5,085 kilometers of continuous navigation on the Sea River all year round.

2.2 Geological Structures and Navigation

There are no obstacles over the long navigable stretch in the main stream of the Amazonas. This is due to the geological structure of the Amazonas valley itself. This valley was formed during the tertiary and quaternary periods and extends from the east to the west of South America. Roughly speaking, it follows the equator line. The unconsolidated sediments that cover a deep tectonic fault, filled during the tertiary and recent periods, have made it possible for waters to excavate a deep bed and shape it so there are no obstacles to the flow of river waters. In general, the morphology of the valley is closely related to the free navigation of rivers. As we encounter obstacles such as rapids and waterfalls, we can be almost entirely sure that we are over older geological structures or structures produced by volcanic activity.

The valley has the Andes Mountains to the west, the Guyana Shield to the north, and the Central Brazilian Shield to the south. These geological structures are made up of consolidated rocks whose ages range from the Mesozoic to the Pre-Cambrian period. A few areas are more recent (Putzer, Hannfrit 1984).

At the Andean foothills, the Amazonas valley extends over hundreds of kilometers. This allows for the navigation of rivers all the way to the foot of the mountains. However, as rivers reach the mountains, they almost immediately lose navigability. For instance, the Pongo de Maseriche, on the Marañón River, and the Pongo de Aguirre, on the Huallaga River, are obstacles that determine the furthest limits to the navigation of these rivers.

The Guyana Shield is not formed only by the mountains or table mountains that surround the upper Orinoco and its tributaries. Most of its old rock formations have been showered by meteors for millions of years and now are reduced to baselevel (peneplains and pediplains). They extend millions of square kilometers to the north of the basin. Thin layers of sand or soil cover these rocks, allowing for the growth of not very dense forests and of not very dense bush. These forest and bush formations are known by the Tupi-Guarani name of *caatingas*. When rivers run through these rock surfaces, rapids and waterfalls are formed. They make navigation more difficult. Therefore, navigation upstream the northern tributaries of the lower Amazonas is abruptly blocked at the Guyanese formation. This becomes especially obvious when the valley plain first meets the rocky peneplain because the different degrees of erosion result in a difference in height that forms waterfalls and rapids.

Something similar occurs to the south with the Central Brazilian Shield. The first waterfalls clearly indicate the existence of old formations and, consequently, the end of navigation or the transfer onto smaller vessels in order to continue traveling upstream.

2.3. Connections between the Orinoco and the Amazonas

Although the existence of numerous connections between the Amazonas Basin and the Orinoco Basin is constantly emphasized, it is necessary to make it clear that they are mostly still water transfers few fish can cross. This occurs during flood seasons or at the riverhead of upstream tributaries. This also occurs at passages that connect rivers that are close to one another, where canoes or medium-sized vessels are dragged from one river to the other. The only connection where there can be continuous navigation is the Casiquiare channel. This natural channel links the upper Orinoco and the Upper Negro River, also called Guainía. This is the biggest tributary of the Amazonas and it can be navigated by vessels weighing up to 100 tons in spite of the Cabarúa waterfall.

Due to the current socio-economic and technical conditions, it is not possible for there to be continuous navigation from the Amazonas to the Orinoco. Navigation is only possible for small boats or when it involves transfers, which are costly. This is due to the fact that there are several rapids and waterfalls that present obstacles to navigation. Along the Middle Orinoco, there are the Atures and Maipures rapids, which extend 50 kilometers. The river drops twenty meters from the upper to the lower section. In order to cross these rapids, all cargo must be unboarded and a road must be used from Puerto Ayacucho to Samariapo. The navigation of the Middle Negro River is even more problematic from the mouth of the Cauaburí to the mouth of the Içana. There are about 10 rapids and waterfalls that extend over 200 kilometers. The most important of these rapids and waterfalls is the São Gabriel da Cachoeira waterfall, which completely blocks the passage. Another difficult transfer is necessary at this point.

Connecting the Orinoco and the Negro River to the Amazonas is an old dream. However, even though the technology is available today, it would not be a sensible thing to do. There would not be cargo or passengers to transport since traveling by sea or taking the road is faster and easier. The fact that something can be done does not necessarily mean it should be done.

2.4. Great Differences between Rising Tides and Droughts

Amazonian rivers are very different in terms of depth and the maximum and minimum amounts of water in their riverbeds. Likewise, they are very different in terms of the duration of their high and low tides. In any case, this phenomenon is less significant than what could be expected if we consider the continental dimensions of the basin.

Since the Equator line roughly coincides with the main stream of the Amazonas, the basin is located in two different climatic hemispheres. The Continental Equatorial Mass goes towards the meridians. It is located in the south during the austral summer, and it causes rains that fill southern tributaries from November to March. Tides fall in April, and they remain low until September or October. The volume of northern tributaries, on the other hand, increases due to the rains that fall from April to October, and at the end of the year their tides fall. When the Negro River and the Japurá reach peak levels, the Ucayali, the Madeira and the Xingú reach their lowest levels. If a tugboat leaves Caracaraí in July on the Branco River and goes down the Negro River to Manaus, there will be problems in relation to navigation on the Madeira if the purpose is to reach Porto Velho. In northern tributaries tides will be high, but in southern tributaries tides will be low.

In the lower Amazonas, a phenomenon occurs which is known as *interference* (Delgado de Carvalho. 1942; Soares. S:F:) or compensation. It involves southern and northern waters. Due to this phenomenon, high tides are not catastrophic but riverbeds are still deep. The average difference between peak levels and the lowest levels is ten and a half meters. The average depth varies from 50 to 130 meters (Soares. 1963:86). On the Solimões, the difference between the peak level and the lowest level reaches 18 meters. This is due to the influence of the austral hemisphere, which is not sufficiently compensated by the northern tributaries (Putumayo and Japurá). The average depth varies from 50 to 80 meters. This shows a certain level of *interference*, which prevents rivers from reaching their lowest levels and makes navigation easier.

When tributaries are located in only one hemisphere, be it boreal or austral, they undergo great seasonal changes in depth and, therefore, in navigability. High tides allow for fast navigation to take place, but during droughts navigation is interrupted due to the fact that there is not enough water in the riverbeds. Nevertheless, tides can rise suddenly and be catastrophic for smaller rivers when heavy rains flood the riverbeds.

3. CURRENT SITUATION AND POSSIBILITIES FOR CARGO AND PASSENGER TRANSPORTATION IN THE AMAZON

3.1. Waterways and their characteristics

River navigation has been a fundamental means of transportation in the Amazon even though since the 1930s roads have been built that go through the basins in each of the Panamazonian countries. Especially in the Brazilian Amazon, rivers have enormous potential in terms of cargo and passenger transportation due to the fact that ships can be used. This makes it possible for several thousands of tons to be transported in one single trip, and costs are very low in terms of ton/kilometer. In relation to the rest of the basin or to smaller rivers in Brazil, rivers play an important role since they are the only possible way to reach remote areas or areas where floods occur and roads cannot be built.

The relationship between river navigation, roadway transportation and airway transportation includes many factors that make one means of transportation or another more widely used. The idea that navigation is always the cheapest and most comfortable way to travel is incorrect. In fact, it depends on a number of aspects.

River navigation is slow when compared to roadway transportation and very slow when compared to airway transportation. For the hasty traveler in modern life or for the transportation of perishable fruits and vegetables, planes, buses or trucks are sought instead of boats or motorboats when a choice can be made. On the other hand, for a traveler who wants to enjoy the trip, a slow means of transportation is better than a fast one. Also, when there is a great amount of cargo to be carried or when the cargo is very heavy, speed is less important than cargo-carrying capacity. When there is the need to transport thousands of tons at the same time, boats, lighters or barges are preferable to trucks or planes.

In relation to passenger transportation, the cost of the trip is proportional to the number of days the trip lasts. This is due to the fact that costs with the passenger's meals are added to costs with fuel. When the trip is too long and slow, this issue becomes crucial and makes this kind of transportation uneconomic. This is why in such cases it is best to travel by bus or airplane although boat or motorboat fares seem cheaper.

The smaller the boat, the higher the cost for waterway transportation. Although a boat uses thousands of gallons of fuel per trip, the ton/kilometer relationship is extraordinarily low when compared to the terrible ton/kilometer throughput of an outboard motor. Therefore, when a river only allows for small boats to navigate, waterway transportation costs turn out really high. In this case, it is best to build roads parallel to the rivers or landing strips at arrival and departure locations.

Another factor that has an influence on the high costs for navigation in small rivers is the increase in distance due to the existence of meanders. Smaller downward inclination of the river creates greater difficulties to navigate this river. Therefore, there is a greater tendency towards the formation of meanders. Due to these meanders, the distance between two places can be doubled or tripled. This proportionally increases costs with fuel and the duration of the trip. In cases such as these, it is also preferable to build roads alongside the rivers and landing strips.

Other very important factors are the number and distribution of people living on riverbanks. The existence of large cities or the existence of many communities living on the banks of navigable rivers create the necessary supply and demand so navigation routes and companies can be founded. River traffic density is directly proportional to the population density on riverbanks. It is possible to increase river traffic through tax incentives or direct support in the form of cash or subsidized cargoes. However, if this does not lead to a concomitant increase in the number of people living in areas surrounding the basins, this effort will undoubtedly fail.

3.2. Situation in the lower Amazon

Navigation in the lower Amazonas is a lot more intense, economic and profitable than that in the Upper Amazonas. The depth of the river allows for the permanent navigation of large cargo and passenger ships. This makes the ton/kilometer and the passenger/kilometer relationship very profitable. Likewise, the existence of large cities like Belém and Manaus and of numerous medium and small populations along the way generates a relatively high demand for and supply of goods and services. This stimulates river navigation.

It is necessary to consider that most of this traffic takes place on the Amazonas River itself, involving the cities of Belém, Santarém and Manaus. This includes the stretch of the river that links these cities to Santana and Macapá, in the State of Amapá. However, when the issue is closely examined, it can be seen that the traffic that takes place within the states is greater than that which links several states in the Brazilian lower Amazonas. In the State of Pará, there are thirty small and medium-sized companies that offer trips to Marajó Island, Salgado, Monte Alegre, Santarém and Óbidos, but only larger companies that transport both cargo and passengers offer trips all the way to Manaus or Macapá. The same occurs in the State of Amazonas. Most companies travel within the state, preferably down the Amazonas River until they reach the Pará state border or up the Negro River and the Solimões until they reach the populations that live close to Manaus. Only larger companies go to Santarém or Belém do Pará. Nineteen river navigation companies are based in Manaus.

The ships that go from Belém to Manaus do not start navigating the Amazonas itself from the Atlantic Ocean through the northern channel. Instead, they go to the end of the Tocantins estuary on the Pará River and navigate through the *furo de Breves* (the Breves channel) until they reach the Amazonas at Gurupá Island. The *furos* link gigantic estuaries that are separated by Marajó Island. To the south, they link the Pará River, formed by the Araguaia, the Tocantins and the Amazonas (which are linked through the *furos*) to the Anapu and Pacajá Rivers. This is a set of estuaries, bays and channels where *caboclos* (a race that resulted from the miscegenation of whites and Indians) live on houses on stilts at riverbanks. There are also small villages like Vigía, Ponta de Pedras, Melgaço, Portel, Barcarena and Cametá, where the river traffic is relatively intense. To the north, there is the actual Amazon estuary. Gurupá Island separates the water of the main course of the Amazonas, to the north, from the Vieira Grande channel, to the south. Between the two channels there is a set of islands, most of which are floodable, like Caviana and Mexiana. On the banks of the Norte Channel are the ports of Macapá and Santana, where there are deep draft docks.

From the mouth of the Xingú upstream, there is a more defined channel for navigation. Commercial ships stop at the ports of Gurupá, Almeirim, Prainha, Monte Alegre, Santarém, Óbidos, Oriximiná, Juriti and Parintins before they reach Manaus (ENASA, 2001). Some of these ports are located at the mouth of large tributaries and are the starting point for the navigation in the upstream direction, along these tributaries, up to the rapids. In general, this service is provided by smaller boats, whose owners live in the villages along the rivers. These boats transport the passengers brought by ships and river ferries whose final destination is the tributaries. From Santarém, they go up the Tapajós to Itaituba. From Parintins, the Paraná do Ramos and its numerous sub-tributaries are navigated, and from Manaus the Madeira River is navigated to Porto Velho.

Manaus is a link between the lower and the upper Amazonas. Its strategic location allows for it to influence places as far as the Andes, to the west, the great Bolivian tributaries of the Madeira, to the south, and the Orinoco, to the north. Many of the ships and river ferries that go up the lower Amazonas unload their cargo in Manaus so it can be divided along thousands of kilometers of navigable ways.

The number of boats and barges that leave Manaus to go upstream the Solimões, the Madeira, the Juruá or the Purus is much lower than the number of boats and barges that navigate the lower Amazonas. Each large or medium-sized navigation company charters one or two boats weekly to reach these destinations. The most common boat lines are the following: upstream the Madeira to Humaitá and Porto Velho; from the Purús to Canutama and Lábrea, and from the Solimões to Tefé or Tabatinga. In the case of tributaries like the Japurá (Caquetá) and the Içá (Putumayo), navigation from Manaus is practically inexistent. However, in Tefé and Tabatinga there are local boats that travel on the Japurá, and in Tabatinga there are boats that navigate the lower Icá and the Javarí.

The navigation of the Negro River and that of the Branco River, starting in Manaus, are very important for the States of Amazonas and Roraima. Boats go up the Negro River 315 kilometers and up the Branco River 360 kilometers until they reach the Caracaraí port. This port is located downstream of the rapids that go by the same name, which are famous for being dangerous. Due to the existence of these rapids, Caracaraí is linked to Boa Vista, the capital of Roraima, by a paved road that extends 135 kilometers. The Caracaraí port is strategically located in relation to bimodal transportation involving the Amazonas and the Orinoco. There is a road that extends 1,530 kilometers from Manaus to Ciudad Bolívar (Venezuela). It is completely paved and there are bridges that are open to trucks with gross weights up to 40 tons. Caracaraí is 950 kilometers away from Ciudad Bolívar. Transportation can continue through the navigation of the Orinoco, the Apure and the Meta, and it can also go on by roadway to the Caribbean (Caracas and Barranquilla) and to the Pacific (Buenaventura).

4. NAVIGATION ON THE ORINOCO AND HOW IT CONTINUES INTO THE AMAZON

4.1. The Orinoco

The Orinoco is one of the most volumous rivers in the world. However, compared to the Amazonas, differences in volume are too great in relation to high and low tides. At its mouth, there is a water discharge of 35,000 cubic meters per second during the dry season. During the peak of the rainy season, the water discharge may reach 100,000 cubic meters. The reason for this extreme phenomenon is the fact that the entire basin, which is located in Venezuela and Colombia, is only influenced by one climatic hemisphere. This means that there is rain from April to November, and the dry period, which is very intense, goes from December to March.

Over 4,520 kilometers of Orinoco basin rivers are navigable to tugboats that can carry up to 2,000 tons. Small boats that can carry up to 100 tons can navigate 700 kilometers further, which adds up to a total of 5,220 kilometers of waterways. Transatlantic ships go upstream to Ciudad Bolívar (360 kilometers) and there the cargo is transferred onto barges and boats so it can be transported upstream the Orinoco and its tributaries. The main course of the river is navigable all year round for vessels with a draft of up to 9 feet all the way to the mouth of the Apure River. From there on, vessels with an average draft of 5 feet can go upstream another 200 kilometers for eight months out of the year to San Fernando, on the Apure River. They can also go up another 250 kilometers to the El Baul port, on the Portuguesa River, which is a tributary of the Apure. These two ports offer easy and fast transportation to Caracas.

Also in regards to the navigation of the Orinoco, tugboats with drafts up to 4 or 5 feet and a carrying capacity of 2,000 tons go from the mouth of the Apure upstream. When they reach Puerto Carreño - Puerto Páez, 350 kilometers upstream, two different ways can be followed: they can continue navigating the Orinoco to the city of Puerto Ayacucho, in Venezuela, or they can go up the Meta River to the city of Puerto López, in Colombia.

From Puerto Páez to Puerto Ayacucho there are 75 kilometers where navigation conditions are bad due to the Tabaje and Borja rapids. Passengers and cargo must be transported via roadway to the small port of Samariapo, 60 kilometers upstream, in order to avoid the Atures and Maipures rapids. From there on, small motorboats that can carry from 100 to 300 tons navigate, and so do barges that can carry up to 500 tons. The navigation of the Orinoco and that of its tributaries has no navigable connection with the ocean. This is also true in relation to the place where the Orinoco meets the upper Negro River. The most important navigable stretch goes from Morganito, on the Orinoco, to São Gabriel da Cachoeira, on the Negro River, through the Casiquiare Channel. This stretch is 1,000 kilometers long. Another 950 kilometers are navigable to motorboats on the Guaviare and its tributaries, the Inírida and the Atabapo (Domínguez. 1998).

Barges that can carry up to 2,000 tons and have a draft of 4 or 5 feet can go upstream the Meta River from Puerto Carreño to Puerto López for a distance of 780 kilometers. They normally transport cattle during the rainy season, from April to November. The outskirts of Puerto López and Bogotá are a very important region, since one can go from one city to the other in less than six hours using a paved road. From the Boca Grande del Orinoco to Puerto López there is a road that extends 1,890 kilometers and offers great possibilities for the economic and cultural integration of Brazil, Venezuela and Colombia.

It is possible to reach the port of Buenaventura, in the Pacific Ocean, and the ports of Cartagena, Barranquilla and Santa Marta, in the Caribbean, using paved roads that go through the city of Bogotá.

4.2. Situation in the upper Amazon

The twin cities of Tabatinga (in Brazil) and Leticia (in Colombia) set the limit between the Portuguese-Brazilian world and Andean-Amazonian countries. From that point on to the west, other political and economic centers have more influence on each national portion of the Amazon. Due to this, traffic flows from west to east. Bogotá, Quito, Lima and La Paz are the reference points for the organization of Andean-Amazonian traffic flow, and traffic on the rivers is adapted to this reality. Up to Tabatinga, other economic and political centers have an influence on transportation, making traffic flow towards the east. These centers are São Paulo, Rio de Janeiro and Brasília. This is a flexible border at which boats and planes turn back. It is only crossed occasionally. Brazilian transportation lines go to Tabatinga and return to Manaus. Peruvian transportation lines go as far as Santa Rosa or Caballo Cocha then return to Iquitos. Colombian transportation lines cross the border and go a few kilometers further to Putumayo, but their reference point is Puerto Asís, in the Andes.

The former condition of the Andes as a geopolitical barrier is no longer true. On the contrary, the various trans-Andean roads have made it possible for a populated belt to be formed in the west of the Amazon. This belt is very influential due to the fact that it is a market and it can provide services. There are six trans-Andean roads that lead into the Colombian Amazon, five that lead to the Equatorial Amazon, seven that link the Andean Amazon to the Peruvian Amazon and four that lead to the Bolivian Amazon. There is also the Marginal de la Selva road, at Andean foothills, which connects almost all of the cities to one another. It also links the Trans-Andean roads and forms a corridor with many entranceways.

In the Colombian Amazon there are only two rivers which are navigable to tugboats: the Guaviare, which is part of the upper Orinoco basin, and the Putumayo-Içá, which has better connections with the Amazonas. Other rivers, like the Caquetá-Japurá and the Vaupés, flow over a rocky peneplain, and their courses are extremely tortuous. There are many rapids and waterfalls and some stretches are very narrow. This interrupts navigation and makes it cost-ineffective. As previously mentioned, the Guaviare is navigable to tugboats from the city of San José del Guaviare to its mouth at the Orinoco, at a distance of 620 kilometers. San José is the northern entranceway into the Colombian Amazon. It is linked to Villavicencio and Bogotá by the Marginal de la Selva road. A bridge crosses over the Guaviare River and the road goes toward the west. One hundred kilometers of this road have to be built so it will reach San Vicente del Caguán, at the Andean foothills. There is also a road that goes south of San José del Guaviare and connects the city to the port of Calamar, on the upper Vaupés, which is a tributary of the Negro River.

San Vicente del Caguán is located on the northern Amazonian foothills. From there southward there is an almost continuous belt of roads and cities close to the Andes that extends over 3,300 kilometers until it reaches the city of Santa Cruz de la Sierra, in Bolivia. This belt connects the sources of the main tributaries of the Caquetá River, like the Caguán and the Orteguaza, to the main river. The upper section of the Caquetá and that of its tributaries are navigable to small boats all the way to the Araracuara rapids.

The Marginal de la Selva continues past the upper Caquetá to the upper Putumayo, which it crosses on the Santa Ana village. It reaches the border with Ecuador at the San Miguel River, a large tributary of the Putumayo. Another part of the road leads into the city of Puerto Asís, which is the most important boarding location for the Colombian tugboats that navigate the Putumayo. Puerto Asís is the southernmost part of the road system known as Troncal del Caribe. It connects Colombian ports in the Caribbean to Colombian ports in the Pacific Ocean, to the Orinoco River basin and to the Amazon. The Troncal del Caribe crosses the Andes. It goes from the city of Pitalito, on the upper Madalena River, to Mocoa, where it meets the Marginal de la Selva and goes on to Puerto Asís.

The Putumayo is a river that serves four nations, all of which make bad use of it. Colombia, Ecuador, Peru and Brazil navigate its waters haphazardly. There is no development plan for the river, its services or for the conservation of the basin. There are many projects, but none have been put into practice. Nevertheless, the Putumayo offers the possibility for fast navigation from Puerto Asís to the Amazonas, for 1,928 kilometers. During high tides (from March to August) it is navigable to vessels with a draft of up to 6 feet. Vessels with an 8-foot draft can go as far as the mouth of the San Miguel River, and vessels with a 12-foot draft can go as far as Tarapacá. During low tides, it is navigable to barges with a 4-foot draft all the way to the mouth of the San Miguel, and to barges with a draft of 2.5 feet can go as far as Puerto Asís.

Two thousand, six hundred and sixty four kilometers of the Colombian Amazon basin are navigable to tugboats and motorboats with a carrying capacity of over 100 tons. This is true if we add the 116 kilometers of the Amazonas River that are located in Colombia to the navigable stretches of the Guaviare and the Putumayo. In addition to the previously mentioned river sections, there are another 1,200 kilometers which are navigable to small boats carrying up to 20 or 30 tons of cargo. The most important stretch is a section of the Orteguaza and the Caguán Rivers which, together with the Caquetá, make up a navigable network with over 1,000 kilometers. Colombian Amazon rivers are navigable for a total of 3,864 kilometers.

In the Equatorial Amazon, only short stretches of two rivers are adequate for the navigation of tugboats and barges: an 85-kilometer section of the Putumayo River, from the mouth of the San Miguel River to the Guepí River, and a 225-kilometer stretch of the Napo River, from Francisco de Orellana to the mouth of the Aguarico River. By resorting to the free navigation of shared rivers, Ecuador attempts to turn these waterways into its own connection with the Amazonas and with the Atlantic. This is why the port of El Carmen de Putumayo, located at the confluence of the San Miguel and the Putumayo, was adapted to receive double-hulled tugboats with a carrying capacity of 600 tons and a 3-foot draft. A floating pier was built where 70-meter-long vessels can dock. Other improvements are being implemented in relation to storage and unloading. The port of El Carmen is currently connected with Quito and with the port of Esmeraldas, in the Pacific. It serves as a link between oceans.

On the Napo River, the port of Francisco Orellana, also called Coca, is the highest spot that can be reached by tugboats and barges with a 4-foot draft during high tides. Due to the fact that navigation on the lower Napo, in Peru, has been blocked for over half a century, the port of Coca has not been cared for and docking conditions are not good. Currently hydraulic engineering work is being carried out to improve arrival conditions for larger vessels.

Other rivers whose sources are in Ecuador, like the Aguarico, the Coca, the Tigre, the Pastaza and the Morona-Santiago, are only navigable to canoes or outboard motorboats. This is due both to the fact that there are rapids and to the fact the river has a low flow rate. This problem is solved by the excellent network of roads that go across the territory. This is especially true in terms of the Marginal de la Selva, which is completely interconnected all the way from the San Miguel international bridge, at the border with Colombia, to the village of Zumba, at the border with Peru. Due to conflicts involving Ecuador and Peru, the section of the Marginal de la Selva from Zumba to San Ignacio, across the border between the two countries, was not built. These villages are 44 kilometers apart. When this small section is built, the Marginal will meet another road which has already been built and goes through Jaén and Santa María de Nieva to Sarameriza.

The Peruvian Amazon is, next to the Brazilian Amazon, the part of the basin that has the best river connections. This is due to the fact that all of the rivers that form the Amazonas are located there, and the country shares many of its large tributaries. The confluence of the Ucayali, the Huallaga and the Marañón creates an amazing body of water that is navigable to sea ships all the way to the Atlantic Ocean, 3,665 kilometers away. The Marañón is navigable after the Pongo de Manseriche (Manseriche Strait) is crossed. The river is known as Marañón until it meets the Ucayali, 790 kilometers downstream. In this section it meets the Huallaga, its largest tributary, 390 kilometers dowstream of the Manseriche. From the strait to the border with Brazil, a total of 1,355 kilometers of the river are navigable to vessels with a 4-foot draft all year round. They can continue 890 kilometers upstream on the Ucayali to the port of Pucallpa, and another 250 kilometers on the Huallaga to the port of Yurimaguas. During high tides, these same routes are navigable to vessels with a draft of up to 7 feet.

These 2,355 kilometers that are navigable all year round are not the main course for river connections in the Amazon plain in Peru. Cargo and passengers are transported along the Iquitos-Pucallpa route and, increasingly, along the Iquitos-Yurimaguas route, to and from the coast, the Andes and the Amazon. The Lima-Tingo María-Pucallpa road, which extends 860 kilometers, is the most important connection to link these Amazonian waterways to the Andes and to the Pacific Ocean. It also links the Pacific Ocean to the Atlantic Ocean. Since 1944, the year it was inaugurated, this road has replaced the inefficient route involving sea and river transportation according to which vessels left the port of Callao, went through the Panamá Canal and went up the Amazonas to the port of Iquitos.

Lately, there have been problems with the port of Pucallpa due to the sedimentation in the Ucayali. There have been serious problems making it difficult for vessels to dock at the pier. The port of Yurimaguas, on the Huallaga River, has taken over much of the service related to loading and unloading vessels. However, the road that links this port to the rest of the country is not good and there is no other alternative for a connection across the Andes. Another route is being implemented in the north. On the right bank of the Marañón, downstream of the Pongo de Manseriche, the port of Sarameriza was established. The location of this port makes it possible for there to be a direct connection with the north of Peru, up the Marañón to Abra de Porculla, where it is possible to cross the Andes and get to the port of Paita, in the Pacific Ocean. The road from Sarameriza and Santa María de Nieva, upstream of the Marañón, is being built. When the work is finished, the roads will extend 675 kilometers, linking the Pacific Ocean to the Atlantic Ocean. This means that there will not be the need to go up the Cerro Pasco, which is difficult. The Abra de Porculla, the lowest passage from Peru into the Amazonas, is only 2,144 meters high. This makes it very easy to cross the Andes Mountains. Also, the use of the port of Sarameriza by the Equatorial economy will guarantee that the peace agreement between Ecuador and Peru will be respected. In order for this to take place, the only thing left to do is to build a section of the Carretera Marginal de la Selva, linking Zumba to the Marañón River. The use of the port of Sarameriza by the two countries will boost the capacity of this port.

The navigation of the Napo River partially complements the Peruvian axis. This river is navigable all year round to vessels with a 3-foot draft all the way to the port of Pantoja downstream from the mouths of the Yasuní and the Aguarico Rivers. During the rainy season much heavier vessels can go upstream, with drafts of up to 12 feet. Two hundred and seventy kilometers from its mouth, the Curaray River meets the Napo, which increases its volume. From there onward the influence of Iquitos is strongly felt, and the population density increases. Motorboats of all sizes transport all sorts of products, especially wood to the veneer industry in Iquitos. In Puerto Arica there is a 75-kilometer-long road that connects the city to the Putumayo River at the Flor de Agosto village. This road is increasingly being used for the purpose of transportation from Iquitos to the Putumayo. This avoids going down the Amazonas and upstream of the mouth of the Putumayo all the way to the binational territory (Colombia-Peru) at the mouth of the Yaguas River. There are transportation lines for cargo and passengers that take daily trips from Iquitos to Santa Clotilde and back, and several times a week there are trips to the Curaray.

The right bank of the Putumayo, between the Yaguas River and the Guepí River, is located in Peru. This section is 1,315 kilometers long and is navigable all year round to tugboats with a three-foot draft that can carry up to 600 tons. Due to the low demand on the part of the few villages located on the banks of the river and on the banks of some of its important tributaries, like the Algodón, local traffic involves basically small boats that can carry from 10 to 50 tons. Guepí is 1,750 kilometers away from the mouth of the Putumayo on the Amazonas.

The navigation center in the Peruvian Amazon is Iquitos. In the beginning of the 19th century, Booth Line, a North-American company, built a floating dock there that was used for exporting products during the rubber era.

"Booth Line was the only regular international line that went from New York to Manaus and Iquitos. This happened both during World War I and during World War II and took place for 75 years until 1970, using barges that could carry 2,500 tons. For the last few years, however, there were only trips from Manaus to Iquitos if there was enough cargo to be transported. If there wasn't, cargo was kept in Manaus until there was enough of it to make the trip profitable. This resulted in damage to the cargo and losses for importers and exporters because of the time lost. When a wheat mill was established in Iquitos, there was the need for transportation so large amounts of wheat could be imported from Houston."... "Currently this waterway is used for the transportation of the heavy cargo necessary for the development of the exploitation of petroleum and gas in the Lower Jungle. It is also used for the transportation of massive cargo like cement, sugar and the wood that is exported (in the form of veneers and boards) to other countries from Iquitos" (Torres, 2001).

In the south of the Peruvian Amazon, where the country borders Bolivia and Brazil, navigation is restricted to the Madre de Dios River and some of its tributaries. Small commercial boats and mining dredges navigate over short distances on the stretches where there are no rapids or waterfalls. Puerto Maldonado is becoming an axis of regional connection due to the recent construction of a road that links the port of Ilo, in the Pacific, to Iñapari, at the border with Brazil. On the other side of the border is Assís Brasil, in the State of Acre, and the road goes on through Rio Branco and Porto Velho to where the navigation of the lower Madeira starts. The road extends 810 kilometers from Iñapari to Porto Velho.

"There are over 6,000 kilometers of navigable waterways on the rivers of the Amazon Region in Peru. This allowed for the development of commercial river transportation, which is responsible for the transportation of 90% of the passengers and cargo. This is the most important means of transportation in the region. The costs of river transportation are relatively high since there are no organized and permanent lines that link riverbank towns. This would make the integration and socio-economic development of populations in the Amazon region easier." (Torres, 2001)

River connections within the Amazonian territory in Bolivia are much more complicated. The entire region is located in the upper Madeira basin. This includes the Beni-Madre de Dios and the Guaporé-Mamoré, as well as their tributaries. Because the Madeira is not navigable from Porto Velho to Guayaramerín, it is necessary for these tributaries to be connected to the Amazonas. During the rubber era, navigation on these rivers was the only means of communication, but it is currently not as important because only short stretches of the river are navigable due to the existence of rapids and waterfalls. The airplane is the most common means of transportation to more remote regions. However, roads are being constructed that lead increasingly further into the region. A road is being constructed linking La Paz, Yucuma, Trinidad and Santa Cruz. It links the stretches of the Beni and Mamoré Rivers which are navigable to small boats. In Yucuma, which is close to San Borja, there are waterways which are navigable during the summer that link the city to Guayaramerín, on the lower Guaporé, and to Puerto Heath, on the upper Madre de Dios.

One thousand, four hundred and sixty kilometers of the Mamoré and of its tributary, the Ichilo, are navigable. This stretch goes from Guayaramerín to Puerto Grether, which is very close to Santa Cruz de la Sierra. Eight hundred and fifty three kilometers of the Beni River are navigable, from Cachuela Esperanza to the San Buenaventura port. From this port, it is easy to get to La Paz. There is a road that goes through Yucuma and Coroico. Three hundred and fifteen kilometers of the Orthon River can be navigated, from Humaitá to Puerto Rico. The Madre de Dios can be navigated for 249 kilometers, from Sena to Puerto Heath, at the border with Peru. A total of 2,877 kilometers are navigable to small boats in the Amazon basin in Bolivia.

5. AIRWAY TRANSPORTATION AND WATERWAYS

Since World War II, airway transportation has played a very important role in the economy and in the management of the Amazon basin. From 1941 to 1945, the United States built a great quantity of small landing strips. These landing strips were strategically located and were used to transport rubber. This was indispensable to the maintenance of war efforts. Also, if the Nazis invaded the continent, this is where combat planes would land. Rivers were used to transport the rubber produced in the forest to these landing strips, from where it was sent straight to North America. Many of these landing strips turned into villages and cities, where the model river-airport continued to control the economic and political life for many years. In some places, it still does. The harder the navigation of a given river, the more important the airport. Likewise, the farther away it is from administrative centers, the more the village needs an airport to deal with national, regional and local bureaucracies.

The previous information explains the fact that there are ports and airports on the banks of large rivers. There are villages along the riverbanks and behind them there are landing strips, normally bigger than the village itself. Daily life is related to the river, but the weekly or monthly arrival of the airplane is the great attraction and the cosmopolitan touch that links this water-related world to the metropolises. The whole village turns to the landing strip to receive or send products, travel to different cities or return to the village and to update themselves with the news. When the plane takes off again, everyone goes back to their boats or outboard motorboats, and the village goes back to its regular tranquility. At these places, even to this day, the river controls life and the airport is the touch of modernity that links the last corner of the forest to the world of economy.

Amazonian airlines tend to link small villages to regional or national urban centers. However, they do not link villages to one another. Due to this, traveling from one small town to another may require various stops, which makes airway transportation very expensive. Likewise, national borders tend to be an obstacle to international transportation within the basin. In general, when someone wants to go from an Amazonian city in one country to an Amazonian city in another country, this person has to fly to the capital of the first and, from there, he or she has to fly to the capital of the latter. After that, they have to find an airline in that country that will fly them to the Amazonian destination they want to reach. Ships from other countries cannot cross borders, and the same happens with airlines.

6. ENVIRONMENTAL RISKS RELATED TO TRANSPORTATION AND TO THE CONSTRUCTION OF WATERWAYS

6.1. The erosion of riverbanks

The great amount of sediments carried by the rivers that flow on tertiary and quaternary plains form the oversteepened slopes that are typical of white water rivers. These slopes get steeper and steeper every year. During low tides, they become very unstable because rivers erode their lower part. This occurs because of currents and because of the natural waves caused by the wind. In addition, the infiltration of rainwater through the upper part of the clay structures damages clay soils. They become fragmented and gullies are formed. Attacked from above and from below, slopes irremediably collapse, causing a great deal of damage when there are villages or farms on them. They also cause damage to the vegetation on the riverbanks. This increases the amount of forest debris carried by river waters.

The greater the variation of the level of rivers, the steeper the slope and, consequently, the greater the possibility that gorge falls will occur. In regards to the Amazonas River itself, there have been famous catastrophes in its mid-course (the Solimões), where the difference in river levels reaches 16 to 20 meters. This forms gorges as high as that. It is not rare for small villages to disappear overnight, nor is it rare for small boats to be swallowed by gorge falls when they navigate too close to the riverbank. On the lower Amazonas, where the difference in volume is between 10 and 16 meters at the mouth of the Negro River and between 5 and 7 meters on the lower section of the river, this phenomenon is milder. Studies carried out by Sternberg (1998) on Careiro Island show that a different phenomenon occurs in these areas: landslides. Landslides, which can occur in the form of slides or slumps, are not as impressive as gorge falls, but they can cause greater damage. This is due to the fact the lower Amazonas is more densely populated and the infrastructure there is better developed.

Gorge falls enhance the effect of the waves caused by vessels. When a tugboat or a ship gets too close to the riverbanks, the noise coming from the back of the ship indicates that there has been a series of mudslides. Larger vessels create higher waves and, consequently, greater the damage. Since there is now a tendency to use increasingly larger and faster ships, and there has also been a significant increase in river traffic, the excavation of riverbanks will increase as well.

The erosion caused by vessels increases the amount of sand and clay and the number of tree trunks on riverbeds. This makes navigation even more difficult. Even though this is mostly due to deforestation at the basins and to the inappropriate use of fertile lowlands, increased navigation causes greater damage to the banks and constantly removes riverbed mass. This causes a decrease in depth and endangers the safety of vessels. Therefore, there has been a decrease in the navigation of smaller tributaries and in the use of ports. This occurs because there is a decrease in depth which makes it impossible for vessels to dock. It also occurs because rivers dry up.

6.2. Fuel spills and wastewater and garbage discharged from boats

Another problem that resulted from the increase in the navigation of Amazonian rivers is the increase in the number of fuel spills and in the amount of wastewater and garbage discharged from boats.

Data is not available regarding the amount of fuel spilled in Amazonian waters despite the fact that this information is very important. There has been a notable increase in the transportation of fuel, however. The growth of the cities has caused an increase in the consumption of diesel oil, gas and fuel oils. This is true both in relation to power plants and to cars, planes, motorboats and ships. Almost all of the heavy transportation takes place by waterway. Transportation conditions are generally precarious, which constantly causes spills. They are due to accidents, to the fact that the cargo is handled improperly or to the fact that fuel is excessively exposed to sunlight. The latter causes the liberation of gases and liquid due to the dilation of the fuel. If we add this to the oil spilled by the engines of old boats and by inefficient outboard motors, we will have an idea of the amount of fuel that is spilled into the waters of the Amazonas.

Another phenomenon which is not properly analyzed is the increase in the amount of garbage and wastewater discharged from vessels, especially passenger and tourist boats. This phenomenon is currently secondary when compared to the increasing amount of debris cities dispose of into the rivers. However, it may be catastrophic if there is a great increase in tourism in the Amazon, which is expected.

6.3. Excessive stress involving aquatic fauna

A permanent complaint on the part of biologists is the fact that there has been a great increase in the stress aquatic fauna is subjected to. This is due to the increase in tourism. Reproduction sanctuaries in brooks and lagoons are constantly invaded by visitors. Whether they mean to or not, these visitors are causing great damage to basic ecosystems. Endangered species include the manatee, the turtle and the *pirarucú* fish. These animals are permanently injured by the propellers of motorboats. This accelerates extinction.

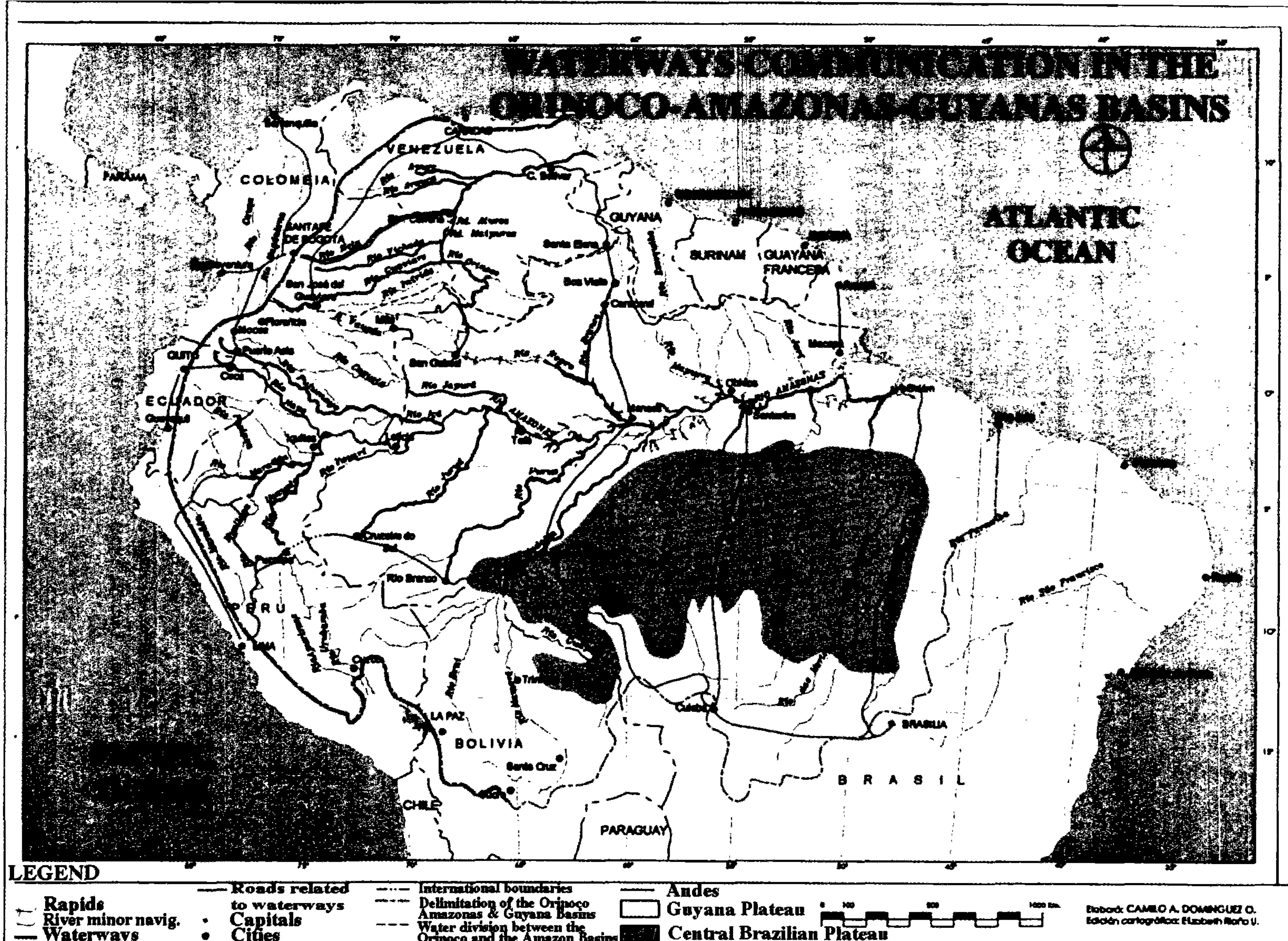
Likewise, vessels are very fast and remove the layers of eggs that lie buried in the riverbed. This exposes them to predators. They also stir the water in a way that kills small fish. This happens because their gills are filled with mud or because oxygen levels in the water are reduced to critical levels. Most of these sanctuaries should never be visited by motorboat. Only rowboats should be allowed in these places.

6.4. The construction of dams

The construction of dams across Amazonian rivers is the most controversial of the technical transformations. This is due to the fact that they undoubtedly affect ecosystems and the Indians and settlers who live in the areas that are flooded. People who are in favor of the construction of dams highlight the benefits they bring about. Among these benefits is the production of cheap energy which is cleaner than any other kind of production that has been massively used so far. There is also the role played by dams in the control of the high and low tides of the rivers. They can also be turned into huge pools for fish, and they can be used as systems to improve the navigability of rivers where there are waterfalls and rapids by flooding their riverbeds.

However, many people oppose the construction of dams. They highlight the fact that there are various other aspects which are negative. Poor countries fall into debt because of its high costs. Unknown ecosystems where there may be many useful plants and animals will be flooded, as will areas that are used for agriculture. Communities whose ancestors lived on those lands and who believe that the region is sacred will be driven out of the area. Diseases like malaria and schistosomosis will increase. This is due to the fact that this great amount of pooled water is the perfect breeding site for the vectors for these illnesses, snails and mosquitoes (Junk; Mello. 1987).

Although much has been said about the use of dams with the objective of improving navigation in Amazonian rivers, it is not possible to reach a conclusion based on the examples we have. Tucuruíg, which was planned from the start to have a system of floodgates and ports of call that would allow vessels and migrating fish to pass, never received the necessary investments to complete the initial project. Other available examples regarding navigation with the help of dams are the cases of navigation limited to a pooled lake. This is what happens in Balbina, which is close to Manaus, in the State of Amazonas, and in Jamarí, in Rondônia. Navigation in these cases is only local. It is worth questioning whether the seven hydroelectric power plant dams designed for the Tocantins River will actually improve navigation conditions or whether navigation will simply be used as an excuse to the local population until the works that will provide the rest of the country and large mining companies with energy are finished.


WATERWAYS COMMUNICATION IN THE
ORINOCO-AMAZONAS-GUYANAS BASINS
ATLANTIC
OCEAN
VENEZUELA
COLOMBIA
PANAMA
GUYANA
SURINAM
GUAYANA FRANCESA
ECUADOR
PERU
BOLIVIA
BRASIL
CHILE
PARAGUAY
QUITO
LIMA
LA PAZ
BRASILIA
SANTAFE DE BOGOTA
Santa Cruz
Rio Branco
LEGEND
Rapids
River minor navig.
Waterways
Roads related to waterways
Capitals
Cities
International boundaries
Delimitation of the Orinoco Amazonas & Guyana Basins
Water division between the Orinoco and the Amazon Basins
Andes
Guyana Plateau
Central Brazilian Plateau
Elaboró: CAMILO A. DOMINGUEZ O.
Edición cartográfica: Elizabeth Ibaño U.

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6. DETERMINING FACTORS IN THE CONSTRUCTION OF HYDRO ELECTRIC POWER PLANTS IN THE AMAZON: REASONS FOR CLAIMING DAMAGE PAYMENTS [1]

José Alberto da Costa Machado [2]
Rubem César Rodrígues Souza [3]

1. - INTRODUCTION

The hydrographic network in Brazil covers an approximate area of 8,512,000 km^2. It extends over almost the entire Brazilian territory and comprises eight main water basins (see section 2). Hydroelectricity currently amounts to 90% of the total energy mix in the energy sector. This dependence was caused by the use of this hydrographic network for generating electricity.

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Up until the 1980s, the South, the Southeast and the Northeast regions most intensely exploited the use of their basins to generate electricity. This was because they were the more developed regions in the country and consequently the regions with the greatest demand for electricity. From the 1970s onwards, basins in these regions became economically less attractive to large investments. As a result, the vast unknown basins in the north of the country became an interesting prospect as studies identified them as demonstrating the best cost-benefit ratio for the construction of hydroelectric power plants.

These hydroelectric power plants were initially to serve the Northeast region, and supply consumers in the aluminum industry and in the field of metallurgy that had recently set up business in the Amazon (as was the case with the Tucurui hydroelectric power plant). They were also intended to serve isolated local markets (Manaus and Porto Velho). Afterward, they would serve potential consumers in the South/Southeast region. The intention was to take advantage of the rain and drought regimes at the basins at various times in these regions.

Plans for the development and implantation of hydroelectric power plants began to be implemented from the 1980s. However, this did not entirely correspond to the beginnings of the conflicting relationship between the electricity industry and the interests of the region. The objective of this exercise is to ascertain the nature of this conflict of interests. This is carried out by firstly examining the history and secondly, analyzing the consequences brought about by the changes on the region that occurred in the sector in the 1990s. The latter seeks to understand the driving force and the nature of the dynamics that led to the construction of hydroelectric power plants in the region. One fundamental question needs to be answered: which factors determine the demand for hydroelectric power plants in the Amazon?

2. ELECTRICITY IN BRAZIL AND IN THE AMAZON: A BRIEF RETROSPECTIVE

2.1. From regional operation to national integration

The development of the electricity industry in Brazil[4] can be divided into seven important phases: *early stages*[5], *implantation*[6], *regulation*[7], *expansion*[8], *consolidation, nationalization,* and *privatization.*

During the *consolidation phase* (1962-1973), procedures began in order to systematize and integrate the activities of participants whose actions were relevant to the sector. The first step would eventually lead the sector to a model of activity based on integration and on centralized management as demonstrated in the integration of Rio de Janeiro, Minas Gerais and São Paulo (1963) which took place after the Furnas Hydroelectric Power Plant began operating. They can also be seen in the creation of the Integrated Operation Coordinating Committee (1968), which was later replaced by Integrated Operation Coordinating Groups (1973), that was set up to broaden the scope of activities with regard to the integration and centralization of operations. These steps also included the comprehensive studies on demand trends and on possibilities for offering electricity in the Southeast by utilizing its own energy potential. The goal was to prevent energy shortages occurring in the most dynamic region of the country. In order to achieve this, initiatives were taken in order to use hydroelectric potential in the South and the North. This includes the construction in 1973 of ITAIPU and the creation of the Amazonian

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4 The historical evolution of the sector can be found in *MEMÓRIA DA ELETRICIDADE* (2002) and *ESCELSA* (2002)

5 ***Early Stages*** (1879 – 1899): this is when small thermoelectric and hydroelectric power plants were established. They had a local influence and were designed mostly for public lighting or for supplying streetcar lines with energy.

6 ***Implantation*** (1903 – 1927): this stage is characterized by the financial support received from Canada (Brazilian Traction, Light and Power Company, a Canadian company known as "Light") and by the financial support received from the U.S.A. (American & Foreign Power Company, a North-American company known as "Amforp"). Various large hydroelectric and thermoelectric companies began operating during this phase.

7 ***Regulation*** (1934 – 1945): this includes publishing the Water Code, which was created by the National Council on Water and Energy, the regulation of the situation of thermoelectric plants, the regulation of the calculation of fees and the creation of state and federal companies to act as public agents in the production of energy.

8 ***Expansion*** (1952 – 1961): there was an increase in the number of federal and state companies (Furnas, Escelsa, etc.). The Ministry of Mining and Energy was created. ELETROBRÁS was established in order to coordinate the Brazilian electrical energy sector.

Coordinating Committee for Studies on Energy, founded in 1968. This Committee was at the origin of the creation of ELETRONORTE.

During the *nationalization phase* (1975-1986), this linked and centralized operation model became the major basis for the operation of the sector. Committees were created in order to achieve that goal. They include the Committee for Distribution in the South-Southeast and the Coordinating Committee for Operation in the North-Northeast (1975). Light Electrical Services, Inc. was nationalized in 1979. The National System for Supervision and Coordination of the Operation was established in 1979. The- Coordinating Group for Planning Electrical Systems was created in 1982. The first large hydroelectric plant, Tucuruí, started operating in the Amazon in 1984, making it possible for the North-Northeast Linked System to begin operating. Finally, the South-Southeast Transmission System was implanted in 1986. Its objective was to transport electrical energy from the Itaipu Hydroelectric Power Plant to the Southeast of the country.

The *privatization phase* (1988-1999) began with a comprehensive institutional review of the sector, which took place in 1988. This review guided all of the changes made in the electricity sector in the 1990s. In 1990, the National Privatization Program began to be implemented. A new regulatory agency for the sector was created in 1997 - the National Electrical Energy Agency (ANEEL); in 1990, the National Electric Energy Transmission System (SINTREL) started operating. Its objective was to make the generation, distribution and commercialization of energy sectors competitive. The Wholesale Energy Market (MAE) was regulated in 1998. This reinforced the distinction between the activities of generating, transmitting, distributing and commercializing energy. During this phase, the linked and centralized operational model maintained its consolidation process through the implementation of the National Operator of the Electrical System (ONS)[9]. Its objective was to replace the former Linked Operation Coordinating

[9] Until 1998 ELETROBRÁS coordinated interconnected operations through the Linked Operation Coordinating Groups. In that year, as part of the reorganization in the electric sector, the National Operator of the Electrical System (ONS) was created. Its objectives were to manage the National Linked System and the basic energy transmission network in the country. Its institutional mission was to ensure continuity, quality and economy with regard to electrical energy supplies to users of the National Linked System. The National Operator of the Electrical System works to maintain synergic gains related to the coordinated operation, thus creating conditions for a fair competition among agencies in the sector. The ONS was created by Law 9.648/98 and Decree 2.655/98. Its operation was authorized by ANEEL through Resolution 341/98. The National Operator of the Electrical System took over the management of the National Linked System on March 1, 1999. The ONS is a non-profit civil society organization. It manages the National Linked System through the distribution of responsibilities among agencies (companies responsible for generating, transmitting and distributing energy). It follows the rules, methodologies and criteria established in the Network Procedures – approved by the agencies themselves and ratified by ANEEL. ONS (2000)

Groups (1998) in the management of the National Linked System (SIN). It was also responsible for putting the first level of the North-South interconnection into practice. This was a fundamental step for the integration of the electric sector in the country and also for the final adaptation of the sector to the interconnection and centralization of operations.

2.2. Evolution of the energy sector in the Amazon[10]

The national conditions for the use of regional hydroelectric potential began in 1934 when the ownership of waterfalls and the responsibility for regulating their use were turned over to the government, which was set up through the Water Code. The regulation of the price of electricity started to be based on its cost[11] rather than on the mechanisms that pegged it to the international price of gold. From the 1930s onward, during the Getúlio Vargas administration, there was a sharp increase in national industrial and energy sectors. This was especially true for oil and electricity. This increase was followed by a surge in industrial development (during that decade, the industrial sector grew 125% while the agriculture sector grew by only 20%). This triggered the first dynamic boost in the electric sector. However, contrary to what was happening in the rest of the country, where public and private initiatives began to take place in the Amazon (the number of private energy generation plants increased 30.9% in that decade), these changes did not happen. This was due to the lack of economic activity in the region. Up to 1939, a few early thermo-power plants generated all of the electricity in the Amazon.

The creation of the Single Electricity Tax (*Imposto Único sobre Energia Elétrica - IUEE*) by the Constitution of 1946 (although it was only implanted in 1954) and the creation of the Federal Electrification Fund (*Fundo Federal de Eletrificação - FFE*) made it possible for the sector to gather funds. This happened through public resources and made it possible for the second dynamic boost to take place in the sector. The Federal Government started creating its own distributors in various regions of the country. It also started making investments in the Amazon. In 1952, the Federal Government created the Manaus Central Electric Operation (*Centrais Elétricas de Manaus-CEM)*. There were other initiatives: in 1956, the State of Amapá established the Amapá Electrical Company (*Companhia de Eletricidade do Amapá-CEA)* and in the same year, the Pará Lighting Power Company *Companhia de Força e Luz do Pará – FORLUZ)*, was founded. However, during this decade there were no significant energy initiatives in the Amazon, especially in terms of hydroelectric power plants. The reasons for this are described below:

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10 This section is based on SOUZA (2000). Thus, where there is no specific citation, this is the reference.

11 The value of the fee to be paid for electrical energy should be defined based on operational expenses, taxes and fees, depreciation reserves and payment of the resources invested.

1 Public sector investments were minor and did not involve state governments. The main objective of the federal government was to supply major cities with energy. There was no commitment to rural municipalities;

2 The interests of other regions in relation to investments in the sector minimized the possibilities for the development of the sector in the North. At first, the objective of the distribution of the Single Electricity Tax among the units of the federation was to transfer resources to less developed regions. Regulation Decree 40.007 of September 20th, 1956 established that the Federation would receive 40%, states and the Federal District would receive 50% and municipalities would receive 10%. However, the criteria for the distribution were: population - 50%; electricity consumption - 40%; territory - 4% and electricity generation - 1%. It was obvious that Northern states were disadvantaged, for it was only in terms of territory that the States of Pará and Amazonas really had an advantage, but in general this criterion was irrelevant compared to the other criteria;

3 President Juscelino's goal plan, in which the energy and transportation sectors were responsible for 73% of the programmed investments and consolidated the control of other regions over access to the revenues generated by the Single Electricity Tax and by the Federal Electrification Fund. It overshadowed the needs of less dynamic regions.

Also, in relation to the second dynamic boost in the sector, Amazonian interests were not considered. They were neglected while great efforts were made in other regions regarding energy power plants.

In the 60s, concern with supplying the interior of the region with electric energy was on the agenda of the regional state public authority. In 1961, ELETROBRÁS was created, and planning in the electrical sector became its responsibility (until now, it was a responsibility of the National Economic Development Bank), as was the management of the Federal Electrical Fund. This was the reason for the establishment in 1963 of the Amazonas Central Electric Operations (*Centrais Elétricas do Amazonas, S. A. – CELETRAMAZON)*, of the Acre Central Electric Operations (*Centrais Elétricas do Acre* - ELETROACRE in 1965, of the Rondônia Central Electric Operations (*Centrais Elétricas de Rondônia, S. A.* - CERON) and of the Roraima Central Electric Operations (*Centrais Elétricas de Roraima* - CER), both of which were established in 1971. These were all government initiatives whose objective was to supply the interior of these States with energy and to replace the obsolete wood and diesel-powered plants. The potential of these initiatives was amplified by the establishment of a new federal policy for the development of the Amazon[12], which would obviously require an increase in the number of energy-generating facilities.

However, this third dynamic boost in the sector, which now specifically occurred in the region, came up against the interests of other regions. In 1969, due to a new federal development policy for the region, the Ministry of Mining and Energy established a tax incentive for distributors of electrical energy in the North and in the Northeast whose purpose was to expand their investments. This incentive involved giving them a discount on the income tax they would have to pay, making it possible for them to make investments. Despite the fact that this was a federal initiative to support its own policies, which were in progress, there were people who opposed it. In 1971, the tax rate decreased from 17 to 6%. In any case, it was in the 1960s that the region began having access to more energy. Thus, its consumption profile reached a new level (see Table 1).

TABLE 1: Per Capita use of electricity in the Amazon (in KWh/inhabitant).

State	1961	1970
Rondônia	97	38
Acre	24	30
Amazonas	22	114
Roraima	19	70
Pará	47	102
Amapá	186	173
Region	**43**	**101**

Source: Brazilian Institute of Geography and Statistics Foundation - IBGE (1991a).

12 This new policy was known as *Operação Amazônia* and was established through a set of legal tools from 1966 to 1967. Law n. 5.173 of October 27, 1966 established these basic guidelines: to establish development centers and stable population groups, to foster immigration, to encourage private capital, to develop infrastructure and to carry out research on potential natural resources. Economic guidelines were based on the implantation of the Northeast development model in the Amazon; industrialization via the substitution of funded importation for internal/external private capital, making the public sector responsible for attracting resources to the region via monetary and tax mechanisms and establishing infrastructure. Geopolitical guidelines were based on fostering the occupation of the region (especially borders) via interregional and international migration, meeting the level of occupation of Amazonian regions in other countries. The basic administrative structure of the new phase was the Superintendence for the Development of the Amazon (SUDAM) and the Bank of the Amazon (BASA), which was the funding source for SUDAM.

The total per capita consumption in the region more than doubled during the decade, and this despite the population growth by migration. Pará and Amazonas should be highlighted not only because the new development policy first had an effect in these regions but also because in other states public investments in the area of energy generation was to take place only at the end of the decade. Even though there was an increase in the use of electrical energy, the energy consumed in the region amounted to only ° of the average national consumption, equal to 398 kWh/inhabitant. This demonstrates the inequalities in the way the region was dealt with in relation to other regions.

However, as pointed out in section 2.1, at the end of the 1960s, concerns with limitations of the water potential in the Southeast started to emerge. To counter this, the sector turned its attention to the North, especially to the Amazon. In the Coordinating Committee of Amazonian Studies on Energy (ENERAM) was created in 1968. The results of this Committee were the basis for the creation of ELETRONORTE[13] in 1973. For reasons unacceptable to Amazonians, the company was initially based in Rio de Janeiro and subsequently established in Brasília. ELETRONORTE began as a company *for* the region and not a company *of* the region, or at least a company *in* the region.

In 1974, by means of Decree no. 1.383, tax equality was included in the system. This meant that throughout the country the same fees would be applied for the use of electricity. The objective of this measure was to encourage the development of regions where the price paid for the service was high. A compensation system was created, the General Guarantee Reserve (RGG - *Reserva Geral de Garantia*), whose objective was to transfer resources from companies with revenues exceeding the maximum remuneration of 12% a year. This would guarantee that other companies receive at least 10% a year. Since the approval of federal administration taxes was a responsibility of the Ministry of Planning, the economic definition of these values was frequently used for other purposes, including combating inflation. This provision led to a dramatic decrease in remuneration levels in the national electrical sector. The financial damage was still worse in economically less dynamic regions. In addition, this same tax system contributed to maintaining regional inequalities. This aspect will be discussed later, when the National Linked System is analyzed.

In 1975, effective measures were taken so better use would be made of Northern potentials. However, they were not adopted for the benefit of the population. They were adopted to give support to investments in the areas of mining and metallurgy, whose demand for energy was high (Vale do Rio Doce and C. Ithoh, a Japanese company, had

[13] ELETRONORTE was created by Law 5.824 of November 14, 1972. At first, its sphere of activity encompassed the States of Amazonas, Pará, Acre, Mato Grosso (north of the 18° south parallel) and Goiás (north of the 15° south parallel) and the territories of Amapá, Roraima and Rondônia. In March, 1980, ELETRONORTE's sphere of actuation was altered. The State of Maranhão, the entire State of Mato Grosso and the area in Goiás, north of the 12° south parallel, were included.

announced the establishment of an aluminum factory in Belém a year earlier). This is the reason why the Tucuruí Hydroelectric Power Plant was built in the State of Pará, which was ready in 1984. For this investment

> *"... the Japanese were gently exempted from spending any money by the Brazilian Government ... under the pretence of consuming only 30% of the electrical energy. This saved the Japanese seven hundred million dollars. In 1975, when construction began on the hydroelectric power plant, its cost was estimated at two and a half billion dollars. By the time it was inaugurated, nine years later, it had cost five billion and four hundred million dollars..."*(SOUZA, 1994).

David Zylberstajn (apud. Magalhães *et al,* 1996) commenting on the exogenous nature of the interests that had fostered the construction of this hydroelectric power plant, noted:

> *"The obvious injustice in relation to priorities concerning the use of the energy produced (currently largely excedent) clearly demonstrates the inadequacy and dishonesty of the motive* (referring to the use of energy for the development of the region). *The separation of the Tucuruí project from regional development is made clear by the existence of hundreds of thousands of unassisted or badly served citizens living in the surroundings of the hydroelectric power plant. The opportunities that were lost in terms of regional development are enormous".*

Table 2 shows the huge increase in electricity consumption in the North from 1970 to 1980. However, this increase did not have the same effect in the economy of the region because its objective was to serve specific companies. While the increase in consumption reached 432%, Table 3 demonstrates that the number of industrial establishments had grown by only 223.3%. Table 4 demonstrates that the participation of the North in the amount paid to industrial workers rose slightly from 0.81% to 1.97%. The value of production rose from 0.89% to 2.05% and the regional acquired value went from 0.99% to 2.58%. The increase seen by these indicators was not even close to the increase in energy consumption. This suggests that the fourth dynamic boost in the sector did provide benefits to the region, at least not at the same rate.

TABLE 2: Use of Electricity in Northern States (1970/1980.)

States	Use in GWh (1970)*	Use in GWh (1980)**
Rondônia	5.8	145
Acre	8.2	55
Amazonas	145.8	681
Roraima	3.9	36
Pará	263.2	1291
Amapá	8.3	107
Norte	**435.2**	**2,315**

* Source: IBGE (1991a)
** Source: National Energy Summary – 1989

TABLE 3: Institutions and People Working for the Industry in the North (1960/ 1980)

Year	Number of institutions		Workers	
	Number	Increase	Number	Increase
1970	3,196	—	40,229	—
1980	7,169	124.3%	130,093	223.3%

Source: Brazilian Institute of Geography and Statistics - IBGE (1991b).

TABLE 4: Salaries, Production Values and Industrial Transformation – North (1970/80)

Year	Salaries		Industrial Production Values		Industrial Transformation Values	
	Brazil (Cr$ 1.000,00)	Contrib.of the North - %	Brazil (Cr$ 1.000,00)	Contrib.of the North - %	Brazil (Cr$ 1.000,00)	Contrib.of the North - %
1970	12,637.981	0.81	118,427.561	0.89	54,837.311	0.99
1980	675,559.465	1.97	9,618,082.869	2.05	3,988,506.259	2.58

Source: Brazilian Institute of Geography and Statistics Foundation - IBGE (1991b).

In 1980, ELETRONORTE took over the energy generation system at the Pará Electrical Centers (CELPA), formed by the Miramar, Tapanã I and Tapanã II power plants. In addition, in 1980, the hydroelectric power plant of Balbina[14] began construction in the State of Amazonas with a total installed capacity of 250 MW. In 1982, the construction of the hydroelectric power plant of Samuel in the State of Rondônia began. By mid 1984, the transmission system at Tucuruí already began to serve part of the State of Pará. This was possible because of the connection with the São Francisco Hydroelectric Company (CHESF) that exported the exceeding energy on to ELETRONORTE. However, the reason the energy was passed on to ELETRONORTE by the São Francisco Hydroelectric Company was, above all, to guarantee that ELETRONORTE's large industrial consumers, like Albrás/Alunorte in Pará and Alcoa/Alumar in Maranhão, could be served. This energy also supplied the Pará Electrical Centers (CELPA). Very little of this extra energy went to the population or served regional interests. In 1983, ELETRONORTE began to transfer energy from Tucuruí on to the Maranhão Electrical Centers (CEMAR), and by 1984, the Goiás Electrical Centers (CELG) began receiving energy as well.

In 1995, a big opportunity arose in the electric sector (Laws no.8.987/95 and 9.074/95). This change involved promoting competition in the sector of energy generation and the free access to transmission while defining the basic network whose expansion would be subjected to bidding. This included the right for large consumers to choose suppliers and determine fees based on bidding prices or the market value. It also included the creation of Independent Energy Producers, the mandatory completion of unfinished projects and the creation of measures to facilitate the privatization process. The effects brought about by this change on the region will be analyzed in section 2. Currently (2001), the states in the North receive their energy supplies from isolated systems[15], except for the city of Belém and a few municipalities in the State of Pará. Table 5 demonstrates this distribution.

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14 This is an example of how technical and supposedly scientific aspects may have an impact on the region in terms of the construction of hydroelectric power plants. Balbina did not generate as much energy as it was expected to. A huge area was flooded, which seriously harmed Indian populations (Waimiri-Atroar). It made it impossible to live in the areas surrounding the tributaries of the Uatumã and of the Abonari; the submerged forest was putrefied.

15 Electrical systems that are not linked to the National Linked System and that provide the rest of the country with electricity.

TABLE 5: Isolated Systems in the North – 2001

State	Company / Location	Installed capacity (MW)	
		Hydraulic	Thermoelectric
Amazonas	Eletronorte (Manaus)	250	339
	CEAM (Rural Areas)	—	144
Roraima	Eletronorte (Boa Vista)	—	90
	CER (Rural Areas)	10	15
Acre	Eletronorte (Rio Branco)	—	111
	Eletroacre (Rural Areas)	—	26
Rondônia	Eletronorte (Porto Velho)	216	80
	Ceron (Rural Areas)	—	81
Amapá	Eletronorte (Macapá)	40	70
	CEA (Rural Areas)	—	23
Pará	Celpa (Rural Areas)	33	116

Source: Based on the Electric Energy Information System Newsletter of Eletrobrás (2001)

The table above reveals that approximately 78% of the installed capacity in the region is generated from thermoelectric plants that use diesel oil or other fuel oils. It is worth emphasizing that operational costs at these plants are high, and require federal government subsidies in order to charge fees that are accessible to the population in the region. This masks the true situation in the region; enormous energy production potential though still relying on subsidies and favors. This is the real and awful truth, for despite the fact that the region has great potential, there is a chronic lack of services attending to the needs of the majority of the population living in the Amazon. According to Bertha Becker *et al.* and Magalhães, *et al.* (1996):

> *"It is estimated that in the North, 3,400,000 people do not have access to electricity. The problem is much more serious in rural areas. This is due to the fact that, in some states, energy supply services are restricted to capitals and large cities. Many of the people who live in rural areas do not have access to services of this nature."*

The worst cases in the country regarding rural area access to electricity are found in the states of Pará, Amapá, Acre and Roraima, where the percentage of the population with access to these services varies from 15% to 23%.

3. FACTORS THAT DETERMINE THE CONSTRUCTION OF HYDROELECTRIC PLANTS IN THE AMAZON

In order to analyze the factors that determine the demand for hydroelectric power plants in the Amazon, it is necessary to consider at least the following vectors: the ideology behind the large integrated systems created to meet the demand; the ethics of a supply based planning model; and the important methodology variables that determine supply requirements and the interests of identified participants.

3.1. The ideology beneath the large integrated systems created to meet the demand

Currently, the system of production and transmission of electric energy in Brazil is conceived and administrated in its entirety. The most important part of this system is the National Linked System (SIN). The SIN is the only system of its type in the world in terms of its size and characteristics. It is a large hydrothermal system, with multiple owners and in which most of the energy is produced by hydroelectric power plants. It is comprised of companies from the South, Southeast, Central West, Northeast and part of the North. Only 3.4% of the installed capacity for electricity production in the country is unconnected to the National Linked System. This electricity is produced by small isolated systems located principally in the Amazon.

National Linked System operations are coordinated by the National Operator of the Electrical System (ONS). This organization has already been referred to previously[16]. At year end 2001, its *installed capacity* was 67,987 MW, 60,994 MW, of which 50% was produced at hydroelectric power plants (at Itaipu), 5,027 MW was produced at thermal power plants and 1966 MW was produced at nuclear power plants. Hydroelectric power plants are responsible for most of its installed capacity, located at 12 different water basins in the different regions. Hydroelectric power plants are constructed where the river flow and levels can be better exploited, generally far away from consumer centers. This required that an extensive transmission system be developed in order to safely transfer

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16 More details on the relationship between the ONS and the SIN can be obtained in ONS (2002).

energy to consumer centers. These connections also make it possible for energy exchanges between regions, as well as enabling the sale of energy from one region to be to another. This becomes very beneficial with respect to differences in flow rates at different water basins.[17] By the end of 2001, the network comprised 70,033 kilometers of transmission lines carrying over 230 kV.

The participation of regions where there exists better hydroenergetic conditions in the National Linked System is compulsory in order to serve regions where there are adverse conditions. This normally involves the transmission of the available energy from the North and in the South to increase the amount of energy stored in the Southeast and in the Northeast. The operational and developmental reasoning behind the National Liked System determines certain aspects that characterize the regions. The following aspects are identified below:

a) Contribution for maintaining regional economic inequalities

With regard to the Southeast-Central West region, Table 6 demonstrates that in relation to the total National Linked System, this region possesses almost two-thirds of the total load. Production in this region no longer is sufficient and 4% of the load was imported from other regions. This was the case even when taking ITAIPU production into consideration. ITAIPU production represents 22.3% of total production in the National Linked System. Accordingly, if the National Linked System works to bring energy to high-energy demand areas, clearly the largest consumption region will benefit most from the system, as witnessed in the Southeast. If the National Linked System guarantees energy to the energy production sector with fees that are comparable for all regions, and if it so happens that the largest markets are found in these regions, then motivation for economic expansion to other regions will diminish.

This situation minimizes any eventual comparative advantages that are based on potential or effective energy availability for different regions. This situation obliges society to finance costly policies of regional decentralization, which invariably has little effect. In fact, according to the Brazilian Institute of Geography and Statistics (2001), for the period 1996-1999, the participation of the Southeast-Central West region to Brazilian

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17 During periods when hydrological conditions are not favorable, thermal power plants contribute as a whole to supply the market. This complementary participation approached-_10.35% of the total production of energy in 2001. In order for this to occur, it is necessary that agents be interconnected and integrated within the system, with the objective of optimizing the use of available resources for the generation and transmission of energy. This would build trust and maximize availability of the supply thus reducing consumer costs.

GDP remained at the same level and experienced only minor growth (during the period: 64.15% to 64.69%). Despite the fact that this region represents almost two-thirds of the total GDP of all regions in Brazil. At the same time, the regions importing energy (North and South) to the Southeast-Central West registered decreases in their participation to the Brazilian economy. The per capita GDP for this period increased by 19.28 % in the Southeast and by 23.68 % in the Central West while the North, which supplies energy, increased by only 10.74 %.

b) Over-exploitation of resources from peripheral regions to serve hegemonic regions

Despite the fact that the Southeast-Central West is the region that generates the most energy (59.7%, Table 6), Table 7 reveals that 54.67% of the total energy exchanged in the National Linked System benefit this region. This suggests that a large part of efforts of generating parks from other regions end up serving the insatiable Southeast-Central West. As a result, the region of origin reaps only extremely small monetary benefits. Transfer fees for exportation from one region to another are prohibited by the Constitution of 1988 (Art. 155, Paragraph 2., item XI, line b).

From the table, it can be seen that the North contributes 40.05% of the total energy exchanged. Thus, presenting us with a paradox: a needy region in all aspects, the Northeast, ends up providing energy to other regions with extremely small returns.

TABLE 6: National Linked System energy, in 2001, in GWh.

Indicators	North	South	Northeast	Southeast-Central West	Total	Observations
Load	20,412.10	60,660.30	46,341.00	202,990.80	330,404.20	**Imports**: Come from Paraguay and Argentina for the South. Come from the North (6,687.30) and from the South (2,416.56) for the Northeast. Come from the North (1,156.71) and the South (6,984.59) for the Southeast-Central West. **Exports**: From the North, 6,687.30 go to the Northeast and 1,156.71 go to the Southeast-Central West. From the South, 2,416.56 go to the Northeast and 6,984.59 go to the Southeast-Central West. From the Southeast-Central West, everything goes to the Northeast.
% relative to National Linked System	6.2	18.4	14.0	61.4	100	
Production						
Hydro	28,256.06	55,340.79	36,844.09	171,944.53	292,385.47	
Thermo	0	10,454.29	393.06	22,904.86	33,752.21	
Total	28,256.06	65,795.08	37,237.14	194,849.39	326,137.68	
% of National Linked System	8.7	20.2	11.4	59.7	100	
Importation	0	4,266.46	9,103.86	8,141.39		
% of load from the region itself	0	7.0	19.7	4.0		
Exportation	7,844.01	9,401.24		2,416.56		
% of Production + Import	27.8	13.4		1.1		

(1) ITAIPU production for Brazil was 72,733.91 and includes the Southeast Region. This figure represents 22.3% of the National Linked System and 35.8% of the Southeast + Central West load.

(2) Own load=consumption + losses in generation and transmission.

Source: Provided by the authors based on National Linked System Operations Report (2001)

TABLE 7: Inter-regional and international exchange in the National Linked System, in 2001, in Mwh

From	To	Total	% in relation to National Linked System national energy
South	Southeast-Central West	112,217,352	47.70
Southeast-Central West	Northeast	28,790,616	12.23
North	Southeast-Central West	14,067,684	5.97
North	Northeast	80,175,900	34.08
	National Total	**235,251,552**	**100.00**
Outside of Brazil	National Linked System (South)	51,125,988	
	General Total	**286,377,540**	

(1) MWmed is Average Megawatt. 1 MWmed-year = 8,760 MWh/year. This includes average energy for the examined time period. (2) Argentina, Uruguay and Paraguay represent countries outside of Brazil. (3) ITAIPU is included as a Southeast plant.

Source: Provided by the authors based on National Linked System Operations Report (2001)

Operations for energy potential in the North and South by the Southeast-Central West tend to increase. Table 8 reveals that the energy stored in the system in this region demonstrate a continual loss in storage capacity. In 1999, the maximum stored reached 71% of total capacity. This figure fell to 59.4% in 2000, and to 34.5% in 2001.

TABLE 8: Evolution of Energy Stored in the System in % of maximum storage capacity, 1999/2001.

Years	Southeast-Central West		South		Northeast		North	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1999	71.0	18.1	87.9	52.9	58.7	15.9	83.7	24.0
2000	59.4	22.1	96.2	29.6	71.2	27.5	83.7	29.0
2001	34.5	20.6	98.6	77.0	41.4	7.8	76.4	18.0

Source: Provided by the authors based on National Linked System Operations Report (2001)

c) Imposition of technical and management complexity according to increasing amounts of investment

The introduction of the National Linked System Operations Report of 2001 (ONS, 2001) confirms that SIN administration is extremely complex from a technical point of view. In the year 2001, 586 Norms and Instructions were revised and established in reference to real time operations alone; the Technical Database had 30 million entries. The Supervision and Control Systems for the Operation Centers in all the regions had to modernize as new Network Procedures had to be established in order to regulate National Linked System activities. Technical aspects are so complex that the report states that communicating "complex questions of a technical nature" to the public presents a new challenge to be met.

From a managerial point of view, the complexity is greater still. Faced with the fragmentation of the sector, the National Linked System began to explore a complex and diversified web of interests, of:

- generation agents;
- transmission agents;
- distribution agents;
- independent consumers (those with the right to select their electrical energy supplier);

- the Energy Supplier Market (responsible for energy sales transactions and purchases, through registration of bilateral contracts and accounting and liquidation of sales and purchases of electricity sales on the Short Term Market[18]);
- ANEEL (responsible for the regulation and monitoring of the sector[19]);
- importation and exportation agents;
- ITAIPU Commercial Agent for Energy;
- connected regulatory agencies (National Water, Petroleum and Telecommunications Agencies); and
- government representatives (Ministries of Mining and Energy, National Council on Energy Policies, Coordinating Committee of Planning and Growth).

The managerial and technical complexity of the National Linked System becomes a separate issue compared to the political will of government representatives or in relation to the interests of society. The end result is that the demands produced by the technical instruments of this nature tend to become unquestionable truths that need to be dealt with. Otherwise, severe threats of electricity blackouts and economic crises, among other things, would occur. Obviously, this scenario is the result of political choices that are made during periods of gigantic investment undertakings. These choices are based on an ideology of Brazilian power whereby economic growth is the priority at any cost. This ideology does not take other interests into account. Certainly, these choices are not the only options available in supplying energy needs. This is evident in the current focus of transformation in the sector, in search of de-verticalization[20]. This focus recognizes that gigantic vertical action compromises sector operations. Furthermore, the Small Central Hydroelectric Operations (*Pequenas Centrais Hidrelétricas – PCH)* will begin to take on greater importance in the sector in order to:

> *"meet demands near the load centers in areas on the peripheries of the transmission system and in areas that have been marked for national agricultural growth, promoting the remote regions of Brazil."* (ANEEL, 2002:41)[21].

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18 More information may be found on site www.asmae.com.br

19 More information may be found on site www.aneel.gov.br

20 Maintaining the interlinking and centralized operation as the backbone of the system.

21 It is commonly said that interlinking operations increases energy availability in the generation park by 24%, with no investment in new plants or equipment (ROMA JUNIOR, 2001). However, as FERREIRA, 2002, states *"the relative losses in energy in an interlinking system are larger than those in regional systems that are interlinked due to transferring loads over long distances."*

On the other hand, the restructuring process that definitively consolidated the National Linked System includes the deverticalization of businesses as one of its central concerns. It also includes intense commercial competition and free access to the network as well as reducing the role of the State in business functions. Pursuing this logic will certainly bring about a constant increasing need to expand the National Linked System infrastructure, especially in relation to transmission lines. In fact, Table 9 shows that the high-tension transmission system increased by 11% in only 4 years. Forecasts from the National Linked System Operations Report (2001) predict increases of over 10,400 km of additional transmission lines. This represents an increase of over 15%.

This increase is not simply due to expected increases in the sector. It is also due to the increasing distances of generation sources from consumption centers. This situation drive increases in the number of transmission and high-tension lines. This leads to higher costs and more complex technology. Table 9 demonstrates that over half of the registered increase from 1997 to 2001 was for 750 kW lines.

d) Insurmountable structural limitations that force annexation of the North's power and the Southeast's needs

Table 6 shows that nearly 90% of electrical energy generated by the National Linked System is hydroelectric. As stated in ANEEL (2002:17), in spite of the trend to increase other sources *"there is every indication that hydraulic energy will continue to be the primary generation source for electrical energy in Brazil for many years."* This situation creates a serious problem for the future of the sector, as forecasts predict that hydroelectric power, as used today, will run out in two decades (ELETROBRAS, 1994:12). Table 10 shows that the basins located in the regions of largest energy consumption are becoming depleted. The basin of the Paraná River in the Southeast has already used 64% of its existent power and 75% of its stocked power. In the Amazon Basins (Amazon and Tocantins), which represent 51.1% of the total existing power in Brazil, only one fifth - of both existent and stocked power has been used.

TABLE 9: Extension of transmission lines in km, 2001.

Years	Tension in kW												Total and % 97/01	
	230	% 97/01	345	% 97/01	440	% 97/01	500	% 97/01	600CC	% 97/01	750	% 97/01		
1997	30,816.9	—	8,989.6	—	5,936.1	—	13,972.2	—	1,612.0	—	1,783.0	—	63,109.8	—
2001	32,537.3	5.6	9,023.5	0.4	6,667.5	12.3	17,510.1	25.3	1,612.0	0	2,683.0	50.4	70,033.4	11

Source: Provided by the authors based on National Linked System Operations Report (2001)

TABLE 10: Brazilian Hydroelectric power in MW, as of December 2000.

Water Basin	Existent		Stocked		Remaining		Used (total, % per Basin in relation to Existent and Stocked)			
	MW	%	MW	%	MW	%	MW	%	%	%
Amazon River	105,410	40.5	31,889	19.4	73,510	77.0	592	1.0	0.5	1.9
Tocantins River	27,540	10.6	24,831	15.1	2,709	2.8	5,394	8.9	19.6	21.7
North Atlantic/ Northeast	3,402	1.3	2,047	1.2	1,355	1.4	303	0.5	8.9	14.8
São Francisco River	26,319	10.1	23,847	14.5	2,472	2.6	10,473	17.3	39.8	43.9
East Atlantic	14,092	5.4	12,037	7.3	2,055	2.2	2,367	3.9	16.8	19.7
Paraná River	60,378	23.2	51,708	31.4	8,670	9.1	38,580	63.8	63.9	74.6
Uruguay River	13,337	5.1	10,903	6.6	2,434	2.5	294	0.5	22.0	2.7
Southeast Atlantic	9,617	3.7	7,327	4.5	2,290	2.4	2,508	4.1	26.1	34.2
BRAZIL	**260,095**	**100**	**164,599**	**100**	**95,496**	**100**	**60,511**	**100**	**23.2**	**36.8**

Source: ANEEL, 2002:18 and 30.

This overview makes it impossible to imagine another alternative to the supply of electrical energy via the National Linked System to the larger consumption regions. In terms of production dynamics, this would involve annexing power from the North. The following is foreseen in the official planning of ELETROBRAS, 1994: 90:

"In the period 2005/2015, it will be necessary to count on hydroelectricity from the Amazon region in order to supply the North and South. Operations of these plants will begin in the last fifth of the 2005/2010 period with the Belo Monte

Hydroelectric Plant on the Xingu River. This will promote integration of the North/ Northeast and South/Southeast systems via Tocantins. In this way, the electrical energy market in Brazil will be supplied by a single national system. This will be the case at least for the isolated systems in the North that represent less than 1% of the total."

As a consequence, the rivers in the Amazon Region will start to be dammed, not because of the needs of the region but so that the region can meet the demands of other regions. National planners impose this condition and there is little scope for these regions to avoid these obligations. Finally, as previously mentioned, the electricity sector is dependent on the National Linked System. There is no other place for expansion of the system other than the Amazon. The beginning of natural gas use for thermal generation has already been identified in different regions in the Amazon. Again, this presents us with another paradox. The region will resolve its energy needs with less damaging sources and yet it will be obliged to accept huge hydroelectric plants[22] to supply other regions. The financial returns to the Amazon will not justify the damage to the environment and to the resources. This vision of the future (2020) of the official planners is stated below:

"Technological advances in transmitting huge blocks of energy over long distances are associated with the drying up of the sources of electric energy in certain regions. These advances provide a relatively rapid process of integration in the Brazilian electrical system.

The Amazon Region tends to be the largest source of energy in relation to generation, transmission and distribution. The Amazon will be integrated into the national network and this will bring about an increase in efficiency and an optimization of resources." (ELETRONORTE, 1999:156)

This situation is not unique to the Amazon. Power generation in the Amazon is finite. According to the National Linked System annexes, a situation will eventually arise when all growth possibilities for hydroelectric power for the National Linked System are exhausted. This inter-relatedness implies that the Brazilian system is held hostage by the very element that allows for its growth. This element is hydroelectricity.

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22 This is foreseen in Xingu for Belo Monte as well as Altamira; in Tapajós for TA-1; in Madeira for MR-1; etc.

4. THE ETHICS OF A SUPPLY BASED PLANNING MODEL

The operations of the National Linked System, described in the previous section, would not be responsible for causing problems if the planned expansion was based on real social needs and commitments that are in harmony with development objectives throughout all the country's regions. Unfortunately, this does not happen in this way. Projections of demand only take in account market forces. Official planning of the Brazilian electricity production sector becomes a self-serving practice. This is why the greater the demand, the more optimistic scenarios become. The priority is to efficiently serve every aspect that is demanded by economic growth and expansion. With this perspective in mind, the sector plans to meet the demands regardless of the conditions while considering this to be the optimum plan for the sector. Under these circumstances, any effort to reduce the demand that leads to an increase in energy production becomes inconsistent. Social and environmental costs are the inevitable externalities of this relentless conjecture. The premise being that there is a need to supply energy for "development" regardless of the value of the end uses of the energy concerned.

From this point of view, the planning model examines the trend toward growth in the market and analyzes the decisions of large government funded investments. It also identifies the objectives of the important projects while taking into consideration the currents of large migratory flows. Estimates have also been formulated on the potential market based on these flows and they serve as the foundation for planning the expansion of energy supply and consequent generation requirements. Little or no consideration is given to the effective importance these demands may have for society. For instance, environmental costs are not taken into consideration and neither are ethical foundations, as today, they would have to be justified in light of current thinking. An alternative was proposed and demonstrated by Carvalho and Jannuzzi (1994:7-33). This alternative begins by estimating the future energy market by identifying the real needs for goods and services. The alternative anticipates a certain level of societal well being. Energy demands required for all the sectors necessary in the production of these goods and services are then identified. This identification serves as the basis for planning supply growth. In order for this process to succeed the author identifies three basic ethics that simply cannot be ignored: prevalence of a general desire and will to treat the public utility as common property; transparency in the planning and decision-making processes, and harmony with the environment. The results of the application of this method are the numerous constant factors in official planning, which is detailed in Table 11.

TABLE 11: Official estimates of needs and consumption for the generation of electrical energy compared to estimates based on socially effective needs, for the year 2015

Comparative Items	Annual Consumption (MW/year)
1- Alternative Model	
1.1- With no energy conservation programs	560,409,364
1.2- With energy conservation programs	459,920,000
2- Official Model	
2.1- Immediate Scenario (III)	
2.1.1- With no energy conservation programs	767,200,000
2.1.2- With energy conservation programs	661,900,000
2.2- Most Optimistic Scenario(IV)	
2.1.1- With no energy conservation programs	867,000,000
2.1.2- With energy conservation programs	743,300,000
Difference between official intermediate scenario and alternative without conservation	36.9%
Difference between official intermediate scenario and alternative with conservation	43.9%
Difference between most optimistic scenario and alternative without conservation	54.7%
Difference between most optimistic scenario and alternative with conservation	61.6%

Obs.: this table does not include self-production segments (consumption and generation).

Source: Based on CARVALHO and JANNUZZI, 1994: 29 and ELETROBRAS, 1994:18, 80.

Clearly, the differences shown of the assumed ethics of the supply based planning model enlarge consumption forecasts and the subsequent needs for the generation of electrical energy. This creates expectations among all the stakeholders (contractors, equipment producers, financing banks, etc.). These groups may apply pressure so that the forecasts become reality. This perspective and the resulting ethics eventually create the basis for a future that is not necessarily the only future possible.

5. IMPORTANT METHODOLOGY VARIABLES TO DETERMINE SUPPLY REQUIREMENTS

This situation, centered on supply and the resulting ethics, could be minimized in terms of its effect on the Amazon. Instead, truly regional interests could be prioritized in ELETRONORTE that guide activities in the region. The development of scenarios has been the primary resource for planning initiatives in the Amazon. In particular, these scenarios have served as the basis for determining future demand projections for electrical energy in the market place. This methodology seeks to use global and national scenarios as conditioning factors that most influence the future of the region. In this way, a scenario for the region is based on a combination of internal processes and behavior that are observed in terms of global and national conditioning factors. Global scenarios are incorporated as exogenous determining factors for Brazil's future. The confrontation between international uncertainties and expectations vis-à-vis internal national processes is submitted to mediation from Brazilian social participants. This process finally concludes with probable national scenarios. For the Amazon, these scenarios have been part of an *object* system and are built on the combination of the effects of various external variables (national and international) and current internal processes, which are in the process of maturing. This combination also includes mediation from participants with interests in the region[23].

The nature of the applied methodology deserves separate analysis in order to examine its foundations. However, the intention here is to analyze the origin of the conditioning factors that end up gradually defining the forecasts for electrical energy demands and subsequent ELETRONORTE efforts to provide for those demands. Firstly, there are the international and national conditioning factors that define the possibilities and limits for the region. Selecting these factors involves denying other options that are not necessarily included in the interests based on the dynamics of international and national economic and political systems. This configuration of regional interests is based on a concept of the future that is grounded on external interests. This becomes even more explicit when the premises that are used to construct regional scenarios are analyzed.

The Structural Analysis[24] technique was employed in order to define and interpret the region and to design its future. This technique considers the region as a complex system comprised of sub-systems that are linked to areas of knowledge – dimensions. It begins by qualifying the variables according to their ability to influence and determine the *object* system and then establishes a hierarchy of variables. This technique is based on identifying social partners in the Amazon and the ability of each to influence the

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23 Details of the scenarios (global, national and regional) and the methodology used can be found in ELETRONORTE, 1999.

24 The Structural Analysis technique is one of the various techniques used in the methodology of building scenarios.

future of the region. The system associates different values to these participants in terms of power structure. The region was represented by 39 variables[25], of which 18 of these were considered to be external to the region while 21 were considered to be internal. They were distributed according to economic (7 external, 10 internal), socio-cultural (2 external, 4 internal), environmental (1 internal), institutional policies (9 external), technological (3 internal) and spatial (3 internal) dimensions. Table 12 illustrates this distribution.

There is a strong presence of external variables (nearly half) as well as economic variables (also nearly half). This is as true for internal as much as external origins as well as for the totally external nature of the institutional policy variables. The environment issue – the largest differential in the region – is represented by a sole variable. This simple classification and positioning of the variables permits an interpretation of the demand-planning model as one that is strongly influenced by economic issues. This model is almost completely distorted in terms of environmental concerns. It is shaped completely by external sources in institutional policy issues, which are considered as variables.

25 Descriptions of all of these variables may be found in ELETRONORTE, 1999:143-147

TABLE 12: Defining variables of scenarios in the Amazon that determine the demand for electrical energy

Dimensions	Areas	
	Internal	External
Economics	*Regional Economic Dynamics, Private Investments in the Region, Public Expenditures and Investments in the Region, Production Structure, Transportation Supply, Energy Supply, Communication Supply, Regional Demand for Electrical Energy, Regional Demand for Goods and Services in the Region, Non-legalized Economic Activity*	*National Economic Dynamics, Demand for Natural Resources and Agricultural and Animal Breeding Products, Demand for Bio-products, Demand for Genetic Information, Global and National Demand for Energy Intensive Products, Global and National Demand for Manufactured Products, National Demand for Electrical Energy*
Socio-cultural	*Regional Population Dynamics, Socio-cultural Standard, Social Situation, Agricultural Issue*	*National Population Dynamics, Migratory Flow to the Region*
Institutional Policies		*Role of the State, Environmental Policy, Land Policy, External Trade Policy, National Defense Policy, Indigenous Policy, Regional Development Policy, Education and Science and Technology Policies, Energy Policy*
Environment	*Availability of Natural Resources*	
Technology	*Forms of Exploiting Natural Resources, Scientific and Technological Capacity of the Region, Information Technology Network*	
Space	*Urbanization, Continental Integration, Distribution of Socio-economic Activities in the Region*	

Source: Based on ELETRONORTE, 1999:143-150

There is the creation of a hierarchy of variables in order to identify those that have a greater ability to determine the future behavior of the conditioning factors and thus the region itself. This process involves grouping the variables into four categories: explicable variables, linking variables, autonomous variables and result variables. The first two categories are considered to be the most important in determining the *object* system. This is why they are treated with significant emphasis. The autonomous and result variables, and the conditioning factors, which may alter their behavior, are considered to be less important in terms of explaining the *object* system. This is why they are omitted in the analysis phase of determining factors for the future. Table 13 shows the distribution by area and category. The way in which they fit into the category demonstrates the importance of the model conferred to the variable in the methodology, planning and hierarchy. The final importance given to each variable is indicated at the foot of the table.

With respect to the 19 most important variables in terms of defining the region's future for ELETRONORTE activity planning, which entail hydroelectric enterprise, the following variables can be validated:

- Nearly half (9) are from the external sphere. Among these, seven variables are identified from the institutional policy area. This means policy definition and public agency decisions. The other two variables come from the economic domain. One of these received the highest importance rating (Demand for Natural Resources and Agricultural and Animal Products). The other variable (National Economy Dynamics) represents the principal demand for electrical energy in other regions of the country. It is clear that the planning model is strongly influenced by external factors and brings about decisions that strongly depend on non-regional factors;

- Not a single variable from the socio-cultural domain is among the most important variables identified. The only variable from the environmental domain focuses solely on the availability of natural resources. This variable does not focus on conservation issues or sustainable use and protection. It is clear that this planning model is truly refractory as regards to social and environmental issues;

- Issues of great regional importance are not considered to be important within the model. This is the reason for their treatment as autonomous or result variables. This is the case for the categories Demand for Bio-products, Demand for Genetic Information, Global and National Demand for Manufactured Products, Global and National Demand for Energy Intensive Products among others. This clearly shows that the model is not committed strictly to regional issues. The model is applied to the Amazon more in terms of making it function than in terms of making it more dynamic.

TABLE 13: Classification of the variables used in defining scenarios for the Amazon according to their importance in determining the future of the region.

Area/Category		Types according to ability to determine regional future			
		Explications	**Linked**	**Autonomous**	**Results**
Internal	Economics		*Public Expenditures and Investments in the Region, Private Investments in the Region, Regional Economic Dynamics, Transportation Supply, Energy Supply, Communication Supply*	*Production Structure, Non-legalized Economic Activity*	*Regional Demand for Electrical Energy, Regional Demand for Goods and Services in the Region*
Internal	Socio-cultural			*Regional Population Dynamics, Socio-cultural Standards*	*Social Situation, Agricultural Issue*
Internal	Institutional Policies				
Internal	Environmental		*Availability of Natural Resources*		
Internal	Technology	*Information Technology Network*	*Forms of Exploiting Natural Resources*	*Scientific and Technological Capacity of the Region*	
Internal	Space		*Continental Integration*	*Urbanization, Distribution of Socio-economic Activities in the Region*	
External	Economics	*Demand for Natural Resources and Agricultural and Animal Breeding Products*	*National Economy Dynamics*	*Demand for Bio-products, Global and National Demand for Manufactured Products, Global and National Demand for Energy Intensive Products, Demand for Genetic Information*	*National Demand for Electrical Energy*
External	Socio-cultural			*National Population Dynamics*	*Migratory Flow to the Region*
External	Institutional Policies	*Role of the State*	*Regional Development Policies, Energy Policy, Environmental Policy, Education and Science and Technology Policies, National Defense Policy, Indigenous Policy*	*Land Policies, External Trade Policy*	

Final Hierarchy of the Variables

1. *Demand for Natural Resources and Agricultural and Animal Products*
2. *Role of the State*
3. *Information Technology Network*
4. *Regional Development Policy*
5. *Energy Policy*
6. *Environmental Policy*
7. *Education and Science and Technology Policies*
8. *National Defense Policy*
9. *Indigenous Policy*
10. *Public Expenditures and Investments in the Region*
11. *National Economy Dynamics*
12. *Private Investments in the Region*
13. *Regional Economy Dynamics*
14. *Forms of Exploiting National Resources*
15. *Availability of Natural Resources*
16. *Transportation Supply*
17. *Communication Supply*
18. *Energy Supply*
19. *Continental Integration*

Source: Based on ELETRONORTE, 1999:148-150

In this model, identifying the most important variables enables the selection of the most important conditioning factors for the future (current real processes and events). These factors are chosen for their abilities to alter the status of the variables. Selecting the conditioning factors implies building a model of the Amazon that allows for intervention. It is appropriate to keep in mind the planner's interests, which is essential to this equation. This process creates a false reality that is based on the planners' proposals and commitments. The Amazon that emerges from this process is stripped of its true interests. The plans formulated for the Amazon become techniques that serve as a basis for the interested social partners to use in order to apply pressure for the effective running of the hydroelectric plants, which are anticipated in these plans.

6. METHODOLOGY TO PROVIDE VISIBILITY FOR THE INTERVENING SOCIAL PARTNERS IN THE PROCESS OF THE CONSTRUCTION OF HYDROELECTRIC PLANTS IN THE AMAZON

The fact that plans exist to construct hydroelectric plants in the Amazon does not necessarily suggest that they should be established even if they are inappropriate. Hopefully, this is what will be achieved when the rights of the social partners concerned are taken into consideration. The World Report on Dams (World Dam Commission, 2000:18-20) takes the following approach to this issue:

> *"... we need to consider the proposed development projects for water and energy resources within a much broader scenario (...) This means that new voices, perspectives and criteria must be incorporated into the decision-making process. It also means that we must adopt an approach that is capable of obtaining consensus on the decisions made (...) (taking into consideration the) rights and nature and magnitude of the possible risks to all involved parties (...). Including rights in the context of a proposed project is an essential step in identifying the demands and prerogatives (or acquired rights) that may be affected by the project (...) (and should play) a formal role in the consulting process and later on, in negotiations on specific project agreements (...). Traditionally, the definition of risk is restricted to constructing companies or institutional investors in terms of capital to be applied and expected returns. These individuals assume these risks themselves and have the power to define the degree and type of risk they wish to assume. They can explicitly define the acceptable limits of these risks. In contrast, a Global Study demonstrated that there is a much larger group of people that are obligated against their will to take risks that are administrated by others. As a rule, those that run involuntary risks have little or no active voice in water and energy policies in general. They have no voice in choosing specific projects or in the development and establishment of a project. (...). Finally, as in the case of rights, the risks must be identified, given names and definitively confronted. This demands recognition*

of the risk that is extended to a larger group and should not include governments and construction companies. This risk also includes the people that are affected by the project. This risk also involves the environment as public heritage.

(...) An approach like this allows for decision-making processes that are focused on seeking negotiated results carried out in an open and transparent fashion. These results include everyone that is effectively involved in the issue – helping to resolve the numerous and complex issues involving water, dams and development."

How are the important social participants defined in ELETRONORTE planning related to the employment of hydroelectric plants? This question is dealt with in ELETRONORTE (1999:169-180) as noted below:

"Two different analyses of social partners were performed in order to determine the Amazon scenarios. The first sought to understand the potential of the partners in terms of the object system. This included examination of how the partners acted and what the means and instruments were that influenced their most definitive concrete variables, particularly explicatory variables. The second analysis concentrated on analyzing the relationships among partners. It sought to understand the power structure and the different importance levels that defined policies and control of the State.

These two analyses will define the methods that will form the policy structure of the Amazon scenario based on coalitions and alliances that could define, with support or resistance, different representations of the reality and of policy definition."

There were 27 social partners defined with different interests and different levels of involvement in the future of the Region. These partners were split into two groups – internal and external partners – according to their position in the context or in the *object* system[26], illustrated in Table 14.

26 Two participants appear simultaneously on the external and internal lists. This emphasizes that the internal segment of the region includes broad social participation particularly from ecologists and regional development agencies.

TABLE 14: Important Social Participants in the Construction of the Amazon's Future

External Participants	Internal Participants
Ecologists Construction Companies Businesspersons from the Financial Sector National Businesspersons National Agricultural Industry Businesspersons States enterprises Transgressor Groups Various Religious Groups Catholic Church Multi-lateral Financial Institutions International Timber Companies Military Federal Regional Development Agencies Pan-amazon Countries	Sub-regional Development Agencies Landless Agricultural Workers Scientific Community Indigenous Communities Ecologists Local Businesspersons Large Property Owners Illegal Appropriators and Sellers of Public Land Extraction Method Minority Groups Federal Regional Development Agencies Rural Producers Liberal Professionals Urban Workers

In the methodology, Structural Analysis of the Participant Variable was applied to define importance level in terms of the influence exerted by each group of social partner on the *object* system. This included the differentiated effect of each group's decisions and the instruments available to them in terms of affecting the Amazon's future. This table of hierarchy is outlined below:

TABLE 15: Hierarchy of the Social Participants

1. Federal Development Agencies	13. Ecologists (endogenous)
2. States enterprises	14. Scientific Community
3. National Agricultural Industry Businesspersons	15. International Timber Companies
4. Federal Development Agencies (endogenous)	16. Military
5. Sub-regional Development Agencies	17. Rural Producers
6. National Businesspersons	18. Large Property Owners
7. Multi-lateral Financial Institutions	19. Catholic Church
8. Local Businesspersons	20. Landless Workers
9. Construction Companies	21. Various Religious Groups
10. Ecologists	22. Illegal Appropriators and Sellers of Public Land
11. National Businesspersons from the Financial System	23. Extraction Method Minority Groups
12. Pan-amazon Countries	24. Indigenous Communities
	25. Liberal Professionals
	26. Transgressor Groups
	27. Urban Workers

Based on this hierarchy it can be said that:

- The 10 most influential partners on the *object* system are: the Federal Development Agencies; States; National Agricultural Industry Businesspersons; Federal Development Agencies (internal); Sub-regional Development Agencies; National Businesspersons; Multi-lateral Financial Institutions; Local Businesspersons; Construction Companies and Ecologists. Among these, the Local Businesspersons are the only completely internal entity. This is because the Federal Development Agencies have strong ties to the Federal Government. Furthermore, the Sub-regional Development Agencies depend on decisions from the Federal Public Agents and National Businesspersons. This implies that the planning model assumes external uniformity among partners who influence the fate of the region.

- The government, in its federal capacity, is the most important partner in the Amazon. The federal government acts through State Development Agencies and Sub-regional Development Agencies. The regional governments (state and municipal) are not considered important and are not even mentioned among the 27 partners in Table 15. The population living in the region select the governments mandates. This confirms that the planning model functions, with the understanding that the federal government is the most important partner in the public sector and that the state and municipal governments are insignificant.

- The private sector nationally also has a significant position in the hierarchy. This sector is represented by National Businesspersons from the Agricultural and Animal Breeding Industry Sector, Construction Companies and National Businesspersons from other sectors. The regional private sector is represented "generically" as among the 10 most important partners. The sector is represented by Local Businesspersons and demonstrates that the planning model considers the non-regional businesspersons to be more important for the region's future.

- National Ecologists are included among the most influential partners. This implies that the planning model acknowledges that the regional environmental agenda is primarily defined outside of the region. The Multilateral Financial Institutions (World Bank, IDB, etc.) are also included among the 10 most influential partners and this affirms that the possibility of funds represents a huge power centre as concerns the region, and.

- The regional participants that have been most affected by large hydroelectric plants in the past (rural producers, extraction method minority groups, indigenous communities, etc.) are last on the list. They are therefore considered with low importance in the analysis of the planning model.

To what extent does this methodology affirm the amount of political power partners wield over their causes, or how much power they might amass by way of alliances? A second hierarchy was developed to interpret the extent of power that these accumulated inter-relationships grant each partner. This new hierarchy differs from the partner-variable relationship, which represents the influence of partners on the *system*. The new hierarchy represents the power relationship that exists among partners as well as the subtle political and ideological games they play among themselves. A number of adopted conceptual assumptions tend to disguise what really takes place in practice. The document states:

> *"The primary difference between the two treatments is found in the absence of the Public Institutions (Regional and State Development Agencies). They are not part of the power game, but they are a focus of conflict among partners. From a conceptual point of view, these institutions become much more of a tool for negotiation, pressure and political influence for the social partner, than an independent partner with its own power."*

> *The Public Institutions are emphasized as regards the variables of the system (analysis of the partner's power), but they do not represent a political partner who negotiates and fights for space and influence with the representative of interested social groups such as Businesspersons, Workers or Extraction Method Minorities, etc."* (idem, pp. 177).

This position may even be considered to be conceptually valid for partners that are genuinely part of the public sector. However, under no circumstances can it be extended to the states. This is especially true when dealing with the electricity sector, which acts competitively in an environment where the notion of the private sector serves as the driving force. In reality, this does not happen in practice, even with regard to the truly public sector. Moreover, public positions are sought out precisely in order to augment the power behind the social dominance of partners' demands. They are the assumed representatives of the more powerful partners. The methodology ends up confusing this issue. Even though this is true, the result of the partner-partner analysis is extremely close to the previous hierarchy. The power structure in the Region is represented in Table 16 below:

TABLE 16: Power Structure in the Amazon

Social Participants	Power Potential
National Agriculture Industry Businessperson	255
National Businesspersons	249
Multi-lateral Institutions	233
Local Businesspersons	228
Construction Companies	197
National Businesspersons from the Financial System	166
Ecological Groups	156
International Timber Companies	152
Pan-amazon Countries	135
Large Property Owners	124
Scientific Community	121
Rural Producers	103
Military	97
Extraction Method Minority Groups	92
Religious Groups	87
Transgressor Groups	75
Landless Workers Movements	74
Illegal Appropriators and Sellers of Public Land and Unofficial Miners	66
Urban Workers	61
Liberal Professionals	59
Indigenous Communities	58

Based on this hierarchy, the following statements apply:

Even when public sector states and agencies are removed, external partners still have an enormous presence in defining regional policies. Local

Businesspersons are the only completely internal partners in the region. Ecological Groups represent a coupling between internal and external Ecologists from the previous hierarchy, and Large Property Owners commonly live outside of the region.

- The power of the social partners, situated at the top of the list, represent about five times the power of those situated at the bottom of the list. Furthermore, the bottom of the list represents those most affected by the hydroelectric plants.

- Even partners considered as having some power in the region, such as the Scientific Community and the Military, are not included in the group of powerful partners in the region. The power they exercise is equal to half the power held by Businesspersons.

This is how planning priorities for the region are defined. Furthermore, in seeking alliances in order to install hydroelectric plants, it is evident that ELETRONORTE would never replace a partnership of National Businesspersons with the Indigenous Communities.

7. CONCLUSIONS

Due to regional economic apathy, the Amazon was not included in what was considered as the original dynamic surge in the electricity sector. This surge took place in the 1930s and 1940s with the second surge occurring in the 1950s. During this time, little attention was paid to the energy sector and capital was blocked according to distribution criteria for resources that penalized the region. These criteria included the standardization of other resources in terms of their access. Criteria were defined in accordance with the performance of Juscelino's Plans *(Plano de Metas)* that favored transportation and energy sectors in the more dynamic regions of the country.

The third surge began with federal political support in developing the region. However, despite this impetus, initiatives at this time did not succeed. The mechanisms that were used for the regional capitalization of the sector were minimized in terms of their power. This maintained the region's per capita consumption rate at a mere quarter of the national average, equal to 398 kWh/resident at that time. The fourth surge began to put regional hydroelectric potential at the service of interests that were not located in the region itself. This came about via the National Linked System because of the need to supply electricity intensive industries (aluminum, iron, etc.) or because of the need to supply energy to other regions in the country.

This National Linked System was the backbone of the electricity industry in Brazil. The system's logic is based on links and centralized operations that contribute in:

- Maintaining a concentrated economy in the Southeast and consequently, maintaining regional inequalities. This system guarantees energy for the production sector with comparable tariffs in all regions in the country. Important markets are located in this region, yet limited direct economic expansion is observed in other regions.

- Committing natural resources to peripheral regions, like the Amazon, in order to benefit dominant and more economically dynamic regions by the over-exploitation of hydroelectric power. This provides little financial or economic income for the region.

- Technical and Managerial complexity in the Brazilian electricity sector that is consistently independent in terms of political will or social demands. Additionally, there is greater demand for bigger investments in order to meet the developing dynamic of the National Linked System.

- Imposing realistic conditions and limits on the electricity sector. The overwhelming demands for power is such that we are beginning to witness the first phases of exhaustion in terms of pushing the Amazonian capacity to its limit in order to serve the needs of other regions, especially the Southeast. This deprives the region from using these resources for select development focused goals and forces the region to tolerate the socio-environmental impacts that result from the construction of hydroelectric plants.

The supply based planning model used for the electricity sector is based on consumption forecasts and the consequent needs of electrical energy generation on market trends. However, the real needs of society are not taken into account. This creates expectations for contractors, equipment producers, financing banks, etc. who then apply pressure in order to realize their projects. This scenario leaves little flexibility for other visions of the future.

The ELETRONORTE planning strategy for the Amazon is based on what are basically economic variables that are totally incoherent in terms of social and environmental issues. In terms of institutional policy issues, these variables are unequivocally composed by external sources. The variables selected in the development of the Amazon model are based on allowing for flexibility that permits intervention. The strategic planning referred to involve social partners that are identified as power sources in the Amazon. Essentially, they are external and are primarily from the federal public sector and non-regional Businesspersons. The most influential social partners are shown to have as much as five times more power than the partners that are directly concerned the implantation of the hydroelectric plants. The interests of these influential parties end up being incorporated into priorities of the ELETRONORTE plans.

Conclusions drawn from these statements reveal that the region had been neglected in the past and that its future role in the electricity sector has been predetermined. Any vision that involves integrating the Amazon with other regions in Brazil always involves appropriating power from the Amazon in order to benefit the more dynamic regions. Now, more than ever, the region has a resource providing electrical energy that is vital to the Brazilian economy. However, it is also equally true that the other regions have never before been so dependent on the natural resources (hydroelectric power) of the region. Therefore, if over-exploitation is inevitable, then it should at least benefit the region and provide the best economic returns to serve the people of the region and the local environment. A situation could be envisaged whereby damages are paid by the hydroelectric plants for their imposed self-serving policies. Machado (2002) has the following observations on the issue:

> *"...the location of any hydroelectric plant in any region unequivocally occurs for reasons of the national system that almost always completely ignore regional interests.*
>
> *Therefore, after the plant is installed, the internal dynamics of the region are completely shaped by the logic of the system. The population in the region is re-located and is either forced to move or because of the newly generated economic attractions. The power of the rivers is diminished and their natural functions in the ecosystem are lost, as they are seen as mere sources of energy. The lands are flooded and natural economic activities, which they had previously sustained, become impossible to maintain. Immigrants flock to the region and add to the problems and social demands. Finally, development options become definitively bound to the obligation to generate energy in order to serve other distant regions. Obviously, this is something that responds to national demands. Authorities in charge of the issue cannot allow regional authorities and social agents (governors, mayors, businesspersons, etc.) to make independent decisions on the fate and direction of activities. The area in the region where the plant is implanted becomes an enclave of external interests. Autonomous management by the people and their directors is expropriated."*

What is the price of this form of obligation? Some argue that compensation will be derived through royalties and the generation of new jobs, etc. and thus represents the social returns expected from the enterprise. However, the self-determination of these regions is rooted in our cultural ambitions based on federalism. As witnessed in the Amazon, this has been the driving force for enterprises of this nature. However, regions must not be allowed to continue damaging their own interests. If a region is being denied its right to decide its own path for its proper development, then this suggests an imposed undertaking and fair compensation will be sought.

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7. INCLUSION OF THE AMAZON IN THE GEOPOLITICS OF WATER

Bertha K. Becker *

Throughout history, ideas on the geopolitics of the eastern world have changed. With the expansion of civilization and technological advances, various perceptions regarding the world as it was known were elaborated. Power was linked to certain areas and to certain natural resources.

In the past, fertile valleys were looked upon as a source of power, as later was the Mediterranean climate. Mercantilism and navigation broadened horizons and made land possession and strategic positions valuable. Coal and iron were valorized by the Industrial Revolution. In the 19th century, the invention of steam navigation and the construction of railroads made it possible for the planet to be seen as a whole. Later, this perception was refined upon the invention of the airplane. Control over transportation systems was regarded as a source of power. In the XX century, the development of circulation systems and war methods made the power based on the control of transportation systems obsolete. Furthermore, the industrial development made petroleum a crucial item for power.

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However, it was only when satellite technology allowed man to see the Earth from space that humanity became aware of the planet as a unit and as common property. Everyone has to take responsibility for its use. What also became clear was that nature had become a scarce good. An ecological challenge was posed which had two objectives: the survival of humanity and the valorization of natural resources. The latter involved considering nature strategically valuable. This made nature a political issue, and the uneven distribution of technology, dominated by central countries, and that of natural resources, found in peripheral countries and areas which were not completely regulated, generated serious conflicts. These conflicts occurred among powerful countries, with the objective of controlling natural resources, and between powerful countries and peripheral countries, in an attempt to influence their decisions on how to use their natural resources. This situation began to involve issues related to sovereignty (Becker, 1997; Mendes, 1997). To say that the Amazon has become a symbol of these challenges would not be an overstatement.

On the one hand, there is an actual and continuous concern about human survival. On the other hand, the current dominant trend is the commercialization of natural elements: a market for air, life and water is forged (Becker, 2001) under the rhetoric of great risks and threats to humanity.

The latest concern is the lack of water. This situation has been noted and announced as an actual global catastrophe. Water has been given a strategic value similar to that of petroleum in the 20th century and has been called "blue gold". Hydropolitics is developing in the world.

It is true that each place on the planet is either directly or indirectly affected by global processes. However, they are not affected in the same way. This is due to the volume of resources, the different kinds of use and management and to different needs. Therefore, it is necessary to distinguish between the legitimate need for the conservationist use of resources and the needs related to the geographic diversity of the Earth. Otherwise, there is the risk of accepting global impositions that have nothing to do with the national and regional interests of each country in the name of the common good.

The objective of discussing the inclusion of the Amazon in the geopolitics of water is to contribute to a more objective analysis of the issue. This analysis is developed in three sections. The first question is related to fresh potable water and the challenge of trying to show that the catastrophic global vision is in fact relative. The second section presents a geo-economic vision which shows that there is a tendency towards the commercialization of water. This is done through the discussion of proposals for the global management of this resource. The third section is related to the uneven geographic distribution of water resources. It clearly shows the riches found in the Amazon and the possibilities for Amazonian countries in terms of the geopolitics of water.

1. THE CHALLENGE OF FRESH POTABLE WATER FOR THE GOVERNABILITY OF THE EARTH: "APOCALYPSE NOW"?

Until recently, water was abundant, available and free. Now that it is lacking, it is a strategically important raw material. Placed on the same level as petroleum, water is now called "blue gold".

It is always worth noting that water accounts for 63% of a person's weight. A complex and fragile resource, water is at the same time an economic resource and an ecosystem. It has multiple uses for the population, the industry, agriculture, navigation, energy production, tourism, etc. There is little human work, either in terms of production or consumption, where there is not a demand for water, which cannot be substituted for anything else. Thus, natural water is as a raw material, a product and a production element in all sectors of the economy. However, it is important to bear in mind that water is a raw material with a specific characteristic: it is renewable.

There are various arguments and apocalyptic forecasts about the lack of water. Therefore, the first task is to separate catastrophic forecasts from real facts.

1.1. The Global Apocalyptic View: Blaming the Demographic and Urban Growth.

As is always the case with these kind of forecasts, the "great demographic growth" is considered the factor responsible for the catastrophe. This once again brings up the Malthusian thesis, but it does so in a different light, as follows:

- The world population tripled in the last 70 years, while water consumption is six times what it used to be;
- Fifty-four percent of the available water resources are already being used. The planet's population is expected to increase by 50% until 2025, thus reaching 9 billion inhabitants. Water consumption will increase by 40%. This means that we will be using 70% of the total amount of water resources;
- 1.1 billion people do not have access to potable water and 2.4 billion do not have access to basic sanitation;
- According to UN previews for the year 2025, two thirds of humanity (2.7 billion people) will not have access to the water necessary for their basic needs;
- The demand for water, both direct (domestic purposes) and for agricultural and industrial activities, will grow. However, the quantity of renewable fresh water will probably be the same: 40,000 km^3. The average availability of

fresh water per inhabitant, which was 8,000 m^3 per year in 1990, will be limited to 4,000 in 2040 (Le Moigne et Ténière - Buchot, 1998).

- In 2025, the planet will probably have 650 cities with more than 1 million inhabitants,
- The world's population is concentrated in huge cities along the coastline - 15 out of the 21 cities where there are more than 10 million inhabitants are located on the coast - and while water is becoming scarce, the sea level seems to be constantly rising;
- If a water management program is not carried out, there will be a very high mortality rate unlike anything known in the 20th century.
- Finally, the current forecast is that, if there is a generalized lack of water in the future, water will no longer be a source of life and economy. On the contrary, water will be a source of armed conflict, as was the case with petroleum in the 20th century. There are over 200 water basins that are shared by two or more countries, and 40% of the world's population lives in these countries. Thirteen of the largest rivers - like the Amazonas, the Danube and the Nile - cross the borders of more than one hundred nations. Fierce competition for water resources might result in violent international conflicts (Sironneau, 1998; Lino, 2002, de Villiers, 2002). As is the case with petroleum, the "black gold", countries are ready to resort to armed conflict, if necessary, in order to have access to the precious "blue gold". The reason for conflict is the division of the resource between the countries located upstream and downstream of the basin, and countries that are more or less powerful economically.

1.2. Facts

There are, however, concrete restrictions to be considered.

- Water only seems abundant. Fresh water corresponds to only 2.5% of the terrestrial water mass, and potable water corresponds to less than 0.01% of the total. This is a true fact. Although our planet is made up of much more water than land, the fact is that 70% of this water corresponds to ocean water masses;
- There is a growing competition for different water uses;

TABLE 1 - Distribution of Water on Earth

Nature of the Water Stocks	% of the Total Amount of Water*
Salt Water	97 - 96.54
Fresh Water	2.5 - 3.5
Fresh Water Stocks	
Glaciers and Snow	69.6
Underground Waters	30.15
Lakes and Swamps	0.29
Atmospheric Water	0.04
Rivers	0.006

* Percentages vary and totals are not always accurate.

Source: Fritsch, Jean-Marie 1998

- The water used for domestic purposes corresponds to just 8% of the total water consumption. Water consumption on a global scale is the result mainly of irrigation, which uses three fourths - 70% - of the total amount of fresh water used in the world. Some specialists say that the use of water for irrigation is directly related to the level of development of the countries: less developed countries use more water for irrigation and vice-versa. Thus, peripheral countries use approximately two times more water per hectare than industrialized countries although they produce three times less. Sometimes, the market value of their production is lower than the cost of the water used;
- Over the last three decades, the area taken by irrigated lands - where 40% of the food on the planet is produced - went from 200 million to 270 million hectares, using 70% of the total amount of fresh water consumed annually. However, 60% of this water (42% of the total amount consumed each year) is wasted due to problems with irrigation systems;
- There is a serious problem in terms of lack of access to potable water. This occurs due to problems with water supply and sanitation services. Recent studies show that currently there are over 200 million people that do not even have access to 1,000 m^3 of water per year. Other 400 million people are living in a situation of hydric stress - which means they have from 1,000 to 2,000 m^3/year. This makes it impossible for any kind of development to take place. Finally, 80 countries, or 40% of the world's population, have

difficulties to provide their population with water and sanitation services. Consequently, 5 million people die every year as a consequence of water-related diseases. Thirty million people are affected by epidemics and contamination due to water pollution and the lack of water treatment;

- It is necessary that U$ 23 billion be invested a year to meet the demand for potable water and basic sanitation. However, only U$ 16 billion are invested annually. According to the World Health Organization, this contributes to the death of 3.4 million people every year as a consequence of diseases transmitted by contaminated water;
- Fresh water ecosystems are deteriorating rapidly. Sections of several important rivers are seasonally dry and many species of fish and fresh water mollusks are endangered due to changes in their habitat;
- Floods and droughts occur and have serious consequences.

What happens when catastrophic global forecasts and facts are counterposed against one another? The fact is that the lack of water and the possible occurrence of an armed conflict to gain control over it cannot be blamed on demographic and urban growth anymore.

It is known that blaming the problems of the world on demographic growth alone is a false accusation. In the first place, it cannot be affirmed that growth rates will be the same as they were in the last century. In spite of the "outstanding" demographic growth that took place during the last fifty years - 2.5 billion people in 1950, 5 billion in 1990 and 6 billion in 2000 - demographers themselves previewed the inflection of this process. They expect that there will be a total of 8 - 9 billion people in 2025, and the population will stabilize at around 9 - 12 billion people in 2050 (Lê Moigne and Ternière-Buchot, 1998). According to them, there may be an even greater inflection. Secondly, it was demonstrated decades ago that, on the contrary, development contributes to the reduction of demographic growth.

Likewise, the war for water is not yet defined. Resorting to war might bring a prompt solution for the problems related to the lack of water. However, this should not be a common answer to the challenge posed to humanity. It would be a better idea to invest in cooperation.

Finally, the water issue is a socio-environmental matter. The previously mentioned facts clearly show that the problem resides in how water has been used and in how this resource has been managed rather than in the population growth.

Other elements should be added to this analysis that are not related to the global apocalyptic view. These elements include the market and the differences highlighted by a regional vision.

2. A GEO-ECONOMIC VIEW: GLOBAL WATER MANAGEMENT OR COMMERCIALIZATION OF NATURE?

The most evident expression of the valorization of nature as a natural resource is the process of commercialization involving it (Becker, 2001). In other words, the concern with life on the planet has been exchanged for a concern of an economic nature. This takes place in the form of an association of geopolitics and economy. This is a process in which new elements of nature are commercialized and changed into fictitious commodities. They are called fictitious commodities because they are not produced to be sold in the market; however, there is a real market for these products.

As early as 1944, Karl Polanyi called attention to the transformation of land, work and money into fictitious commodities at the beginning of the 19th century. Currently, the same process is happening with air, life and water. There are forums and conventions trying to implant global environment systems to turn these items into marketable commodities (Becker, 2001).

The regulation of the air market through the establishment of an exchange-traded market for carbon credits is the object of disagreement among countries. The fight for the life market in relation to patents and access to genes occurs more silently. The water market is just beginning. Unlike the air, biodiversity and water are geographically located elements. They are also inseparable from historically built social relations. These relations grant them values and use them in different ways, which generates conflict with a global view. In fact, tension was generated by the Biodiversity Convention itself. Although this Convention was concerned about global problems, it declared that natural resources were the property of national sovereignties.

These observations are essential to remind us all that vital goods like air, biodiversity and water cannot be controlled by market laws. It is the responsibility of the society to establish limits to the commercialization of nature.

2.1. "No water without fees", the most important slogan for the 21st century

Needless to say, geo-economic battles generate tension in relation to the use of water. This involves countries located upstream of the basin or economically advantaged countries in a position of power and the other countries that make up the basin.

There are various examples of this kind of tension. The most significant is the case of Turkey. Turkey is located upstream of the Euphrates River and the Tigris River. It is an economically dominant country whose priority is to use water for its own benefit. The main objectives of Turkey's project for Southeast Anatolia were to create an economic outlet into Kurdistan in order to put an end to a rebellion that has gone on there for decades and to develop irrigated agriculture so the agro-industrial production can be exported to the Middle East and to newly independent countries in Central Asia and in the Caucasus. Also, Turkey expected to confirm its control over the countries located downstream of the rivers - Syria and Iraq. The problem is that these countries do not agree with this control, and the risk of conflict involving not only Syria and Iraq but also Syria, Israel and Jordan tends to increase for the use of the Yarmouk.

Another challenge is the fact that three countries, Sudan, Ethiopia and Egypt, share the waters of the Nile. These countries are located far downstream of the Nile, in an arid zone where it would not be possible to develop any kind of agriculture if it were not for the river. Ethiopia is the country that has the most serious problem. Eighty-three percent of the body of the Nile is located in this country, but Ethiopia's rights to carry out work involving the river are vetoed by Egypt, the most demographically and militarily powerful country in the region. There is also Israel, a country that constantly searches for a hydrologically strategic zone. This is demonstrated by the fact that their military conquests involve territories where there are water resources. After the six-day-war, Israel gained control over all of the Jordan Valley and the Golan plateau, the main source of water for the country. From 1967 on, water was declared a strategic resource and its use was controlled by the army. This favored Israeli settlers (Sironneau, 1998).

In fact, international aid programs are currently confronted with the following political issue: if one country does not have water it is considered poor. However, providing the poor with water creates the risk that they might one day become rich, and therefore competitors (Lê Moigne and Ténière - Bouchot, 1998).

The valorization of water was triggered by two different types of factors. On the one hand, there were catastrophes such as water-related epidemics in Rwanda and Burundi, the lack of potable water in Russia after the fall of the USSR and deaths that resulted from a great number of floods in the USA (Mississippi) and in China (Yang Tsé). On the other hand, water became more present in developed countries due to the considerable increase in its price.

The question is, what are the solutions to this in a context of such inequality in terms of resources and of conflicts involving States that are competing for the same resource and are commonly rivals in the political sphere in a given region?

Various systems have been proposed and utilized, but their basic principle is charging for the use of water. Roughly, there are two categories of solutions. There are legal and institutional solutions, for which there must be the political will of the State in terms of controlling its intensions and developing the management of water resources. There are also solutions that are strictly technical and economic.

Among the strictly economic solutions that are suggested to peripheral countries, the most important one is the quantitative control of the resource and its rational use. This includes prioritizing the fight against the waste of water, especially in relation to irrigation, whose rate of efficacy is below 40%. In order for this to occur, quotas of water to be used in agriculture should be authoritatively defined. There should also be a gradual limitation of subventions that have already been agreed to. At the same time, the investment in irrigation techniques should be encouraged. Unfortunately, these techniques are very expensive.

Another solution would be the construction of large dams - reservoirs to quantitatively control the use of water. This is a common solution in peripheral countries subject to droughts, like Turkey. However, many do not agree with this solution because it may destroy arable lands and encourage consumption.

Another economic solution for peripheral countries would be to give water a market value. It is precisely in countries where water is lacking that it is considered public property. This is particularly true in Mohammedan countries, where water is considered a divine good. According to the World Bank, the concept of water as a common good is one of the reasons why it is lacking, since it leads to the wasteful use of water (Sironneau, 1998). The implantation of a system of fees to be charged for damage and waste in countries where there is a lack of water is previewed to occur within the next ten years. The fee to be paid will depend on the local economic and social reality. This system will evidently be accompanied by the gradual abandonment of subventions to irrigation, since it stimulates the wasteful use of water.

One of the most successful practical answers is a legal-financial combination of public and private interests. BOT (Build, Operate and Transfer) markets allow for a national or a regional public authority that has no financial resources to grant construction and exploitation rights to private companies (energy generation, irrigation, water distribution, sanitation, etc.). This concession could be valid for 20 years or longer. At the end of this period, private companies will have recuperated their investment and construction and exploitation rights will be returned to public authorities. In the meantime, it is expected that the funds (without any increase in the debt) will have helped create a market of users that pay for water and will have fostered social education and professional training.

There is another approach, which originated in the United States, that is more clearly commercial: the creation of a market for water rights. This approach has had variable degrees of success. What generated this experience was the need to transfer water from one basin to another in the west of the country. It involves distributing the rare water resources among users as efficiently as possible. The demand is on the increase. It is the market, not the State, that is responsible for determining the price and the amount of water distributed. There is the clear risk that this vital resource will be monopolized. This is what happened to Chile in the 1980s. The use of the North-American model had disastrous consequences. It resulted in large mining companies and large hydroelectricity producers controlling water resources, to the detriment of other users. This situation triggered speculation and a false lack of water. Furthermore, this system cannot by itself regulate the problem of non-profitable investments (Sironneau, 1998).

If effective international legislation in the field of water is not available and if there isn't consensus on the areas where water is indispensable, it becomes difficult to deal with the powerful countries and companies competing for the control of water resources. Thus, it seems crucial to develop the shared management of resources in order to minimize the tension.

On the one hand, there is a tendency towards the idea that it would more effective to apply the concept of charging for the use of water to a large water basin or hydrographic region. This would include the participation of users and of the private sector, as well as that of a regional authority so resources would be better distributed in relation to the needs of the population. In other words, the division would be equitable. On the other hand, there is an effort to organize the global market.

2.2. From Isolated Projects to the Attempt to Create a Global Market

The countries' actions have not been successful. Thus, the United Nations proposed the implantation of a "global water partnership". Its basic principle is to save water resources by fighting against pollution and the wasteful use of water. Others believe in a more radical solution. They believe it would be convenient to commercialize water at a global rate that expresses its value as a rare economic commodity. This rate should stimulate negotiation and not tension. This mechanism would demand that the market be controlled in order to avoid speculation involving this crucial good.

There are networks of agencies, financial institutions and non-governmental organizations working together in an attempt to organize the water market. A large network has been formed with United Nations agencies that specialize in dealing with aspects related to water. At a central level, that of secretariats, there has been a Commission on Sustainable Development in New York. This Commission was established after a conference which took place in Rio and, in the field of water, it is assisted by a sub-commission named Administrative Committee on Coordination (ACC). This committee gathers a wide variety of water-related agencies: the UNDP, the UN Program for the Environment, UNESCO, the World Health Organization, the World Meteorological Organization, FAO and UNIDO. The World Bank and other international institutions make up a network to fund public projects and to support private projects. There are also numerous non-governmental organizations (NGOs) acting in the technical and in the social field.

This set of initiatives makes it complex for any attempt at coordination to be made. In spite of the efforts of each agency, the result is weak. The World Bank is the most important water-financing agency (2 billion dollars a year). However, this contribution corresponds to only 4% of the total amount registered in the world involving negotiations in which water and water-related services have a price. Currently, the total international aid for the area of water is 2% of the total budget.

After the realization that 8/10 of all direct and indirect expenses with the environment were water-related, new structures were created by global institutions and NGOs in order to coordinate and to develop public and private actions. In 1996, the World Water Council was created. It is based in Marseille, France. In the same year, the Global Water Partnership (GWP) was created in Stockholm, Sweden. In both cases, the World Bank, the United Nations Development Program, UN agencies and international associations got together to try to establish global water policy, a 21st century view of water resources and their use.

The GWP offered to develop an integrated management model for water resources at a global level so that the financial aid meant to help poor countries can be better distributed. However, the GWP will have to think about the innovations it will present and compare them to similar previous programs. Likewise, the WWC, in charge of elaborating a "view" of the balance between resources/water uses in the world in 2015, must beware of the fact that forecasts and reports have never put an end to the thirst of those who need water.

At the legal-institutional level, the international conventions that are currently being ratified could present solutions, as long as the countries were willing to apply them. This is the case with the convention on the use of international rivers for other ends besides navigation and with the convention on the protection of transboundary rivers and international lakes. Both are partly based on the economic principles of international water management. They integrate the set of economic and ecologic uses by defending the "rational and equitable use" of these waters according to the existing interests. They also defend the enforcement of "predator/polluter pays" principle through economic and financial mechanisms in order to decrease the level of damage and pollution. There are studies for projects in which similar principles are proposed for transboundary subterranean waters.

The objective of these two new institutions - the WWC and the GWP - is to gather specialists on water from all over the world in the same network. The speed of telecommunications will certainly have an influence on the development of ideas. In addition, the exclusively technical world of specialists on water will be broadened. New subjects will be included, and economists, demographers, sociologists and geographers will be involved. These professionals will gradually bring up their thoughts and concerns, thus considerably enriching the way water issues are approached. This enrichment will occur through the inclusion of the various interests that are at stake. Telecommunications and a broader approach are seen as promising for decisions to start being made at a global level. This is supposed to go beyond isolated management projects, like the ones that have been developed so far.

2.3. Human Creativity as an Alternative

If there is little water, the choices are conservation, technological advances or a policy of violence (de Villiers, 2002). This means that armed conflicts and economic wars are not the only ways to solve water-related matters. Preservation and technology play a fundamental role, which means that the part played by human creativity is also important.

The process of making fresh water through the desalinization of seawater is costly. Nevertheless, it is the world's greatest technological hope to solve the upcoming crisis. According to some people, making wars or transferring water from one place to another is much more expensive than it would be to develop new technologies to make the desalinization process cheaper. Besides, desalinization plants create a sense of security to the countries, for the resources and the facilities necessary to carry out the process are their property. There are over 7,500 operational desalinization plants in the world, some of which are pretty small. Two thirds of these plants are located in the Middle East. Twenty-six percent of these plants are located in Saudi Arabia alone. At present, the world's capacity to desalinize water is small. However, research is being carried out and desalinization techniques are improving and becoming cheaper (de Villiers, 2002).

Charging for the use of water is not the only way to achieve conservation. Preserving water means using less of it, making consumption more efficient by combining new ethics in relation to water, the proper use of creative technologies and good management. For example, in certain areas in England and in the United States, water is being stored in deep aquifers. In Senegal, a joint venture with Canada is returning water to fossil valleys, which are dry. In Israel, multiple techniques for the conservation of water were developed: drip irrigation and low-pressure sprinklers, for example. Other techniques involve spraying clouds in order to produce artificial rains, cultivating plants in greenhouses where the water that evaporated is reused and reutilizing sewage water, among other things.

There has also been the reutilization of old practices, using knowledge which was accumulated throughout millennia with the help of new tools. This has occurred in Jordan, where water is being collected and stored in wells. There is a tendency in central countries towards redirecting funds to low-cost "village technologies". Results have been good. In Tegucigalpa, Honduras, a program based on the creation of water committees in the neighborhoods reduced the amount of water used by the community by 40%. In Karashi, Pakistan, the installation of a subterranean system to channel water from bathrooms to cisterns which are periodically drained brought sanitation to over 600 million people who live in slums. These initiatives, which are invisible to macroeconomists and have no support from the World Bank or from the International Monetary Fund, have been put into practice and there have been small victories. This is generally done with the support of an NGO (de Villiers, 2002).

These are fundamental examples of how human creativity can help to solve problems, but many times they are forgotten.

3. LOOKING AT WATER ON A REGIONAL SCALE: WHAT SHOULD BE DONE WITH THE GREAT LIQUID HERITAGE OF THE AMAZON?

One of the most important contributions of the geographic method is the demonstration that each phenomenon should be analyzed according to an adequate scale. This means that the same situation has different meanings if different scales are used to analyze it. This methodological fundament is very important today, since the global view tends to make regional and local specificities obscure, thus making it harder to identify the real problems using these scales.

This is what happens with the inclusion of the Amazon in the geopolitics of water. The catastrophic indicators of water scarcity do not apply to this region. Therefore, there is the risk that the Amazon will be subjected to policies based on the global apocalyptic view.

Water is the most unequally distributed resource in the world. Fewer than ten countries share over 60% of the total amount of water in the world. Nine out of fourteen countries in the Near and Middle East are faced with the lack of water. They are located in the region of the world where the lack of water is more serious. At the end of the 20th century, other regions were also affected by the lack of water. These regions include Africa (Maghreb, Sahel and North Africa), northern China, California and southern Europe. Currently, twenty-six countries with a population of 232 million inhabitants can be considered countries that have little water resources. Eighty countries, where 40% of the world population lives, are affected by the lack of water. Most of these countries do not reach the level of 1,000 m^3 per inhabitant/year.

As opposed to what happens at a global level, Brazil and the Amazon are in a privileged position in relation to the scenario previewed for the near future. In Brazil and in the other Amazon countries, a great amount of water is available.

There are two important questions in this context: does the Amazon face problems in relation to water? How can the great regional liquid heritage be used?

3.1. The Paradox - Abundance of Resource X Social Inaccessibility

Brazil has 18% of the fresh water reservoirs on the planet, and most of this water is located in the Amazon. Surface waters in the country are used mainly for agriculture (61%), for domestic purposes (21%) and for industrial purposes (18%). In regards to the use of subterranean waters, there is a significant reduction in relation to the amount used for agricultural purposes (38%) and there is an increase in the amount used by the industry (37%). The percentage of subterranean waters used for domestic purposes is the lowest (25%).

Current conditions in terms of supply X demand in the country show that there is no lack of water resources in most of the Brazilian territory. However, critical conditions are verified in the northeast semi-arid region during droughts. The situation is also critical in the surroundings of medium-sized cities and mainly in metropolitan regions, where water is intensely used.

One of the conflicts observed involves the use of potable water and the use of water for the purpose of irrigation. This occurs in the northeast and in regions in the south of Brazil where there is a great agricultural demand for water. However, it is in large urban areas that the greater conflicts and problems occur. These conflicts and problems include the environmental degradation of water springs, the increase in the risk for organic and chemical pollution, the contamination of rivers by domestic, industrial and rain sewage and urban floods caused by the inappropriate occupation of spaces and by the inadequate management of urban drainage systems. Another problem is the fact that garbage is not properly collected and disposed of. As a consequence, the cities of Recife and São Paulo already experience frequent water usage restrictions (Tucci, C. et alii, S/D).

In addition to these problems, piped water systems and sanitation systems do not serve all of the population in most Brazilian cities. Expanding the scope of these services will certainly increase the consumption of water. So far, around 70% of the total cost with hospital admissions in the country - which corresponds to 2 billion dollars - is spent on the treatment of diseases caused by untreated water. Only 49% of the Brazilian population has access to sanitation services. On average, only 45% of the urban effluents are treated in the country. For every group of 1,000 children under five years of age, 50 die due to the lack of water.

This paradox is what stands out. Eighteen percent of all of the fresh water on the planet is found in Brazil, but 8.8 million households in the country have no access to piped water. It is clear that there is a serious management problem, and there are also socio-economic problems and problems related to public policies.

The situation in the Amazon is no different from the situation in the rest of the country:

- There is no lack of fresh water resources in the region. The Amazon Basin has the longest hydrographic network on the planet in kilometers, with a total of 6,925,000 Km^2 from the springs in the Andes to its mouth in the Atlantic. It includes the territories of seven South-American countries, but 63% of the basin is located in Brazil;
- Many of the river springs that form the Amazonas are located outside the country, but there are no conflicts with upstream countries;
- There is not a problem involving demographic growth. This is true both for Brazil - where demographic growth rates have decreased in the past decades - and for the Amazon, where immigration was reduced and the population growth is not a problem;

- The region does not waste water on irrigation;
- Despite similarities in relation to what occurs throughout Brazil, there are sanitation and environmental problems involving cities in the Amazon. They grew too fast during the last few decades, and this growth was not followed by the implantation of the necessary infrastructure.

Regional problems are, therefore, different from the problems that occur at a global level. Global problems are characterized by a lack of supply and a great increase in consumption. In the Amazon, the Brazilian paradox involving the abundance of natural resources and low consumption levels becomes more serious. This is partly due to the lack of access to these resources, which is a consequence of the lack of access to services.

The low level of occupation and the uneven distribution of the population in the region are clearly demonstrated by the number of households concentrated along the roads that surround the forest, in stretches of the Amazonas Channel and especially in state capitals. The expansion of the frontier, which occurred due to the Cuiabá-Santarém road, is also clear (Figure 1).

The number of households in urban areas supplied with piped water by the general network is low, reaching only 40% in most places. This percentage is higher in the areas surrounding state capitals, especially Manaus and Cuiabá. The difference between the situation in urban areas and that in rural areas is shocking. Only 0 - 5% of the households in rural areas are supplied with water (Figures 2 and 3). Lack of access to sewage systems and septic tanks is even greater, even in urban areas (Figures 4 and 5).

3.2. Making regional and global aspects compatible

Regional problems are specific. However, this does not mean that global tendencies should be neglected, for they can offer important suggestions so the best possible use can be made of the liquid heritage in the Amazon.

A few solutions can be pointed out in this regard.

1. Undoubtedly, the priority in terms of the use of water in the region is to implant water supply and sewage system services for the inhabitants of urban and rural areas. The lack of these services is responsible for the dissemination of diseases and for the deaths of people. Two solutions have been thought about for Brazilian cities that can be applied to the Amazon: a) prevention, which is difficult due to the lack of management capacity and supporting programs; b) preventive or even curative planning, which is difficult due to the lack of institutional and economic capacity on the part of municipalities to carry them out. The consequence of this situation is that each problem is treated separately (Tucci et alii, S/D). This shows the need

for public actions to be more comprehensive than the actions of municipalities.

2. Brazil has to face considerable challenges today. Those related to the Amazon include the consolidation of the institutional aspects of water resource management. They also include the control of water resource management in big and medium-sized cities. Finally, there is the matter of environmental preservation. Important steps have been taken towards institutional consolidation. In 1997, the law on water resources (Law no. 9,433) was approved. The National Policy on Water Resources was created with the objective of developing participatory processes involving society and new economic tools to foster the efficient use of water. In 2000, the National Water Agency (ANA) was created to implement the law. This was the beginning of a management process that would take place through committees and basin agencies. In the potable water and sanitation sector, there is a tendency towards the privatization of the services of companies and public institutions. The payment for services is previewed to occur according to a decision made by water basin committees and agencies, but it is sure to take place if services are privatized. It is worth noting that fees should not be established for the use of water in the Amazon due to the abundance of the resource and the lack of services.

3. An important lesson to be learned from the global situation is the creation of a new attitude in relation to water, even in the Amazon. The way society sees water, as if it were an inexhaustible resource, must change. This will stop the wasteful use of water, and a more efficient use of the resource will be implemented.

4. Another lesson taken from the global situation is that once providing the population with water is established as a priority, there will be no ethical barrier to treating this resource as a commodity, as long as well-defined rules are followed. A rapid increase in the consumption of bottled water has been observed in the last three decades. This increase has reached an annual average rate of 7%. This has created a market of US$20 to 30 billion annually. In many countries where there are not enough water supplies to meet the demand, the price of bottled water is higher than the price of gasoline. In the United States, the annual per capita consumption of bottled water increased from 35 to 76 liters from 1999 to 2001. This means US$6.5 billion for the sale of 20.5 billion liters in 2001. The market has managed to raise the awareness of the population in relation to the importance of the quality of water for a healthy life. The commercialization of water to make up for the shortage of the resource is a different matter. Canada signed a contract with China to provide the country with water for 25 years. Turkey has built a platform similar to petroleum platforms to supply tanker ships with water.

This water will be bought by Israel. According to some specialists, selling bottled water in the Amazon would not be profitable in terms of price, but exporting tanker ships filled with water would be feasible and financially interesting.

5. The coordination of efforts involving Amazonian countries is the core of the new approach for the development of the region. This makes it possible for programs that foster internal development to be carried out more efficiently. It also makes international negotiations and the use of "international public" more effective. This approach is explicitly shown in the IIRSA (2002) for all of South America and it is implicit for the redemption of the Amazon Cooperation Treaty as an organization for Amazonian countries.

Although water is not specifically mentioned in these initiatives, the principles of the IIRSA are totally valid in relation to this resource. Likewise, its guidelines include the positive aspects of "open regionalism", which sees South America "as a fully integrated geo-economic space, for which it is necessary to reduce the internal barriers to the minimum...and strangulations... while commercial restrictions are lifted, which makes it easier to identify highly-competitive global production sectors..." (page 14).

The objective of the Amazon Cooperation Treaty Organization (ACTO) is to put the Amazon Cooperation Treaty into practice and expand it. Amazon Cooperation Treaty already ensures greater freedom in terms of commercial navigation on the Amazonas and other international Amazonian Rivers, provided that each country's rules, bilateral treaties and the principles that guide International Law be respected. It also establishes that contracting parties will coordinate current health services and take action for the improvement of sanitary conditions and to prevent and combat epidemics. Scientific exchange is also a basic objective that has had positive results with the University of Amazonas.

According to the ANA, the creation of the ACTO marked the beginning of a new phase for sustainable management in the Amazon Basin. The next step is to submit a Project to the Global Environmental Facilities in order to obtain financial resources. The Project's objectives and its basic components encompass various fundamental issues (Freitas, 2002). In addition to this Project, there should be an emphasis on supplying the population with services, as provided by the Amazon Cooperation Treaty. This Project can foster the development of joint efforts and take a step forward in relation to the utilization of this liquid heritage.

4. FINAL CONSIDERATIONS

The analysis of the inclusion of the Amazon in the geopolitics of water demonstrates that apocalyptic arguments can be looked at in a different way in the region, for its own good and for that of humanity.

The objective here is to show that, due to its privileged situation in relation to the great amount of resources it possesses, the South-American Amazon may and should play a leading role in the world in regards to the rational use of water as a highly competitive sector. This is related to the management of water as a social and economic commodity. In order for that to happen, some premises are suggested:

- A responsible attitude in relation to controlling the wasteful use of water and to preserving it is the duty of all. This includes the Amazon;
- Water should not be geographically determined. The issue is especially social and political, not Malthusian. Political will and creative technologies in activities on different levels might solve the problem;
- Priority should be given to the social use of resources. Water supply and sanitation services are fundamental for human valorization. This is especially true in relation to the Amazon, where there is a great deal of water but most of it is inaccessible. For this reason, fees for the use of the water should not be established in the region;
- Production systems should be adapted to the rhythm of the floods. This would expand the production in flooded forest areas making use of this natural kind of irrigation;
- Problems that result from the fact that various countries share water from the same basin should be solved through cooperation rather than war. It is important to have multilateral cooperation controlled by an authority from the region so the multiple uses of water in the basin can be planned. This includes negotiating funding and involves developing technology, raising the awareness of the population and sometimes exporting water to countries in need of this resource;
- Creativity for the invention of technologies or even simple techniques and management methods to solve the problem of access to water and basic sanitation should be jointly pursued by Amazonian countries. This creativity would make a difference for the region and in the global market;
- Bilateral cooperation is equally important in border areas where the population is concentrated. This does not involve only large-scale initiatives like the production of energy in the Guri Power Plant. It also involves trying to solve problems related to unhealthy conditions. This is the case with the

Colombian proposal to jointly treat unhealthy areas in Leticia and in Tabatinga (Salamanca, 2001). In the Amazon, this could take place through the definition of prices for local products, both for regional consumption and for exportation, especially to icthyofauna.

Finally, the South-American Amazon could turn water into common property for the population in the region and for the population of the world. This could be done through the commercialization of management techniques and methods developed in peaceful co-operation.

Figure 1 - Legal Amazon. Total number of Households 2000

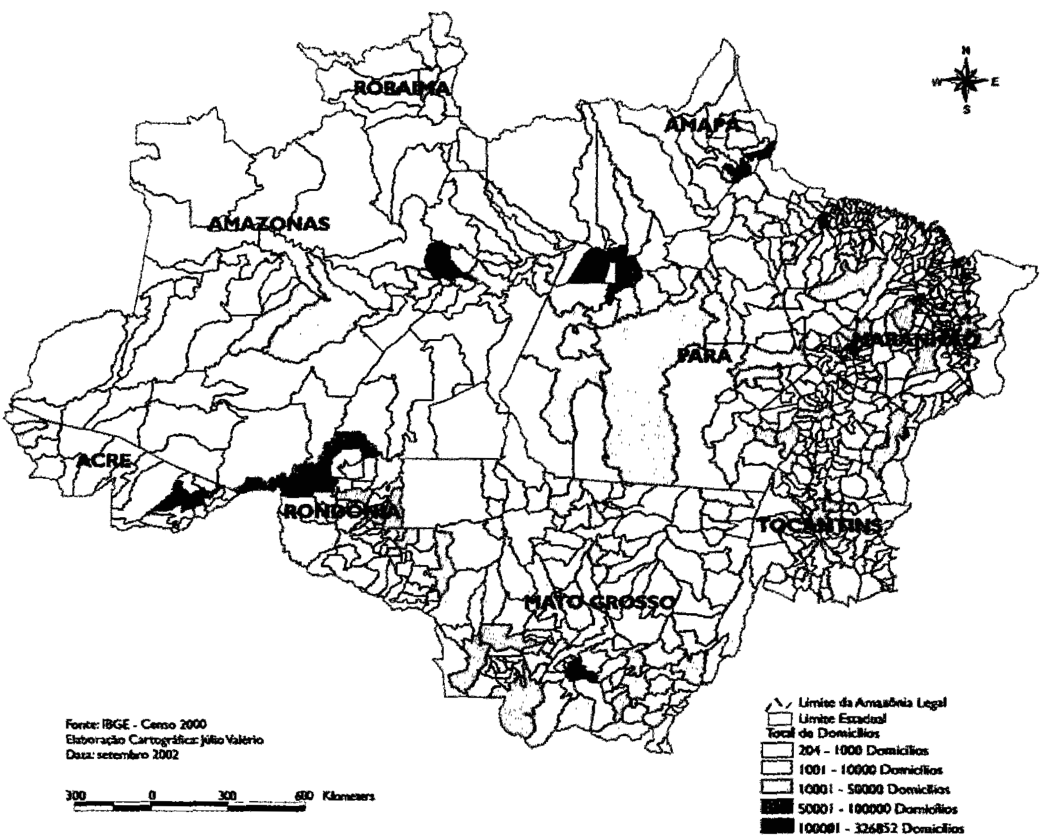


Figure 2 - Legal Amazon. % of Urban Households Receiving Water Supplies - General Network

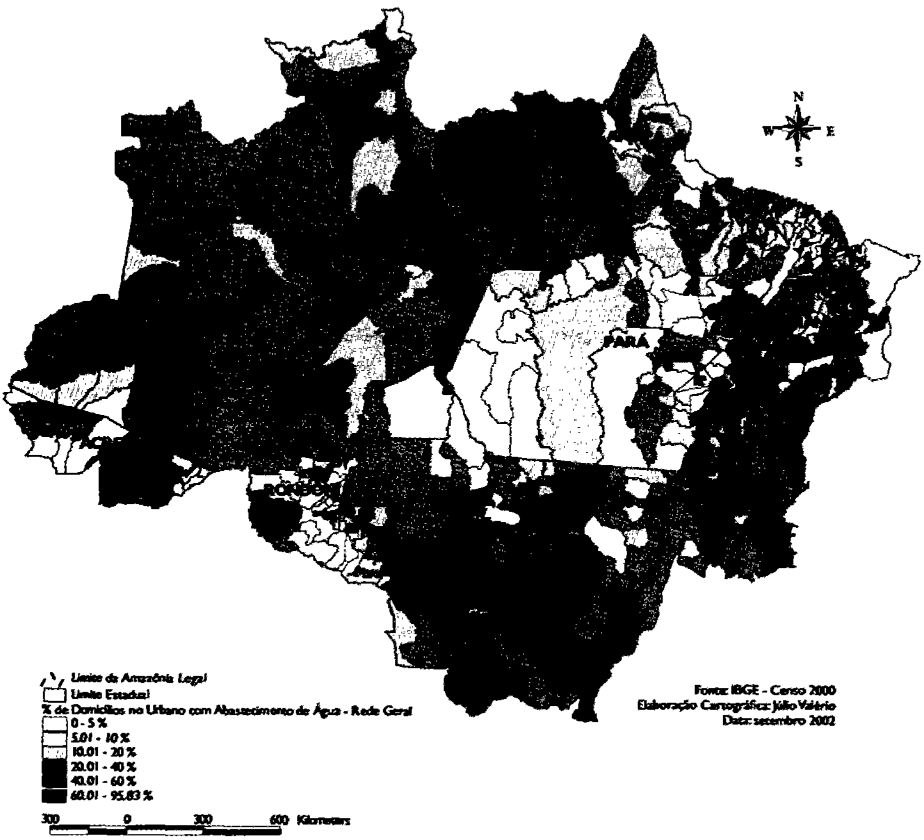


Figure 3 - Legal Amazon. % of Urban Households served by the Sewage System or that have Septic Tanks

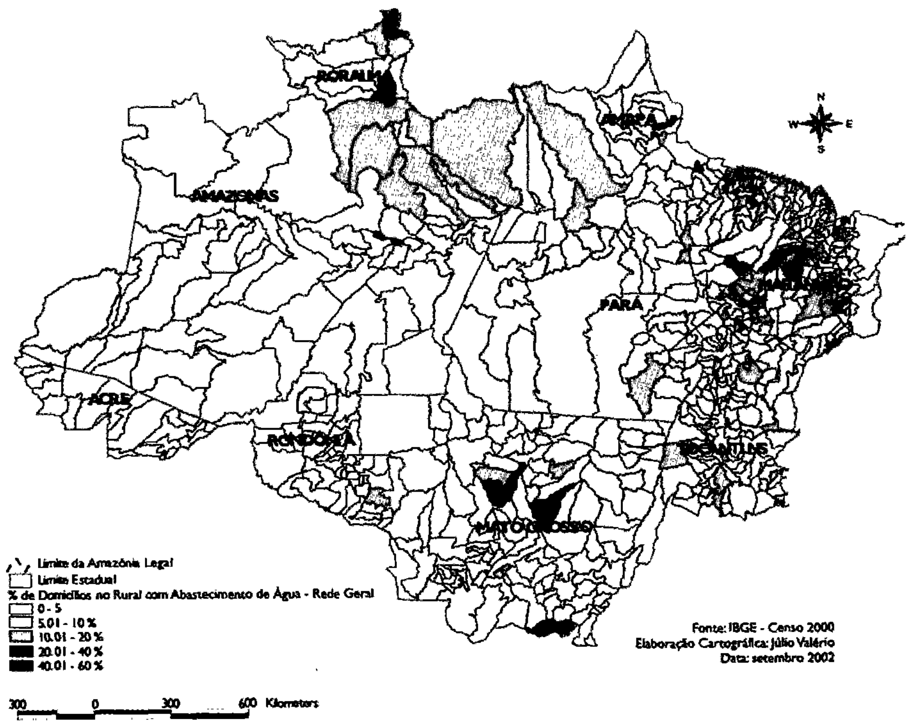


Figure 4 - Legal Amazon. % of Rural Households Receiving Water Supplies

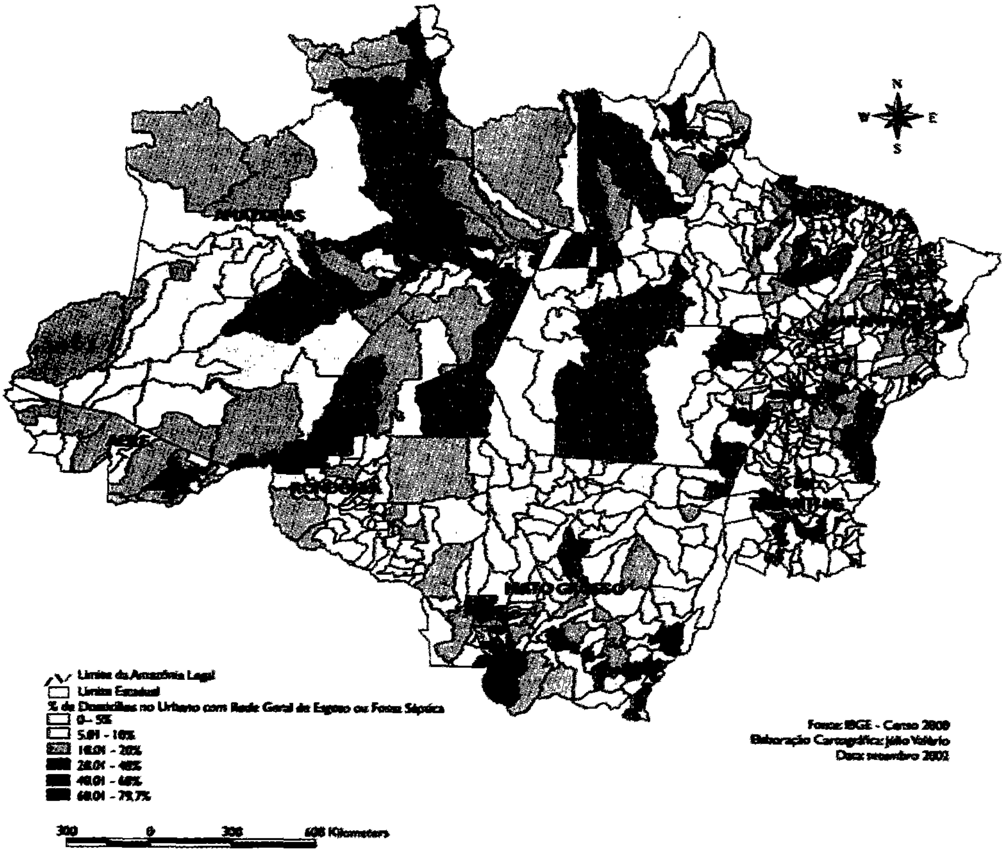
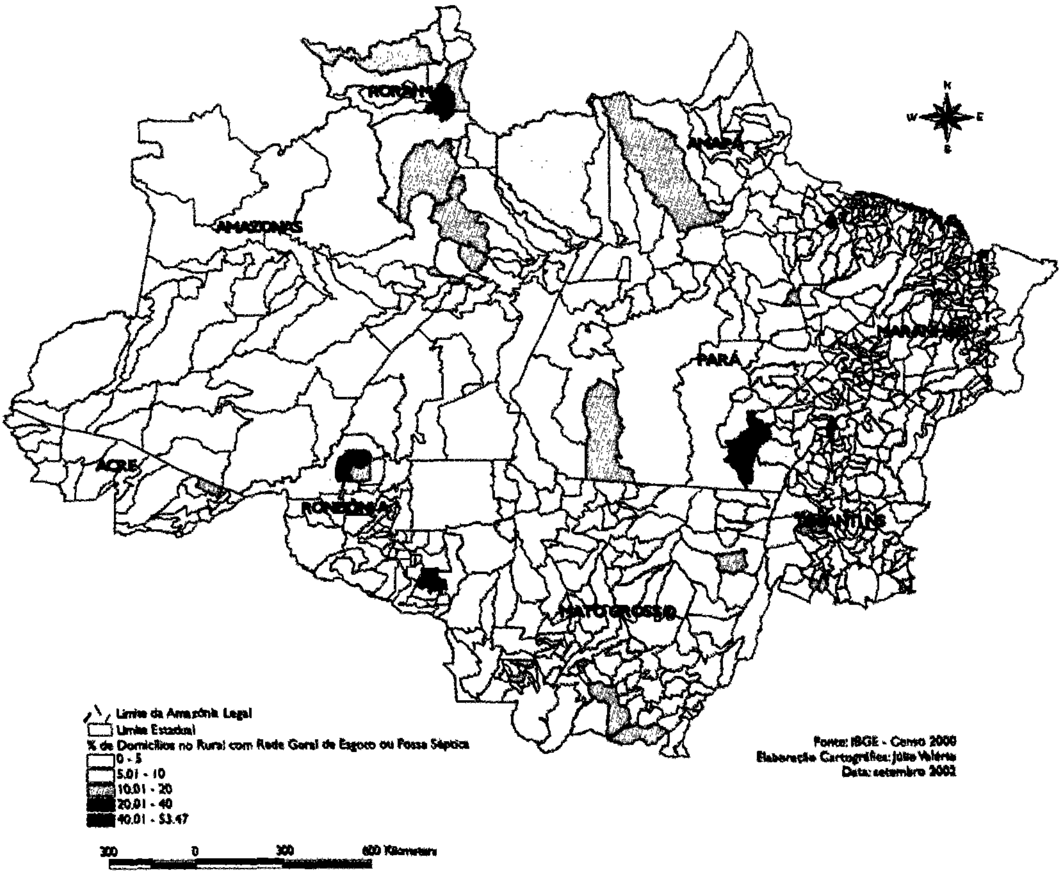


Figure 5 - Legal Amazon. % of Rural Households served by the Sewage System or that have Septic Tanks



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8. LEGISLATION AND INSTITUTIONAL SYSTEMS FOR WATER RESOURCE MANAGEMENT IN BRAZIL AND THEIR RELEVANCE TO THE AMAZON

Arnaldo Augusto Setti *

1. INTRODUCTION

This text is to be complemented with information concerning the legislation and the institutional organization of the Amazonian Countries that signed the Amazon Cooperation Treaty - TCA.

2. WATER RESOURCES IN BRAZIL

With an area of 8,512,000 km and about 170 million inhabitants, Brazil is the fifth largest country in the world, and the most populated country in South America. Due to Brazil's continental proportions, there are many differences, in terms of weather conditions, population distribution and social and economic development etc. These differences contribute to the existence of a wide variety of scenarios.

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TABLE 1- Basic information on Brazilian water basins (Superintendence for Hydrologic Studies and Information - SIH/National Electricity Agency - ANEEL, 1999)

Nº	Water Basin	Area		Population		Population Density Inhab/Km²	Flow M^3/s	Water Availability		Per Capita Availability M^3/Inhab/year
		10 Km	%	Inhab.	%			Km/year	%	
1	Amazon	3,900	45.8	6,687,893	4.3	1.7	133,380	4,206	73.2	628,940
2	Tocantins	757	8.9	3,503,365	2.2	4.6	11,800	372	6.5	106,220
3a	North/ Northeast Atlantic	1,029	12.1	31,253,068	19.9	30.4	9,050	285	5.0	9,130
4	São Francisco	634	7.4	11,734,966	7.5	18.5	2,850	90	1.6	7,660
5	East Atlantic	545	6.4	35,880,413	22.8	65.8	4,350	137	2.4	3,820
6a	Paraguay**	368	4.3	1,820,569	1.2	4.9	1,290	41	0.7	22,340
6b	Paraná	877	10.3	49,924,540	31.8	56.9	11,000	347	6.0	6,950
7	Uruguay**	178	2.3	3,837,972	2.4	21.6	4,150	131	2.3	34,100
8	Southeast Atlantic	224	2.6	12,427,377	7.9	55.5	4,300	136	2.4	10,910
BRAZIL		8,512	100	157,070,163	100	18.5	182,170	5,745	100	36,580

* Brazilian Institute of Geography and Statistics, 1996

** Brazilian water production

The table above shows that Brazil holds a privileged position in relation to most countries in terms of the amount of water resources it possesses. Nevertheless, according to Table 2.1, over 73% of the fresh water available in the country is found in the Amazon Basin, whose inhabitants account for less than 5% of the total population. This means that 95% of the Brazilian population has access to only 27% of all Brazilian water resources.

For a long time, the idea that water is abundant served as a justification for wasting the available water and for not allocating the necessary investments so that water would be more effectively used and protected. This idea also contributed to the low economic value of water.

The problems concerning the lack of water in Brazil result from the combination of mainly two factors: an exaggerated increase in local demands, and water quality degradation. This situation happened as a consequence of the disorganized growth during the processes of urbanization, industrialization and agricultural expansion, which started taking place in the 1950s.

During the second half of the century, the demographic growth in Brazil, and the changes brought about by the Brazilian economy, greatly reflected on its use of water resources.

Industrialization and the migration of the population from rural areas to cities generated a significant increase in the demand for water resulting in the need for greater electricity production. Consequently, there was a need to build hydroelectric stations to make full use of this potential. In addition to this, the population growth called for an increase in food production. Irrigated agriculture was seen as the solution to meet this demand.

Throughout the 1970s, and especially in the 1980s, society became aware of the threats facing the population if they did not change their attitudes toward water consumption. During that time, various inter-ministry commissions were established in order to find ways to improve the system for the multiple use of water resources as well as to minimize the risks associated with any compromise in water quality. These actions are particularly important for future generations as the vulnerability of this natural resource has already began to be observed.

In 1934, a text regarding water laws, the Water Code, was established in Brazil. However, unfortunately, ways to combat drought, water contamination and conflicts due to water use were not included in the Water Code. It also did not include means to promote decentralized and participatory management, which are a current necessity. Thus, Law no. 9,433 of January 1997 was elaborated in order to bridge this deficiency. The project had been exhaustively discussed during the 1980s and 1990s, until the law was promulgated.

The National Congress approved the creation of the Brazilian Water Agency (Agência Nacional de Águas - ANA) through Law no. 9,984 of July 20, 2000. The Brazilian Water Agency is a federal agency responsible for implementing the National Water

Resources Policy. The agency is also responsible for coordinating the National Water Resources Management System. This agency will implant and enforce Law no. 9,433 of 1997, according to its agreed principles, instruments for action and institutional framework (the National Council on Water Resources, water basin committees, water agencies and organizations and agencies related to the federal, state and municipal public service). It is clear that the water resources sector in Brazil has been gaining in importance and societal interest.

In the 1980s, the National Department of Water and Electricity (Departamento Nacional de Água e Energia Elétrica - DNAEE), currently the National Electricity Agency (ANEEL), carried out studies in order to identify the priority problems in various water basins found in the national territory (DNAEE, 1984 and DNAEE, 1985). These studies were called Diagnosis and Planning for Water Basins and served as the basis for the creation of the Special Committee for Integrated Studies on Water Basins - CEEIBH. This committee was made up of the Environment Secretariat (currently the Brazilian Institute for the Environment and Natural Renewable Resources - IBAMA), the National Department of Water and Electricity - DNAEE (now the National Electricity Agency), the Brazilian Electricity Agency - ELETROBRAS and the DNOS.

A synthesis of the priority problems at each of these water basins will be presented in the table below. The objective of this presentation is to provide an overview of the main water-related problems in Brazil at that time, most of which still exist, with the notably exception of the Amazon, and where studies were not carried out on this occasion.

TABLE 2 - Priority Problems (based on data from the National Department of Water and Electricity, DNAEE, 1984 and 1985)

Water Basin	Priority Problems
1. São Francisco River	Section 1 (Lower São Francisco, downstream of Sobradinho): construction work for hydroelectric power use and its effects on floods in surrounding coastal areas. Hydro-agricultural use of these areas and channeling water to the semi-arid region of the northeast. Section 2 (Sobradinho Lake Region): problems resulting from the multiple uses of the lake: energy generation, flood control, navigation, etc. Ongoing studies about channeling water from the lake to other basins. Section 3 (From the Três Marias dam to the Sobradinho dam): hydro-agricultural uses, problems related to the overflow gutter and conflicting uses of the Três Marias: energy generation, flood control and navigation.

Table 2 - (continuation)

Water Basin	Priority Problems
	Section 4 (From the upper São Francisco to the Três Marias dam): used mostly for supplying water to residences and industries. Problems related to maintaining the quality of water. Domestic and industrial residues are discharged into the water without proper treatment. There is inorganic pollution due to mineral processing.
2. Parnaíba River	Problems concerning water availability and pollution in intermittent rivers. Areas subject to periodical floods. Large volumes of waste are disposed of in the Parnaíba, Teresina and Floriano Rivers.
3. Paraguaçu River	Water is lacking in a large area - intermittent rivers presenting problems related to salinity. Urban and industrial residues (from the Subaé Industrial Center) are discharged into the water upstream of the Pedra do Cavalo reservoir, which supplies the metropolitan region of Salvador, Feira de Santana and others with spring waters.
4. Mundaú and Paraíba Rivers	There is a large area where the amount of water available for various uses is limited. There are areas where there are restrictions related to aquaculture. A large area is polluted and there are areas subjected to occasional floods.
5. Itapicuru and Vaza-Barris Rivers	A section of the river has yet to be recharged. Salinity needs to be controlled in the dams and small dams must be implanted in the riverbeds of the Itapicuru River.
6. Jaguaribe River	Area subject to floods in Aracati, Russas and Limoeiro do Norte.
7. Doce River	Mining and iron metallurgy take place in the area. Low quality water in the Caratinga river and in the Casca river. Great demands and high inorganic potential for pollution. Floods in the regions of Mariana, Nova Era and Coronel Fabriciano. Problems related to the quality of water in the raw water intake facilities of Governador Valadares, Colatina and Linhares.
8. Paranaíba River	There are areas where a great amount of pollution is generated. New water springs are necessary in Brasília, Anápolis, Goiânia and Uberlândia. Environmental Impact Assess-

Table 2 - (continuation)

Water Basin	Priority Problems
	ments are necessary for large planned dams, and the proper operation of existing hydroelectric power plants is also necessary.
9. Paraiba do Sul River	Water resources are necessary for the Light/Rio system; a great amount of organic residue is discharged in the regions of São José dos Campos, Taubaté, Volta Redonda and Juiz de Fora.
10. Moji/Pardo Rivers	Mogi Guaçu/Moji Mirim region: vast quantities of water are drawn for domestic use and irrigation. Urban and industrial organic residues are disposed of in these rivers. Sanitation in the river is already compromised in the raw water intake facility of Araras. São José do Rio Pardo region: conflicts involving the operation of the Graminha hydroelectric power plant and the São José do Rio Pardo raw water intake facility. Great amounts of water are drawn for irrigation and great quantities of urban and industrial organic residues are disposed of in these rivers. Ribeirão Preto region: low-quality water in the Pardo and Mogi-Guaçu rivers due to the fact that urban residues and residues from sugar mills and alcohol distilleries are disposed of in these rivers. Poços de Caldas region: The Poços de Caldas Industrial Park. This includes NUCLEBRÁS (Brazilian Nuclear Corporation) areas in the riverbeds of the Pardo River and upstream of the Graminha hydroelectric power plant reservoir.
11. Jaguari/Piracicaba Rivers	Water is channeled to supply Jundiaí and the Metropolitan Region of São Paulo, an important industrial center located upstream of the Jaguari-Jacareí reservoir. The Atibaia river is heavily used both as spring water and as a water catchment. The region of Americana is highly endemic for schistosomosis. Sewage is disposed of in the Claro River, upstream of the water intake facility of the Piracicaba River. Excessive pollution is found in the Piracicaba river.

Table 2 - (continuation)

Water Basin	Priority Problems
12. Grande River	High levels of water consumption. Domestic and industrial polluting residues are discharged in a riverbed section (Uberaba). Vast quantities of water are withdrawn for industrial uses, especially for irrigation and for use in sugar mills and alcohol distilleries. Noticeable deterioration of the quality of water due to the fact that this river's flow rate is too low to dilute all the residues (Fernandópolis and Jaboticabal). In a section of the riverbed, there are significant demands for water to be used for irrigation. Thus, it is predicted that water supplies for urban use will be compromised, and so will the use of this body of water (Mogi-Guaçu/ Moji Mirim region). There is a tendency towards eutrophization at the Furnas, Volta Grande, Porto Colômbia, Marimbondo and Água Vermelha Reservoirs.
13. Ribeira do Iguape River	Water is channeled from the Parigot de Souza reservoir. It is foreseen that water will be channeled to the Metropolitan Region of São Paulo. There are problems related to floods in the plains and to management in the Valo Grande/Mar Pequeno region. Mining occurs in the region.
14. The Alto Tietê Hydrographic Region	Lack of water, water quality, water resource management, conflicts involving electricity X water supplies.
15. Iguaçu River	A considerable amount of pollution is discharged in riverbed sections where the flow rate is too low to dilute residues. Water availability is limited (Curitiba, Guarapuava and Cascavel). A significant quantity of residues is disposed of in the river, thus compromising the quality of the water (MAFRA); There is a tendency towards eutrophization in the Foz do Areia Reservoir.
16. Itajaí-Açu River	Organic residues are discharged upstream of raw water intake facilities in the Blumenau region. There are areas that have great potential for water pollution (Agrolândia, Trombudo Central, Rio do Sul, Indaial and Blumenau). Floods and erosion occur.

Table 2 - (continuation)

Water Basin	Priority Problems
17. Uruguay River	Lajes: There are great amounts of polluting organic waste materials, and there is the possibility that these residues will eventually affect the Campos Novos Reservoir. There are great amounts of polluting organic waste materials in the Marombas river, and there is the possibility that these materials will affect the São Roque Reservoir. In the Peixe River, there are also great amounts of polluting residues, and great amounts of water are drawn for irrigation. This compromises the future reservoirs of Ita and Itapiranga. Vacaria, Passo Fundo, Getúlio Vargas and Santana do Livramento will have difficulties involving water supplies in the future.
18. Guaíba River	Domestic and industrial polluting materials are discharged in the river, which deteriorates the quality of the water. This situation compromises raw water intake facilities and leisure areas. There are floods in Porto Alegre, Festeio, Novo Hamburgo and São Leopoldo. Water sanitation conditions have deteriorated. Flow rates during drought periods are insufficient for the future. Great amounts of industrial and domestic polluting materials are disposed of in the water in Caxias do Sul. The coal basin in Rio Pardo presents inorganic pollution. Future lack of water for expected irrigation demands (Cachoeiras do Sul and Alto Jacuí).

In Brazil today, there is a clear increase in the number of conflicts involving the various users of water resources.

The analysis of tables 3 and 4, regarding specific levels of water scarcity reveals that no state in Brazil is currently suffering severe water shortages. However, there are six states with water availability ranges from 1,000m^3/inhab/year to 1,700m^3/inhab/year. This illustrates a situation of periodic and regular hydrological stress. There is a tendency towards potentially low water levels in four other states.

As was previously cited, the existence of a well-distributed and well-managed hydrometric network in any given region is necessary for the elaboration of a consistent and reliable databank. This hydrometric network is fundamental in order to receive subsidies by decision-making processes of the organizations responsible for the management of water resources. Hydrological information, however, is not the only issue that must be

TABLE 3 - Water availability and the use of water resources per state

State	Hydrologic Potential* (Km^3/year)	Popul,** (inhab.)	Density (inhab/Km^2)	Per Capita Availability (Km^3/inhab/year)	Total Use*** (m^3/inhab/year)	Use in the State	Level of Use (Km^3/year) (%)
Rondônia	150.2	1,229,306	5.81	122,183	44	0.054	0.04
Acre	154.0	483,593	3.02	318,450	95	0.046	0.03
Amazonas	1,848.3	2,389,279	1.5	773,581	80	0.191	0.01
Roraima	372.3	247,131	1.21	1,506,488	92	0.023	0.01
Pará	1,124.7	5,510,848	4.43	204,088	46	0.253	0.02
Amapá	196.0	379,459	2.33	516,525	69	0.026	0.01
Tocantins	122.8	1,048,642	3.66	117,104			
Maranhão	84.7	5,222,183	15.89	16,219	61	0.319	0.38
Piauí	24.8	2,673,085	10.92	9,278	101	0.270	1.09
Ceará	15.5	6,809,290	46.42	2,276	259	1.764	11.38
R. G. Norte	4.3	2,558,660	49.15	1,681	207	0.530	12.32
Paraíba	4.6	3,305,616	59.58	1,392	172	0,569	12.36
Pernambuco	9.4	7,399,071	75.98	1,270	268	1.983	21.10
Alagoas	4.4	2,633,251	97.53	1,671	1159	0.419	9.52
Sergipe	2.6	1,624,020	73.97	1,601	161	0,261	10.06
Bahia	35.9	12,541,675	22.,6	2,862	171	2.170	6.04
M. Gerais	193.9	16,672,613	28.34	11,630	262	4.368	2.25
Esp.Santo	18.8	2,802,707	61.25	6,708	223	0.625	3.32
Rio de Janeiro	29.6	13,406,308	305,35	2,208	224	3.003	10.15
São Paulo	91.9	34,119,110	137.38	2,694	373	12.726	13.85
Paraná	113.4	9,003,804	43.92	12,595	189	1.702	1.50
Sta. Catarina	62.0	4,875,244	51.38	12,717	366	1.784	2.88
R.G. do Sul	190.0	9,634,688	34.31	19,720	1015	9.779	5.15
M.G. Sul	69.7	1,927,834	5.42	36,155	174	0.335	0.48
Mato Grosso	522.3	2,235,832	2.62	233,604	89	0.199	0.04
Goiás	283.9	4,514,967	12.81	62,880	177	0.799	0.28
Federal District	2.8	1,821,946	303.85	1,537	150	0.273	9.76
BRAZIL	5,732.8	157,070,163	18.5	36,498	283.13	44.5	0.78

* National Department of Water and Electricity, DNAEE, 1985

** Brazilian Institute of Geography and Statistics , IBGE, 1996 Census

*** Rebouças, 1994

TABLE 4 - Situation of Brazilian states whose conditions are the worst in terms of the availability of water resources per inhabitant (Lima, 2000)

Nº	State	Per Capita Availability* (m^3/inhab/year)	Situation**
1	Pernambuco	1,270	- Hydrological stress is periodic and regular.
2	Paraíba	1,392	
3	Federal District	1,537	
4	Sergipe	1,601	
5	Alagoas	1,671	
6	R. G. do Norte	1,681	
7	Rio de Janeiro	2,208	- There is a trend towards occasional problems related to the lack of water.
8	Ceará	2,276	
9	São Paulo	2,694	
10	Bahia	2,862	

* Table 2.2 - Modified from Rebouças, 1999.

** Table 1.4 - Beekman, 1999.

considered. Information concerning the environment, the construction of hydroelectric power plants, the weather, climate, censuses and physiography, among other subjects, is also important.

Currently, the Ministry of Mines and Energy is responsible for most of the national hydrometric network. The National Electricity Agency (ANEEL) manages this network, which was previously controlled by the National Department of Water and Electricity (DNAEE). However, this agency no longer exists (Table 5). The hydrometric network is experiencing a transition process in order to be managed by the Brazilian Water Agency (ANA).

TABLE 5 - Distribution of hydrometric network stations controlled by the National Electricity Agency - 1999 (Superintendence for Hydrologic Studies and Information - SIH/National Electricity Agency - ANEEL, 1999)

Basin	Area	Pluviometry		Fluviometry		Sediment Measurement		Quality of the Water	
	(10^8 /Km^2)	Quant.	(Km^2/ State)	Quant.	(Km^2/ State)	Quant.	(Km^2/ State)	Quant.	(Km^2/ State)
Amazon	3,900	352	11,080	243	16,049	57	68,421	57	68,421
Tocantins	757	182	4,159	94	8,053	16	47,313	16	47,313
North/ Northeast Atlantic	1,029	234	4,397	193	5,332	40	25,725	42	24,500
São Francisco	634	237	2,675	169	3,751	32	19,813	32	19,813
East Atlantic	545	392	1,390	317	1,719	73	7,466	71	7,676
Paraná/ Paraguay	1,245	572	2,177	347	3,588	118	10,551	121	10,289
Uruguay	178	122	1,459	84	2,119	47	3,787	47	3,787
Southeast Atlantic	224	169	1,325	109	2,055	44	5,091	44	5.091
BRAZIL	8,512	2,260	3,766	1,556	5,470	427	19,934	430	19,793

Data obtained from the national hydrometric network, which encompasses the previously presented network, serve as the basis for studies on hydrological cycle parameters. However, it was previously demonstrated that knowledge on the flow rates required by the different water users from each region and basin is also very important in order to subsidize the decision-making processes of the organization that manages water resources.

It is estimated that approximately 29.6 million acres are irrigable land in Brazil. This is true when considering irrigable mountain areas (16.1 million acres) and irrigable floodplain areas (13.5 million acres) (Christofidis, D., 1999). Therefore, less than 10% of these areas, or 2.87 million acres, are currently being used. This situation illustrates the great potential in terms of expanding this practice as well as in generating and broadening conflicts related to the use of water.

Data from the Secretariat of Water Resources of the Ministry of the Environment regarding Water Resources and the Legal Amazon (Secretariat of Water Resources/Ministry of the Environment, 1998) demonstrate that 49% of the sewage produced in Brazil is collected. Of the total sewage collected, only 32% is treated. The percentage of urban residences with a water supply is approximately 91%. This means that more than 11 million people living in cities do not have access to potable water. In rural areas, only 9% of the population have access to piped water. Nevertheless, many of the people who reside in these areas make use of water taken from wells and water springs. In view of this situation, it is important to mention that the lack of potable water supply and the accumulation of sewage, which is not collected, are the main causes for the high rates of intestinal diseases and other illness. According to the Ministry of Health, 65% of hospital stays is a consequence of inadequate sanitation services. Every year, diarrhea is responsible for the death of approximately 50,000 children in Brazil (Silva, H. K. S and Alves, R. F. R, 1999).

It is estimated that 45% of the total volume of water supplied to the population in Brazil is being wasted. This represents about 3.78 billion m^3 per year. By reasonably reducing the quantity of water being wasted, the country would save about R$ 1.02 billion a year. The objective would be to reduce the loss of water by 20%, thus decreasing the amount of water wasted to 25%. This represents about 2.1 Km^3 of water per year. This water could be used for the expansion and improvement of the current network (adapted from Water Resources in Brazil, Secretariat of Water Resources of the Ministry of the Environment and the Legal Amazon - SRH/MMA). Hence, according to the data presented, the volume of water used in Brazil to supply the country is approximately 8.4 Km^3/year.

In the electricity sector, the generation of hydroelectricity guarantees the production of approximately 91% of the electricity used in Brazil (Freitas, M. A. V. and Coimbra, R. M., 1998). The Brazilian hydroelectric potential is approximately 260 GW. Only 22% (57 GW) of this potential is currently operational. This means that the country possesses enormous possibilities for expanding this sector (Brazilian Electricity Agency - ELETROBRÁS, 1999).

Even though the use of water for electricity generation does not imply the actual consumption of this water, it does limit the volume of water that can be used for other purposes and, like consumptive uses, it may generate all forms of externalities. Electricity generation requires that a stable average flow rate be maintained so the distribution system can continuously be provided with a certain amount of electricity. If the hydroelectric project considers other possible water uses, it will generally be beneficial since it will keep flow rates balanced.

In Brazil, construction work that provides advantageous benefits for inland navigation was or is being carried out as an initiative of the federal government. This is being done in accordance with investment programs for the transportation sector. The Tietê and

Paraná river basins, as well as the Jacuí and Taquari river basins, in the State of Rio Grande do Sul, are worth mentioning. In terms of cost and cargo capacity, waterway transportation is approximately eight times cheaper than highway transportation and three times cheaper than railway transportation (Godoy, P. R. C., 1999).

Current studies estimate that the total amount of water necessary for the industrial sector is 139 m^3/s, which corresponds to a volume of approximately 4.4 Km^3/year (Secretariat of Water Resources/Ministry of the Environment, 1998).

According to the above mentioned data regarding the sectors that use water in a consumptive manner, the situation is as follows:

TABLE 6 - Current situation of fresh water intake facilities in Brazil per sector (Lima, 2000)

Sector	Water Intake (Volume) (Km^3/year)	%
Agriculture *	33.8	72.5
Supply **	8.4	18.0
Industry **	4.4	9.5
TOTAL	46.6	100.00

* Christofidis, D., 1999

** Adapted from Secretariat of Water Resources/Ministry of the Environment, SRH/MMA, 1998

3. INSTITUTIONAL ASPECTS RELATED TO WATER RESOURCE MANAGEMENT

3.1. Brazilian legislation on water resources

Discussions about the National Water Resources Management System began in 1983 with the International Seminar on Water Resource Management. In 1984, these discussions were broadened with the creation of the Congressional Investigating Committee (CPI - Comissão Parlamentar de Inquérito) on Water Resources in the House of Representatives.

Among specialists, discussions about the National Water Resources Management System began in the Brazilian Water Resources Association (ABRH - Associação Brasileira de Recursos Hídricos) in Salvador - Bahia, in 1987, and went on to take place in Foz do

Iguaçu - Paraná, in 1989, and in Rio de Janeiro - RJ, in 1991. The results of these discussions can be found in charters that were approved at general assemblies. The letters are named after the cities in which the discussions were held. These documents illustrate the progress made in discussions about the institutional aspects of water resource management:

* The Salvador Charter introduces institutional themes to be discussed within the Brazilian Water Resources Association. These themes are the following: the multiple uses of water resources, decentralization and participation, the National Water Resources Management System, the improvement of the legislation, technical development and human resource training, the information system on water resources, and the National Water Resources Policy.
* The Foz do Iguaçu Charter deals with the definition of the word policy. Its basic principles are quite clear. Among these principles are the acknowledgement of the economic value of water and the importance of charging for its use. The Charter recommends that the National Water Resources Management System be implemented, as set out in incise 19, article 21 of the Federal Constitution of 1988.
* The Rio de Janeiro Charter deals with water resources and the environment. According to this Charter, changing the terrible situation of water pollution should be treated as a national priority. The urgent need for integrated planning and management at water basins and coastal areas should also be a national priority. The fact that the great diversity found in Brazilian regions and water basins calls for varied solutions that are adapted to their particularities should also be taken into consideration.

These guidelines have been discussed in depth at dozens of meetings, workshops and seminars. They were included into Federal Law no. 9.433 of January 1, 1997 and in various state laws related to water resources that have been promulgated so far. All of these laws have several issues in common.

3.2. Federal Legislation for Water Resources

3.2.1 The Federal Constitution and the Water Code

The Constitution of 1946 sought to regulate the use of natural resources so that these resources would be economically exploited in keeping with the ideas defended at the time. Emphasis was placed on free initiative and on private property. It was established that the Union would legislate over the riches found in the soil. It was also the Union's responsibility to legislate over mining, metallurgy, water, electricity, forests, hunting and fishing (art. 5, 15, 1). In addition to this, the Union could allow States to legislate over the water in a supplementary fashion.

The Federal Constitution of 1967, through Constitutional Amendment n. 1/69, made environmental resources exploitable. This was due to the development-oriented view at the time. Only a few general rules were established. Article 8, XVII, for instance, affirmed that the Union shall have the power to legislate on forests, hunting and fishing, water, telecommunications, postal services and energy (electric, nuclear or any other).

The Federal Constitution of 1988 classifies water resources as priority resources to be especially taken care for. This is shown in the numerous articles dedicated to the issue:

a) Article 20, Paragraph 1;

b) Article 21, XII b;

c) Article 21, XIX;

d) Article 22, IV;

e) Article 23, XI;

f) Article 26, I;

g) Article 43, Paragraph 2, IV;

h) Article 176;

i) Article 200, VI; and

j) Article 231, Paragraph 3

Among the constitutional directives mentioned above, the following are worth highlighting:

a) Article 20, Paragraph 1:

Under the terms of the law, the States, Federal District, and the Municipalities, as well as the agencies of the direct administration of the Republic, are assured of participation in the outcome from the exploitation of petroleum or natural gas, of hydric resources for the purpose of generating electric energy, and of other natural resources in their respective territory, continental shelf, territorial waters, or exclusive economic zone, or financial compensation for such exploitation.

b) Article 21, XII and XIX;

It is incumbent upon the Union:

....

XII - To operate, directly or through authorization, concession or permission:

....

b) the electric power services and facilities and the use of watercourses for electricity purposes, jointly with the states where hydroenergetic potentials are located;

....

XIX - To institute a national system for the management of water resources and define criteria for granting rights to the use thereof;

c) Article 22, IV:

It is incumbent exclusively upon the Union to legislate on:

....

IV- waters, energy, informatics, telecommunications and radio broadcasting;

d) Article 23, XI:

It is incumbent, in common, upon the Union, the States, the Federal District, and the Municipalities:

....

XI - to register, monitor, and supervise concessions of rights to research and exploit water and mineral resources within their territories;

e) Article 26, I:

The following are included among the property of the States:

I. Superficial or underground waters, whether flowing, emerging or in reservoirs, with the exception, in the latter case, as set forth in the law, of those resulting from works carried out by the Republic;

The Federal Constitution of 1988 gives the Union exclusive power to legislate on water and energy (article 22, IV). This makes it possible for electric power services and facilities and the energetic use of watercourses to be exploited jointly with the states where hydroenergetic potentials are located. This is to be done directly or through concession, permission or authorization (article 21, XII, b). The Constitution states that the hydraulic energy potential is property that is distinct and separate from the soil, for purposes of exploitation or use (article 176). The utilization of this potential may only take place with the authorization or concession of the Union (article 176, paragraph 1). An exception is made for the exploitation of small-capacity renewable energy potential, which does not require an authorization or grant (article 176, paragraph 4). Authorizations or concessions cannot be granted to foreigners or foreign companies (art. 176, paragraph 1).

According to the Federal Constitution, lakes, rivers, and any water courses of any kind on lands owned by the Republic, or which irrigate more than one State, serve as borders with other countries, or run into or from a foreign territory, as well as banks and river beaches, are property of the Union. (Article 20, III). "Superficial or ground water, whether flowing, emerging or in reservoirs, with the exception, in the latter case, as set forth in the law, of those resulting from works carried out by the Republic" remain property of the States (Article 26, I). In fact, the expression "remain" for superficial and underground waters, should be changed; by force of the Constitution of 1988, they became property of the States, where previously they were not.

According to Hely Lopes Meirelles, the Brazilian legal regime for internal waters (rivers, lakes, inland seas, harbors, channels and piers, bays, gulfs and estuaries) is the one established by the Water Code (Federal Decree 24643, of July 10, 1934, and its later alterations, especially Law-Decree 852 of November 11, 1938), and in accordance with the definitions set forth at the First Conference on International Law, which took place in Hague in 1930.

Due to Brazil's affiliation to the Roman-German law system, its Water Code followed the guidelines and principles that rule this system (David, René, Les Grands Systemes de Droit Contemporain, 4th ed. Dalloz, Paris, 1971). The large quantities of water in a great part of the country determined that the law, which was in force in the humid regions that were part of that system, would be adopted as a rule.

The areas periodically affected by droughts benefited from this Code. Article 5 invoked that there would be special laws for these areas, which included opening up these areas for public control. With the exception of Law 4.869 of December 1, 1965, these regulations have not yet been edited. This law stated that groundwater impounded by the Superintendence for the Development of the Northeast were considered public utilities for common use. In terms of ordinary laws, as was previously mentioned, this issue is dealt with by the Water Code (Decree 24643 of July 10, 1934). This includes its later modifications and subsequent regulations.

It is also worth mentioning that the "polluter pays" principle, introduced in Europe as a new concept, is outlined in articles 111 and 112 of the Code. However, for reasons that are difficult to comprehend, much of what is set forth by the Code has not been enforced. This is due to the fact that special laws and regulations were not created to enable this to happen and this despite the fact that the Code has been in force for over half a century.

Issues related to the following subjects may be cited as examples: (1) clearing of watercourses by the Administration at the expense of transgressors; (2) fines; (3) definition of penalties for failure to abide by the regulations; (4) ensuring that riverbeds and riverbanks are returned to their original state when they have been used irregularly; (5) supervision and authorization for the use of public and private water; (6) clearing of public water; (7) the condition and quality of water at the expense of transgressors; (8) urban supplies through aqueducts, channels, fountains and sanitary and rain sewage systems; (9) areas periodically affected by droughts (10) public use of water, whether free of charge or paid for; and (11) the regulation of water springs.

3.2.2. Federal legislation on water resources

Federal Law no. 9433 of January 8, 1997 established the National Water Resources Policy and the National Management System for Water Resources. This law also regulates incise XIX of article 21 of the Federal Constitution, among other provisions.

This is a current, modern and important law for territorial organization. In its broader sense, it is characterized by the decentralization of actions so as to prevent power concentration. This is clearly highlighted throughout the text of this law, which to this day, establishes the basic principles to be put into practice. These principles are enforced in all countries that have made progress in terms of water resources management, and they are the following:

- the adoption of the water basin as a planning unit;
- multiple uses of water;
- acknowledgement of water as a vulnerable and finite resource; and
- decentralized and participatory management.

Five instruments are essential for the proper management of water use. The instruments, which are relevant aspects of Law no. 9.433/97, are listed below:

- The National Plan for Water Resources;
- Granting rights to the utilization of water resources;
- Charging for the use of the water;
- Classifying bodies of water according to their use;
- The National Information System on Water Resources.

In relation to the institutional organization, the agencies created by the new system are the following:

- The National Council on Water Resources, the highest-ranked organization in the National System for Water Resources in administrative terms. This organization is in charge of making decisions regarding important issues related to the sector. It is also responsible for settling major conflicts;
- Water Basin Committees. This type of organization, for the administration of public property in Brazil, is entirely new. Water users, City Halls, civil society, organizations and the state and federal levels of the government, participate in these committees. These committees are meant to serve as a decision-making forum for each water basin;
- Water agencies. These are also an entirely new kind of organization. Their objective is to manage the resources that result from charging for the use of water;

- Civil organizations dealing with water resources. These agencies participate in the sectors concerned with planning and water resource management. Their participation in decision-making process and in the supervision of activities can be very important.

3.2.3. Law no. 9.984, of July 17, 2000

On July 17, 2000, Law no. 9.984, which concerns the Brazilian Water Agency - ANA, was sanctioned. The Brazilian Water Agency is the federal agency responsible for implementing the National Water Resources Policy and for coordinating the National Water Resources Management System.

The Brazilian Water Agency acts under a special regime. Although it is linked to the Ministry of the Environment, this agency is administratively and financially independent. Its objective is to implement the National Water Resources Policy. The Brazilian Water Agency has its head office in Brasilia and may set up regional administrative offices.

Article 4 of Law 9.984/2000 regulates the responsibilities of the Brazilian Water Agency:

"ANA operations shall follow the objectives, guidelines and instruments of the National Water Resources Policy. This agency will be developed in an alliance with the organizations and public and private agencies that make up the National Water Resources Management System. The Brazilian Water Agency shall:

I - supervise, control and evaluate actions and activities that result from compliance with the federal legislation concerning water resources;

II - discipline, normatively, the implementation, operation, control and evaluation of instruments related to the National Water Resources Policy;

III - (VETOED)

IV - grant, by means of authorizations, the right to use water resources of bodies of water controlled by the Federal Government, pursuant to the provisions under articles 5, 6, 7 and 8;

V - supervise the use of water resources of bodies of water controlled by the Federal Government;

VI - elaborate technical studies to serve as a basis for the National Council on Water Resources to define the amounts to be charged for the use of water resources controlled by the Federal Government. This is to be done based on the mechanisms and quantities suggested by Water Basin Committees, pursuant to incise VI of article 38 of Law no. 9.433, of 1997;

VII - encourage and support initiatives related to the creation of Water Basin Committees;

VIII - implement, in an alliance with Water Basin Committees, the payment for the use of water resources that are controlled by the Federal Government;

IX - collect, distribute and invest revenues earned as a result of the payment of fees charged for the use of water resources controlled by the Federal Government, in accordance with article 22 of Law no. 9.433, of 1997;

X - plan and promote actions with the objective of preventing or minimizing the effects of drought and floods. This is to be done within the sphere of activity of the National Water Resources Management System, in an alliance with the main agency of the National Civil Defense System in order to offer support to states and municipalities;

XI - encourage the elaboration of studies to support the investment of Federal funds in works and services to regulate water courses, to allocate and distribute water and to control water pollution, in accordance with water resource plans;

XII - define and supervise the conditions in which reservoirs operate. This is to be done by public and private agents with the objective of guaranteeing the multiple use of water resources, as set out in water resource plans of each water basin;

XIII - promote the coordination of activities developed within the sphere of the national hydro-meteorological network, in cooperation with the public and private agencies and organizations that make up or make use of this network;

XIV - organize, establish and manage the National Information System on Water Resources;

XV - encourage research on and human resource training in water resource management;

XVI - offer support to the states in the creation of water resources management agencies;

XVII - propose the establishment of incentives, including financial incentives, for the conservation of the quality and quantity of water resources to the National Council on Water Resources.

§1º In fulfilling the functions referred to in incise II of this Article, agreements and treaties related to water basins shared with other countries will be taken into consideration in the case of these basins.

§ 2º The actions to which incise X of this Article refers, those involving the enforcement of preventive rationing, may only be carried out in compliance with criteria to be established in a decree by the President of the Republic.

§ 3° For the purposes of the provisions under incise XII of this Article, the operating conditions for reservoirs making use of hydroelectric resources will be set in cooperation with the National Systems Operator - ONS.

§ 4° The Brazilian Water Agency may delegate or assign the responsibility for carrying out activities within its sphere of mandate to water agencies or water basin agencies, under the terms of Article 44 of Law no. 9.433, of 1997, and other applicable legal provisions.

§ 5° (VETOED)

§ 6° The investment of the revenues referred to in incise IX will be carried out in a decentralized manner through the agencies referred to in Chapter IV of Section II of Law no. 9.433, of 1997. In their absence or preclusion, this investment will be made by other agencies belonging to the National Water Resources Management System.

§ 7° In the administrative acts granting the rights to use the resources of water-courses bordering the semi-arid regions of the Northeast, issued under the terms of incise IV of this Article, the restrictions resulting from incises III and V of Article 15 of Law no. 9.433 of 1997 must appear explicitly.

3.2.4 International Treaties on Water Resources

Brazil takes part in the following Treaties: The Bacia Mirim and Lagoa dos Patos Treaty and the Rules of the Jaguarão River, the River Plate Basin Treaty, The Paraná River Treaty (ITAIPU), the Uruguay River Treaty, including its tributary Pepiri-Guaçú, and the Quaraí River Treaty.

3.2.5. State legislation on water resources

Several states have jurisdiction over water and as a consequence, the states passed their own laws concerning the administrative organization of the water resources sector. To date, 23 states already have their own laws. They are as follows:

TABLE 7 - State Laws concerning Water Resources

STATES AND THE FEDERAL DISTRICT	LAW REGARDING POLICIES AND THE WATER RESOURCES MANAGEMENT SYSTEM
ALAGOAS	Law no. 5.965 of November 10, 1997, published on November 11, 1997 - Concerns the State Policy on Water Resources and establishes the State System for the Integrated Management of Water Resources, among other provisions.
AMAZONAS	Law no. 2.712 of December 28, 2001 - Regulates the State Policy on Water Resources and establishes the State System for the Management of Water Resources, among other provisions.
BAHIA	Law no. 6.855 of May 12, 1995 - Concerns the Policy, the Management and the State Plan for Water Resources. (published in the Official Gazette on May 13 and 14, 1995)
CEARÁ	Law no. 11.996 of July 24, 1992 - Concerns the State Policy on Water Resources and establishes the Integrated Management System for Water Resources (SIGERH), among other provisions.
FEDERAL DISTRICT	Law no. 2725 of June 13, 2001 (published in Official Gazette number 116 of June 19, 2001). This Law establishes the Water Resources Policy in the Federal District and creates the Water Resources Management System in the Federal District, among other provisions. - Revokes Law no. 512 of July 28, 1993.
ESPÍRITO SANTO	Law no. 5.818 of December 30, 1998 - Concerns the State Policy on Water Resources and establishes the Integrated Management System for Water Resources in the State of Espírito Santo (SIGERH/ES), among other provisions.
GOIÁS	Law no. 13.123 of July 16, 1997 - Concerns the State Policy on Water Resources, among other provisions.
MARANHÃO	Law no. 7.052 of December 22, 1997 - Concerns the State Policy on Water Resources and establishes the Integrated Management System for Water Resources, among other provisions.

Table 7 - (continuation)

STATES AND THE FEDERAL DISTRICT	LAW REGARDING POLICIES AND THE WATER RESOURCES MANAGEMENT SYSTEM
MATO GROSSO	Law no. 6.945 of November 5, 1997 - Concerns the State Policy on Water Resources and establishes the State System for Water Resources, among other provisions.
MATO G. DO SUL	Law no. 2.406 of January 29, 2002 - Establishes the State Policy on Water Resources and creates the State System for the Management of Water Resources, among other provisions.
MINAS GERAIS	Law no. 13.199 of January 29, 1999, published on January 30, 1999 - Concerns the State Policy on Water Resources, among other provisions. Law no. 13.194 of January 29, 1999, published on January 30, 1999 - Creates the Fund for the Recovery, Protection and Sustainable Development of Water Basins in the State of Minas Gerais, among other provisions.
PARÁ	Law no. 6.381 of July 25, 2001 - Concerns the State Policy on Water Resources and establishes the State System for the Management of Water Resources, among other provisions.
PARAÍBA	Law no. 6.308 of July 2, 1996, published on July 3rd, 1996 - This law establishes the State Policy on Water Resources and its guidelines, among other provisions.
PARANÁ	Law no. 12.726 of November 26, 1999 - Establishes the State Policy on Water Resources and creates the State System for the Management of Water Resources, among other provisions.
PERNAMBUCO	Law no. 11.426 of January 17, 1997 - Concerns the State Policy on Water Resources and the State Plan for Water Resources and establishes the Integrated System for the Management of Water Resources, among other provisions.
PIAUÍ	Law no. 5.165 of August 17, 2000 - Concerns the State Policy on Water Resources and establishes the State System for the Management of Water Resources, among other provisions.

Table 7 - (continuation)

STATES AND THE FEDERAL DISTRICT	LAW REGARDING POLICIES AND THE WATER RESOURCES MANAGEMENT SYSTEM
RIO DE JANEIRO	Law no. 3.239 of August 2, 1999, published in the Official Gazette on August 4, 1999 - Establishes the State Policy on Water Resources, creates the State System for the Management of Water Resources and regulates the State Constitution in Article 261, § 1, incise VII, among other provisions.
RIO GDE DO NORTE	Law no. 6.908 of July 1, 1996, published on July 3, 1996 - Concerns the State Policy on Water Resources and establishes the Integrated System for the Management of Water Resources - SIGERH, among other provisions.
RIO GDE DO SUL	Law no. 10.350 of December 30, 1994 - Establishes the State System for Water Resources and regulates article 171 of the Constitution of the State of Rio Grande do Sul.
SANTA CATARINA	Law no. 9.748 of November 30, 1994 - Concerns the State Policy on Water Resources, among other provisions. Law no. 9.022 of May 6, 1993 - Concerns the State System for the Management of Water Resources.
SÃO PAULO	Law no. 10.020 of July 3, 1998 - Authorizes the Executive Branch of the government to participate in the creation of the Basins' Agency. Law no. 7.663 of December 30, 1991 - Establishes guidelines for the State Policy on Water Resources, as well as for the Integrated System for the Management of Water Resources. Law no. 9.034 of December 27, 1994 - Concerns the State Plan for Water Resources 1994/1995. Law no. 9.866 of November 28, 1997 - Concerns the protection and recovery of water springs. Law no. 898 of December 18, 1975 - Regulates the use of the soil in order to protect water springs, watercourses and reservoirs and other water resources that are of interest to the Metropolitan Region of São Paulo, among other related provisions.
SERGIPE	Law no. 3.870 of September 25, 1997 - Concerns the State Policy on Water Resources and establishes the Integrated System for the Management of Water Resources, among other provisions.
TOCANTINS	Law no. 1.307 of March 22, 2002 - Concerns the State Policy on Water Resources, among other provisions.

3.3. Organization of the federal public administration

Provisional Measure no. 2.123-27 of December 27, 2000 (original text: PM no. 1.795 of January 1, 1999), which is reissued on a regular basis, modified directives of Law no. 9.649 of May 27, 1998. This law concerned the organization of the Presidency of the Republic and the organization of the Ministries. The Provisional Measure defines the following functions in the field of water resources:

a) Ministry of the Environment:

- Enforcement of the national policy on the environment and water resources;
- Creation of policies for the preservation, conservation and sustainable use of ecosystems, biodiversity and forests;
- Development of strategies, mechanisms and economic and social tools to improve the quality of the environment and of the sustainable use of natural resources;
- Creation of policies to integrate the environment and production;
- Creation of policies and environmental programs for the Legal Amazon; and
- Ecological-economic zoning.

b) Ministry of National Integration:

- Creation and development of the integrated national development policy;
- Creation of plans and regional programs for development;
- Supervision and evaluation of the integrated programs for national development;
- Civil defense;
- Works to combat droughts and works related to water infrastructure;
- Creation and development of the national irrigation policy;
- Territorial organization;
- Public works at border zones.

c) Ministry of Agriculture and Supply:

- Protection, conservation and management of soil and water to support production in the domain of agriculture and cattle-raising.

d) Ministry of Mines and Energy:

- Geology, mineral resources and energetic resources;

- Utilization of hydraulic energy;
- Mining and metallurgy; and
- Petroleum, fuel and electricity, including nuclear energy.

e) Ministry of Transportation

- Responsible for the national policy for railway, highway and waterway transportation;
- Responsible for the merchant navy, harbors and navigable waterways.

f) Ministry of Defense:

- National maritime policy;
- Responsible for the safety of air and waterway traffic and also for safeguarding human life in the sea;
- Aerospatial, aeronautical and aeroportual infrastructure.

g) Ministry of Health:

- Environmental health and activities for the promotion, protection and recovery of individual and collective health. This includes the health of workers and that of Indians;
- Critical inputs for the health sector; and
- Preventive activities in general, supervision and control of sanitation conditions on borders and seaports, riverports and airports.

h) Ministry of Science and Technology

- National policy for scientific and technological research; and
- Planning, coordination, supervision and control of activities related to science and technology.

i) Ministry of Planning, Budget and Management:

- Formulation of the national strategic planning; and
- Development of studies and research to assess the social-economic situation and to manage the national cartographic and statistics systems.

j) Ministry of Foreign Affairs:

- Participation in commercial, economic, technical and cultural negotiations with foreign governments and agencies;
- International cooperation programs

- Offering support to Brazilian delegations, parties and representatives at international and multilateral agencies and organizations.

Decree no. 2.972 of February 26, 1999 approved the Regimental Structure of the Ministry of the Environment. A specific agency that is worth mentioning is the Secretariat of Water Resources, an agency of the National Council on Water Resources. This agency is linked to the Brazilian Institute for the Environment and Natural Renewable Resources (IBAMA) and has the following functions:

- It is the duty of the Secretariat of Water Resources to formulate the Water Resources National Policy and to serve as Executive Secretariat to the national Council on Water Resources;
- The National Council on Water Resources is responsible for fostering the creation of links between water resource planning, national, regional and state planning, and the planning of user sectors. It is also the Council's responsibility to mediate, as a last administrative resort, existing conflicts involving State Councils on Water Resources, as well as other functions established in Article 35 of Law no. 9.433, of January 8, 1997; and
- IBAMA, as the federal agency responsible for managing environmental issues, is in charge of coordinating, executing and enforcing the national policy and governmental guidelines established for the environment. IBAMA is also responsible for the preservation, conservation, rational use, supervision and control of environmental resources.

The National Council on Water Resources, pursuant to the terms of Article 51 of Law no. 9.433/97, may grant legally established intermunicipal water basin associations, that are financially and administratively autonomous, the right to exercise the functions of a water agency when this agency has not yet been established. This right can be granted for a limited period and the Water Basin Committee concerned must be consulted on the issue.

4. CONSIDERATIONS

For an adequate understanding of the situation of water resource management, the following issues are extremely important:

1. The model that involves Basin Committees, Water Agencies and water charges is new. In order for this model to be established, important changes need to occur not only in relation to the pre-existing laws but also in relation to the statute and behavior of public administrators. They need to be receptive to a partnership with water resource users and with the community;
2. The establishment of water resource management should be seen as a political, steady and progressive process. This process comprises the succes-

sive stages of improvement with respect to Brazilian characteristics and conditions and taking into consideration the particularities of each basin or Brazilian region;

3. In regions and water basins, where there are cases of serious conflict and where the community and civil agencies have been mobilized to discuss the theme, innovative solutions involving partnerships between the public authority and society are more likely to be encountered;

4. In states where this has not happened, principally for political reasons, innovation is less likely to take place. In this case, it is necessary to search for intermediate stages of water resource management; and long-term guidelines must be made clear;

5. National laws should allow for diversified and progressive solutions. These laws should not inhibit initiatives and they should not impose the adoption of solutions that are incompatible with the economic, political and social conditions of each state or region.

5. GENERAL PERSPECTIVES

It is safe to say that there has never been such an optimistic outlook on the Water Resources Sector in Brazil.

Currently, the Government of the Federal Republic of Brazil has all of the necessary instruments - legal, institutional, technical and financial - to establish in the medium term the National System for the Management of Water Resources jointly with users and civil society.

It is our opinion that advances should be made in the following fields:

1. Consolidation of the Brazilian Water Agency (ANA), through the appointment of its permanent technical staff by means of a public service test at the earliest possible occasion.

2. Elaboration of a study and diagnosis on the Water Resources Sector in Brazil. This should take several aspects into account. These aspects include Inventory Aspects, Technology, Legal Aspects, Institutional Organization, Available Human Resources, Uses, Institutions, Plans and Programs, Civil Public Interest Organizations, NGOs as well as other related areas as well.

3. Definition of a Strategic Plan for the Establishment and Implementation of the National Water Resources Management System by the Brazilian Water Agency, making use of the available Brazilian experience.

4. National Archives and Records on Professionals in the Area of Water Resources.

5. National Archives and Records on Agencies acting in the Area of Water Resources.

6. National Archives and Records on Water Resource Users.

7. Organization of Institutional Archives and Records on Official Water Resources Agencies (both on a Federal and on a State level).

8. Organization of Institutional Archives and Records on Civil Water Resources Organizations.

9. Regional Studies on the Demand for and the Availability of Water for urban supply, industrial use and irrigation. These studies should determine the following aspects: spatial distribution, quantities, quality and temporal distribution.

10. Regional Studies on the Control of Water Pollution resulting from urban, industrial and agricultural uses. These studies should determine the following aspects: where water springs are located, quantities, quality standards and temporal distribution.

11. Director Plan for the Use of Water Resources in the Hydrogeological Province of the Brazilian Semi-Arid Region.

12. Studies of a strategic nature aiming at the management of water resources in the Eastern Amazon, including foreign water springs.

13. Inventory of the Annual Expenses of the Country on water resource management.

14. Definition of Strategies and Implementation of Actions in the sphere of the Amazon Cooperation Treaty.

15. Definition of Strategies and Implementation of Actions in the sphere of the River Plate Basin Treaty.

16. Definition of Strategies and Implementation of Actions in the sphere of the Quaraí River and Lagoa Mirim Treaties.

17. Studies on the payment for the use of water resources and on other legal ways to obtain revenues and to cover expenses. These include taxes, fees, prices charged for services and other economic instruments used in order to fund management, like crossed subsidies, the water market and others.

18. Studies for the adoption of economic-financial mechanisms for the management of water resources. This could be implemented through an exchange of experiences between water user sectors and the States of the Federation.

This would assist in the evaluation of accomplishments and errors and also to communicate to a wider audience the experiences implemented abroad.

19. Elaboration of a Guidance Manual for both public and private institutions. The objectives of this manual are to generate additional revenues for the management of water resources and to recuperate investments made in hydraulic works. These include refunding costs for granting permits, fees charged for recuperating the costs of works, the use of budgetary resources (at the federal and at the state level), resources from existing funds and national and international loans and donations. They also include charging for changes in the hydrological regime and for the redirection of flows (not foreseen by law), and finally, they include contributions for improvements brought about by hydraulic works and other interventions.

20. Studies on Economic and Financial Mechanisms that enable water to be more efficiently utilized, without the need for additional resources in order to finance a management system. These following considerations should be evaluated: the use of crossed subsidies (both intersectorial and interregional), the adoption of tax policies (involving tax raises or the government renouncing the right to collect taxes), the concession of bonuses and incentives to efficient water users, the introduction of water markets (at first in irrigation areas or situations involving irrigation at a water basin), and other measures.

21. Regional Studies on Flood Control, with the objective of locating critical areas, mapping areas subject to floods, carrying out an analysis of the impact of hydraulic works, qualifying provoked damages and using the distributed hydrologic models.

22. Creation of a Program of Emergency Plans for planning and encouraging the permanent defense against public catastrophes with respect to water resources, especially drought and floods.

23. Updated publication of the Legislation on Water Resources by the Brazilian Water Agency. This publication has three volumes: Federal, State and Municipal (Metropolitan Areas).

24. Studies to update the Water Code.

25. Encouragement and support to the States to implement state laws concerning water resources, with technical and legal support.

26. Development of a program to establish technical, organizational and institutional guidelines for the development of the new hydrometeorological network in Brazil, in order to support the single coordination of the national

hydrological network. This should take place within the domain of the Water Resources Information System, as established by Law no. 9.433/97.

27. Studies regarding the hydrological aspects of the Brazilian semi-arid region in order to determine hydrologic parameters and criteria that allow for a more reliable estimation of volumes for flow rate regulation and bypass flows.

28. Creation of a Program for the Development of the Hydrometeorological Network and for the Quality of Water.

29. Official Codification of Federal and State Rivers in the country.

30. Elaboration of maps of Federal Rivers and Basins.

31. Elaboration of maps of State Rivers and Basins.

32. Development of a training program for the Brazilian Water Agency, principally involving technical and managerial training for the Agency based on the priorities outlined by the Professional Diagnosis and by Concentration Areas.

33. Creation of a Technical, Scientific and Professional Development Program, including the inventory on the supply and demand for technical-scientific training in the states. This includes the implementation of training processes for professions in the area of water resources, of instructors-teachers/multipliers through partnerships and contracts with national, regional and intermunicipal organizations. It also includes support to regional Centers of Excellence.

34. Program for awareness-raising in the Community - this includes seminars for discussion regarding different areas of Water Resource Management. These seminars are to be attended by individuals who are not specialists in the area, since they participate (or will participate) in different processes related to the management of water resources as users, taxpayers or citizens.

35. Creation of a Program for Institutional Encouragement - this includes an assessment of the training demands by the states. The objective is to fund technical training events of an institutional nature, and special training projects (internships, technical visits, trainee programs, exchange programs and scholarships).

36. Creation of 54 new libraries specializing in materials related to Water Resources (2 per State and the Federal District).

37. Development of the Water Resources Editorial Program, with the publication of a series of Water Resources Reference Books.

38. Elaboration and Implementation of the National Plan for Training in Water Resources.

6. PERSPECTIVES FOR THE AMAZON

The State Water Resources Systems, and the legislation pertaining to these systems, should be implemented in the Brazilian States that have not yet become involved in the process.

The creation of the Amazon Cooperation Treaty Organization - ACTO provides for the implementation of water resource management in the Amazon basin. Thus paving the way for Brazil to concentrate on caring for water resources.

The Amazon Cooperation Treaty - ACT, is being gradually and realistically implemented. The current international economic-financial situation is taken into consideration, as is the case with the economic-financial situation of member countries. Its activities will be developed in relation to the physical, economic and social integration of Brazilian Amazonian territories into national developmental processes, which will take place in a gradual manner.

According to this view, the following can be noted:

a) Adequate knowledge on hydrology, climatology and management mechanisms requires a lot of time to be acquired. Knowledge acquisition takes far longer than the presidential terms in these countries;

b) The volatile nature of the economies of member countries coupled with administrative discontinuity have caused the misapplication of important human resources, thus harming governmental institutions and programs;

c) A great many activities have already been developed within the mandate of the Amazon Cooperation Treaty. An increase in the number of activities undertaken was observed during early 1998. This increase occurred largely because of international pressure on Brazil's stance vis-à-vis environmental issues;

d) The number of existing Special Committees, and the quantity and complexity of issues to be dealt with illustrates the need to create specialized divisions;

e) There is the need for effective and efficient management and coordination of financial, technical, human, legal and institutional resources so that these resources be invested together with those of international organizations on the maintenance of historical memory.

In order to fulfill previous commitments made by the countries and thus optimize ACT activities in the fields of hydrology, climatology and especially water resources, the following actions have to be carried out:

1. Establishing the Permanent Secretariat of the Amazon Cooperation Treaty - ACT, to replace the existing Ad-Tempore Secretariat. This must be done as soon as possible, as member countries have already made the decision;

2. Creating the Special Commission on Hydrology, Climatology and Water Resources in the Amazon (Comissão Especial de Hidrologia, Climatologia e Gerenciamento de Recursos Hídricos da Amazônia - CHIDRA), within the scope of the Amazon Cooperation Treaty since the Special Commission for the Environment in the Amazon acts in the preservation of natural resources, focusing on the environment and particularly biodiversity and research;

3. Establishing the Executive Secretariat of the CHIDRA in Manaus while concurrently establishing the Hydrometeorological Databank of the Amazon Region, which was approved at the International Seminar on Hydrology and Climatology of the Amazon. This seminar took place in Manaus in 1984;

4. Carrying out legal, institutional, technical and political studies for the management of water resources within the CHIDRA mandate, with support from the International Relations Research Institute in Brazil;

5. Carrying out a study on tropical hydrology. This will be performed by the Universidade Andina, in Bolivia and the Federal University of Amazonas, in Manaus;

6. Carrying out a study on guidelines for the management of water resources in member countries and defining national policies taking all of the countries that use the basin into consideration. This is to be done within the sphere of activity of CHIDRA;

7. Establishing technical cooperation agreements with the participation of specialists from member-countries in the creation of the National Systems for the Management of Water Resources. The objective is to supervise its operation and to establish national plans for water resources;

8. Carrying out a study on the institutional participation of professional associations, consultancy companies and non-governmental institutions in the activities with the objective of fostering transparency and permanent technological support. This study is to be developed within the sphere of activity of CHIDRA;

9. Supervising all of the plans and projects for urban and regional development in member-countries in the Amazon Region. The CHIDRA is to be responsible for this supervision; and

10. Developing the Water Resource Management Project in the Amazon Basin, providing the CHIDRA with multilateral support. Its directive commission should be made up of member-countries in order to make the project more dynamic.

We believe that the Water Resources Sector will be revitalized. This will widen International Technical Cooperation in the consolidation of Centers of Excellency and for the strengthening of research and consultancy in the area. In this way, the Brazilian society and the Amazonian Countries will gain access to the benefits of water as a resource.

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9. WATER RESOURCE MANAGEMENT AS AN ELEMENT OF TRANSFORMATION IN AMAZONIAN SOCIETY *

Ivo Brasil **

1. INTRODUCTION

Fresh water resources are an essential part of the Earth's hydrosphere and an indispensable part of all terrestrial ecosystems. The fresh water environment is characterized by the hydrological cycle, which includes floods and droughts and whose consequences have become increasingly extreme and dramatic in certain regions. Global changes in weather patterns and atmospheric pollution can also have an impact on fresh water resources and their subsequent availability. Furthermore, they can threaten low coastal areas as well as the ecosystems of small islands with a rise in sea level.

Water is necessary in all aspects of life. The general objective is to ensure the maintenance of an adequate supply of good quality water for the entire population of the planet while preserving the hydrological, biological and chemical functions of ecosystems. In order for this to occur, human activities must be adapted to nature's limitations. It is also essential to combat the vectors of water-related diseases. Innovative technologies as well as the improvement of existing technologies are necessary so that the best possible

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use can be made of the limited water resources, and in order that these resources be protected from pollution.

The generalized lack of water, the gradual destruction of water resources and the worsening water pollution in many regions of the world, in addition to the progressive implantation of incompatible activities, require the integration of planning and management systems. This integration must cover all kinds of interrelated freshwater bodies, including both surface and underground water sources. This involves taking into consideration the application of the quantitative and the qualitative aspects of the operation. The multi-sectorial nature of water resources management, within the context of social-economic development, must be acknowledged, as must the multiple interests in the utilization of these resources for supplying water for sanitation, agriculture, industry, urban development, hydroelectric energy generation, transportation and leisure purposes. Rational plans for water utilization in the development of groundwater or surface water sources, as well as that of other potential sources, must be supported by corresponding measures for water conservation. These measures involve minimizing the amount of water that is wasted. However, priority must be granted to establish measures for the prevention and control of floods. Sedimentation control should also be prioritized where necessary.

Transboundary water resources and their consumption are enormously important for the neighboring countries that share the watercourses. It is thus desirable that cooperation among these countries takes place in accordance with existing agreements and/or other applicable arrangements. The interests of all countries involved must be taken into account. The development and integrated management of water resources, as well as their assessment and protection, must be emphasized. The quality of water and of aquatic ecosystems, the provision of potable water, sanitation, sustainable urban development and the use of water for the sustainable production of food and sustainable rural development should also be recognized, as well as the impacts of climatic changes on water resources. In South America, and in particular the countries comprising the Amazon Basin (Bolivia, Brazil, Colombia, Ecuador, Peru and Venezuela), water resource management is a responsibility of the state. For the most part, there is little participation on behalf of the end-users. The organization of water agency structures as well as prices charged for the use of water is subject to variation.

Brazil stands out in the area of water resource management because of its modern legislation. The Brazilian Water Law dates back to 1997. According to this law, water resource management should engage a decentralized and participatory process. In July 2000, the National Water Agency (ANA) was established. This agency was responsible for implementing the National Water Resources Policy. Its duties, among others, were to implement a system for granting rights and fixing rates for the use of water resources of rivers that are federal property, to supervise and to foster the creation of Water Basin Committees and to offer support to states in the creation of water resource management agencies. In this way, Water Resource Plans are specifically created according to the water basin concerned. Water Basin Committees actively participate in the management of basins within their sphere of activity. The charging of fees, as a management tool, for the use of water resources is being implemented, particularly for water basins where there is depletion and/or degradation of water.

In Venezuela, the General Coordination for Water Basins is responsible for the management of water resources. It aims to foster the sustainable management of water basins in order to guarantee an adequate supply of quality water by defining policies and strategies for water use. They are also responsible for the National Water Resources Plan. The General Coordination for Water Basins recognizes water basins as units, and the planning of the units is carried out by means of pilot projects. The participation of committees (representing users) and fee charges for water use has not yet been implemented.

In Ecuador, the National Council for Water Resources is the unit responsible for establishing and enforcing policies related to water resource management and its planning, regulation and control at a national level. In Ecuador, the administrative coordination is carried out jointly with National Committees as well as with Inter-ministerial Water Councils. Basin committees (representing users) participate as advisors but fee charging has not yet been established.

In Colombia, the Institute of Hydrology, Meteorology and Environmental Studies (Instituto de Hidrologia, Meteorologia e Estudos Ambientais - IDEAM), is responsible for water resources management through the sub-direction of Hydrology. This agency ensures the availability of information and knowledge to the community, on both the natural processes that determine the water cycle, and the factors affecting water supply and demand. It also ensures community participation and interaction as concerns social-economic processes. This process is an essential tool to define policies, planning and decision-making in order to achieve sustainable development objectives and a better quality of life for the population. In Colombia, water basins are seen as planning units. However, the participation of committees (users) is not taken into account and fees have yet to be implemented.

In Peru, the Water and Soil Coordination agency (Direção de Águas e Solos - DGAS) manages water resources. This agency is responsible for proposing, supervising and controlling policies, plans and regulations related to the rational and sustainable use of resources. It recognizes the water basins as planning units, but it does not take user participation into account and fees have yet to be implemented.

In Bolivia, the General Coordination for the Classification of Lands and Basins is responsible for the management of water resources and the planning of use, protection, conservation and the sustainable and rational organization of water resources. In Bolivia, the water basin is the unit for analysis and management. The effective participation of committees (users) is not yet taken into consideration. The establishment of fees for the use of water is being planned.

2. THE BEGINNING

We can state that the management of water resources in the Amazon region began with the formation of the great Amazon water basin and the presence of Amerindians, European colonizers and African slaves. After the separation of west Gondwana, the Atlantic Ocean was formed, completely separating South America from Africa. South America became a gigantic island that progressively made its way towards the west. A wide variety of species remained on the continent and the formation of the Amazon Basin made it possible for the most spectacular biome on the planet to come into existence. The rich diversity of the Amazonian flora is unique. Over 30,000 species of higher plants have already been recorded. This represents one third of the total number of species found throughout South America and three times the number of species found in Europe. The Amazon rainforest favored the appearance of a multitude of insect species, estimated at millions of species. These species are ecologically linked to the emergence of higher plants.

Following the separation of the two continents and the emergence of higher plants, the Andes Mountains were formed about 15 million years ago as a consequence of the subduction of the Nazca plate beneath the South-American plate. Where did the Amazon River flow to before and after the appearance of the Andes Mountains? Researchers affirm that the river flowed towards the Caribbean, where it formed the great Orinoco system. The consequence of the Andes and the convergence of the Brazilian and Guyanan plateaus, preventing drainage, possibly contributed to the formation of a large lake with flooded ecosystems dominant in the Amazon region. It was during the Pliocene era, 10 million years ago that the Amazon River finally hollowed out its course through the valley that separated the Brazilian and Guyanan plateaus. The flooded landscape was then transformed into a river and subsequently into a rainforest ecosystem connected to the Atlantic Ocean.

The event that transformed the Amazon River into its present day configuration was the release and retention of great quantities of water by the polar caps. As global temperatures dropped, the polar caps expanded with the effect of lowering the sea level. During this period, Amazonian rivers could flow more rapidly, thus forming riverbeds and banks in the valleys as they flowed. These geological changes led to curious situations such as the position of the Negro River bed, which is at the same level as Manaus, 60 meters below sea level. The current landscape of the Amazon River valley is related to the sharp rise in sea level. This impeded the flow of freshwater and resulted in floods along various tributaries close to the river source, and where the distance between the opposite banks of the river can reach up to 50 kilometers.

Animals to be found in the Amazon include the South American lungfish, reptiles, crocodiles and snakes, such as the anaconda, iguanas, tegu lizards, amphibians, frogs and fish, who have existed in the Amazon since the Mesozoic era. The Panamanian isthmus joining South America and Central America favored the migration of mammals to the Amazon. This was also the case for Homo sapiens - that is, the Amerindians, who reached the Amazon via the isthmus some 10,000 years ago. Thus, the most complex biome, and the planet's richest ecosystem comprised of the most extraordinary biodiversity, was formed. The largest hydrographic network in the world was also completed, including the natural management of water resources.

3. PRESENT DAY

During the 16th century, the above situation began to change by the arrival of Europeans and African slaves to the region. However, diseases carried by the settlers soon decimated most of the native population. The surviving population was turned into slaves. This process began with the Spanish and the Portuguese and with the construction of forts and the first urban settlements. The first family clusters appeared. The caboclo originated as a combination of Europeans and Indians. Missionaries accompanied the colonizers in order to catechize the native population. These clusters, often comprised of one single family spread across the Amazon Forest. This raised the issue of communication and food supplies. Rivers began to be used as the only means of communication and transportation. The clusters soon developed into villages and then cities. This was the start of the use of "water resources as an element of transformation in Amazonian societies". The invention of the steam engine brought about an increase in commercial activities between the city and remote villages and later the diesel engine promoted trade. The inhabitants of the villages extracted products from the forest the most important of which was rubber, which gained vital importance during the Second World War. The products were commercialized in Europe and in the United States and led the beginning of economic transformation in early society.

The development of big cities occurred during the last century and was coupled with the increase in communication through the use of radio and television media and the evolution of transport: aviation, railroads and highways, though there was a decrease in river transportation due to the lack of commercial interest in extractive products. Industrialization soon became widespread. The necessity to generate wealth and meet the basic needs of an economically active society, as well as the demands of other regions and countries, illustrated the new reality for the entire Amazon region. The following five areas of focus directly affect water resources: energy, agriculture and fishing, river transportation, mining and wood exploitation.

3.1. Energy

Many cities in the Amazon, particularly small towns, still depend on petroleum products to generate electric energy. Due to the scale of consumption, small towns will continue to depend on oil or natural gas for the generation of electric energy for many years. The exploitation of oil and natural gas by Brazil, Peru and Ecuador is greatest in the

Amazon Basin. Certain cities could be supplied with biomass energy while others could be supplied with energy generated from vegetable oil or with solar energy. It's possible that within decades, hydrogen will be used as an energy source. However, the greatest energy generation potential comes from water resources. In this respect, the Amazon will be able to offer a great deal of hydroelectric energy, particularly in Brazil, Bolivia, Colombia, Ecuador, Peru and Venezuela.

3.1.1. Brazil (Amazon)

With a hydraulic potential estimated at 80,000 MW, the Brazilian Amazon is considered a strategic energy reserve in relation to its own development and to the development of the entire country. The Tucuruí Hydroelectric Power Plant is already operational producing 11,000 MW. This power plant provides the city of Belém with electricity (1,200 MW). The extra energy generated via an interconnected system supplies other regions, especially the northeast and southeast. There are four other hydroelectric power plants in the region: Samuel, which produces 200 MW and supplies Porto Velho and Rio Branco; Balbina, which produces 250 MW and partially supplies Manaus; Paredão, which produces 50 MW and serves Macapá; and Curua-Uma, which produces 50 MW and serves the city of Santarém.

Studies have been carried out to determine the feasibility of implementing the Belo Monte Hydroelectric Power Plant on the Xingu River located in the State of Pará. With a capacity of 12,000 MW, it is expected to be the largest hydroelectric plant in Brazil, since Itaipu is a transnational power plant. Other plants include the Santo Antonio and Jirau Hydroelectric Power Plants on the Madeira River. They will be located in Brazil, in Rondônia state, with a full capacity of 7,500 MW. It is important to note that these new power plants are being designed in accordance with environmental standards (Environmental Impact Studies/Environment Impact Assessment Reports) and Law no. 9433 of 1997, which stipulates the multiple uses of water resources: energy generation, irrigation, fishing, recreation and river transportation, among other activities. The power plants on the Madeira River will focus on making it possible for the waterways on this river to reach Bolivia. This will turn Bolivia into an axis of integration and transnational development, making an old dream of both Brazilians and Bolivians come true.

In order to serve the more remote communities in the region, diesel oil is used to generate electricity. Small hydroelectric power plants also generate electricity and other energy sources are being researched. In Porto Velho, the installation of a Thermoelectric Plant, sponsored by the Termonorte Association is in its final stage of development. The plant will be able to generate up to 400 MW. The power plant will be fuelled by diesel oil subsequently by natural gas. The gas will be transported via a gas pipeline from Urucu, in the state of Amazonas.

3.1.2. Venezuela

The GURI Hydroelectric Power Plant, operated by the nationalized company, Eletrificación Del Caroni (Edelca), serves part of Venezuela. It also provides the city of Boa Vista, Brazil, with energy. In Guayana, a region bordering Brazil, its operational capacity reaches 12,540 MW. In addition to this, Edelca is investing in the Macagua I and II Hydroelectric Power Plants on the Caroni River. This will provide an additional 4,320 MW to its full capacity. The Cachamy, Tocoma II and Curuachi Hydroelectric Power Plànts, which will eventually add another 16,247 MW to current energy production, are still in their planning stages.

3.1.3. Ecuador

The electricity sector in Ecuador has an installed capacity of 3,902 MW, 44% of this capacity is hydraulically generated and 56% is thermally generated. Energy generation, using diesel oil is responsible for 28% of the entire national production of energy. The energy imported through the network in Colombia represents only 0.23% of all energy consumed in the country. About 80% of the population has electrical energy in their homes (95.5% of the urban population and 54.5% of the rural population). In 1999, 38.2% of the energy used was attributed to domestic use and 26.9% by industry. This suggests the low level of industrialization in Ecuador.

The electricity sector is operated by Interconnected National System (Sistema Interconectado Nacional - SIN), and includes isolated systems and self-production systems. The SIN, which comprises the main generators of electricity, distributors and transmission companies, is responsible for 84% of the country's total installed capacity. Isolated systems, mainly thermal energy systems, (94.3%) are operated by private companies.

3.1.4. Colombia

In the year 2000, the installed capacity of the electricity sector was 12,542 MW. Of the total energy generation, 65% is hydraulic and 35% is thermal. This includes the primary sources of coal and particularly natural gas and oil-derived products (83%). The Colombian electricity system is made up of the Interconnected National System (Sistema Interconectado Nacional - SIN) and small isolated systems in rural areas of the country.

3.1.5. Peru

According to data from the Ministry of Mines and Energy in 1999, 53% of the energy generated by the Peruvian electricity sector is hydroelectric and 47% is thermal. This adds up to an installed capacity of 4,828 MW. The energy sector is made up of two large non-interconnected systems and of various small isolated systems: the Central-North Interconnected System, which serves the city of Lima (SICN, with an installed capacity of 65%), the Southern Interconnected System (SISUR, with an installed capacity of 28%) and the Isolated Systems (the remaining 7%). It is important to note that private self-producers can be found operating in all systems, particularly isolated systems. Their input accounts for 30% of the national system.

3.1.6. Bolivia

According to the National Energy Plan, which was elaborated in 1961, the hydroelectric potential in Bolivia is practically unexploited. Bolivian water resources are not evenly distributed and areas with the greatest hydroelectric potential are located on the west side of the Andes, where hydrological and topographical conditions are favorable. In Bolivia, there are uses for all kinds of hydroelectric facilities. In theory, there is hydroelectric potential for an installed capacity of 190,000 MW. There is a technically exploitable potential of 57,000 MW and reliable energy can reach 11,000 to 20,000 MW. The evaluation of the hydroenergetic and geothermal potential in Bolivia and the elaboration of projects in order to utilize this potential are the main basis for planning the expansion of production capacity of the electrical systems. In Bolivia, there are various projects and studies at the feasibility stage.

3.2. Agriculture and Fishing

The Amazon provides various species of fish for personal consumption. Large-scale production is not yet practiced. Certain experiments are beginning to be carried out with the objective of promoting large-scale production, but a favorable evaluation is not possible at present. With respect to water resources, providing water for animals is considered a priority. However, an attempt to develop cattle-raising in the Amazon was unsuccessful. According to environmentalists, the support given to cattle-raising was to prove disastrous and was seen as the cause of forest fires. Intensive clearings that had the effect of damaging the fragile Amazonian soil provoked these fires. This precipitated the destruction of a valuable ecosystem.

There was also an attempt to develop cattle-raising in the fields of Roraima and Humaitá, however, these attempts have also been unsuccessful. A small number of farmers still struggle in the Humaitá fields together with farmers who plant soy and rice, who do not make use of irrigation. Soy planting and harvesting are experiencing an intense phase in the humid cerrado surrounding the Amazon Forest in the State of Mato Grosso. The soy is sent to Porto Velho port by truck, transported to the modern Itacoatiara port by ferry and is then sent to Europe and to North America on large-tonnage ships. In the near future, it will be possible for the cargo to be shipped to Asia via Peru. When conditions become favorable, the Bolivian soy will also be sent via this corridor. There was also an attempt to produce Conilon coffee along the BR-364, a road that links Cuiabá, in Mato

Grosso, to the state of Acre. However, production has decreased annually mainly because of the low price paid for the coffee, which cannot maintain production. Currently, the Brazilian Amazon is self-sufficient in terms of rice, corn, banana, flour and bean production.

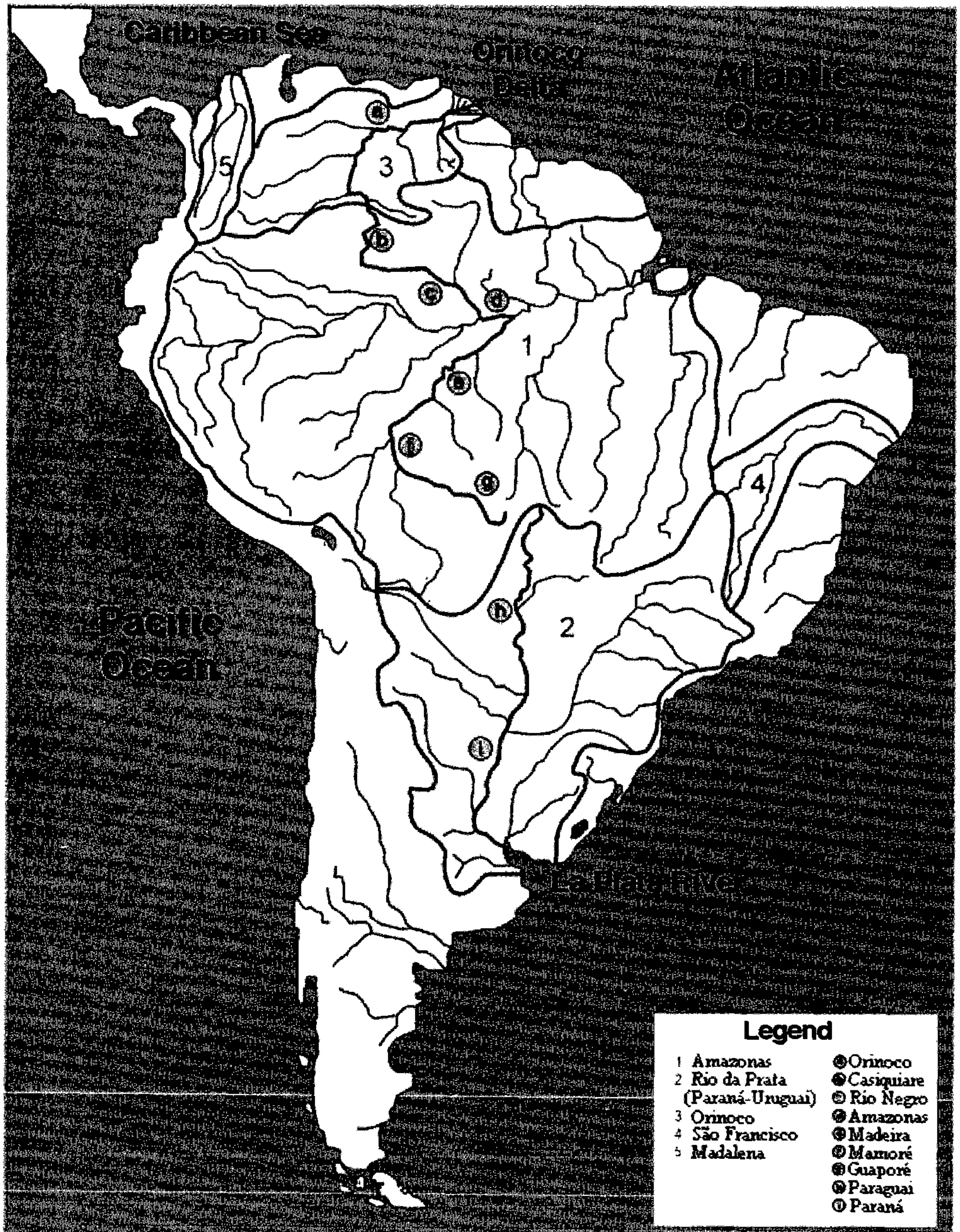
3.3. River Transportation and Waterways

River transportation began with small boats (paddle boats), mainly used by caboclos and fishermen for the transportation of goods and people; these boats continue to be used today. With the use of outboard and inboard motors operating on gasoline, boats have become bigger making it possible to transport ever more people and goods. This situation led to the establishment of small river tradesmen. With the invention of the diesel motor, the livelihoods of most remote rural communities in the Amazon Region were greatly improved. These types of motor serve as propellers to both small and large regional boats and can also generate electricity. Today, these boats have modern navigation instruments, including satellite, GPS (Global Positioning System) and Sonar systems. They are very comfortable with cabin suites that are comparable to suites in most modern hotels offering air conditioning, refrigerators and televisions. This evolution contributed to the arrival of small river tradesmen and *regatões*, which are like large floating supermarkets.

The increase in agricultural production raised the importance of waterways. This is especially true in the case of exportable goods, such as soy, which are planted in remote regions, and whose transportation by truck or train would raise their price, making it uncompetitive in the international market. The Madeira Waterway is worth highlighting. It is used for the transportation of all the soy produced in the states of Mato Grosso, Rondônia and Bolivia to the modern Itacoatiara port. Huge cargo ships then transport the grain from Itacoatiara port to the European and American consumer market. Another very important waterway in the Amazon Basin is the Orinoco waterway, in Venezuela, while the construction of the Araguaia-Tocantins waterway has been evaluated. Waterways and river transportation will become vitally important for the economic development of the Amazon and for the improvement of the quality of life of the Amazon population if the countries concerned introduce and valorize transportation in the region.

Considering the current hydrographical situation, it would be relatively simple to set up a South-American river navigation system. This system would involve the interconnection of the Orinoco, the Amazon and the Prata Basins via the North-South River Axis (Fig. 1). This River Axis, almost 10,000 kilometers long, would be made up of the following rivers: the Orinoco, the Casiquiare-Negro, a small stretch of the Amazon River, the Madeira-Mamoré-Guaporé and in the Southern Cone region, the Paraguay and the Paraná, both of which flow into the Prata river.

NORTH-SOUTH AXIS



Source: Georgescu, C. P., 2000.

To the North and the Central part of the continent, the following rivers are navigable:

* one third of the Orinoco River, the Apure River and its tributary, the Portuguesa River;
* the Amazonas-Solimões and large stretches of the Marañon and the Ucayali, both of which form the Amazon-Solimões;
* to the north of the Solimões, the Napo, the Putumayo, the Caquetá, the Negro and the Trombetas are navigable;
* to the south of the Amazonas, there are the Purus, the Madeira, the Guaporé, the Beni, the Madre de Dios, the Tapajós and the Araguaia.

For navigation and transportation in the Southern Cone, there are the Prata Basin rivers, including:

* the Paraná, the Paraguay and the Uruguay, as well as the Tietê and some of its tributaries. The latter is part of the Paraguay-Paraná and the Tietê-Paraná waterways.

The great length of the waterway axis makes the Amazon Basin very attractive. Experience from the Paraguay-Paraná waterway reveals charter costs of around U$ 0.007 t/km. When compared with other means of transportation, the price is totally justifiable. Furthermore, this type of transportation causes the least damage to the environment. From an ecological point of view, this is a great advantage because of the vulnerability of the environment at the Orinoco and Amazonas basins. Inter-modal integration presents interesting solutions for the flow of trade among Amazon Basin countries, the European Union, the United States and Asia. The use of complementary corridors, such as roads (U$ 1.05 t/km) or railways (U$ 0.06 t/km), would result in a more attractive total price than those currently charged.

With an area comprising almost half of the territory of South America, in an area where the Orinoco and Amazonas water basins cover most of the territory of the Andean Community Nations and Brazil, river transportation is underdeveloped despite the fact that these rivers are among the largest in the world. This is also the case of commercial exchanges of the aforementioned countries that make little use of this mode of transportation. Also, the current infrastructure development for river transportation is quite distinct for different basins. While in countries like Venezuela and Brazil, the infrastructure development for river transportation has substantially intensified, which also occurred in Peru though at a slower pace. In other countries such as Colombia, Bolivia and Ecuador, investments in this sector have been modest.

3.4. Mining

Mining is one of the most damaging activities to the environment, which pollutes and contaminates water resources. The Brazilian Amazon region is considered one of the major mineral regions of the planet, which is in part due to the large amounts of radioactive materials found there. Iron ore exploitation currently takes place only in the region of Carajás, though there are other iron ore reserves to be exploited. Miners work in Serra Pelada and also on the Xingu and the Madeira, where they use barges. Tantalite is another mineral that has been exploited due to its use in the production of high-tech products such as cell phones. Decades ago, the exploitation of cassiterite was very important, however, exploitation decreased due to the overwhelming quantities found on the international market. The exploitation of this mineral in the Amazon region caused immense devastation to environment, forests and to water resources. Mining activities have also been engaged in other Amazon Countries, where they cause the same problems as encountered in Brazil. In the Pre-Colombian era, the exploitation of gold and silver in Bolivia, especially in Potosí, was more intense than today. This is also the case in Peru. The exploitation of copper became less important because of the use of optical fibers and aluminum in transmission lines. However, copper is still irreplaceable in some cases.

According to historians, after the Indian Huallpa discovered the mines in Potosí, even horseshoes were made of silver, as were the altars of churches and the wings of cherubims. At Corpus Christi, the stones that paved the streets of the city from the Main Church all the way to the Recoletos Church were removed and were completely covered with silver bars. In 1573, according to the census, there were 120,000 inhabitants in Potosí. Twenty years later, Potosí was the same size as London and larger than Seville, Madrid, Rome and Paris. Around 1650, there already were 160,000 inhabitants in Potosí, and was one of the biggest and richest cities in the world. It was ten times bigger than Boston. In Potosí, temples, palaces, monasteries and casinos were made of silver. Silver was the reason for joyfulness but also paradoxically the cause of tragedy. Both blood and wine were spilled on account of it. It triggered greed and generated extravagance. This is why it is said "Spain had the cow but others drank the milk". Cuzco, the capital of the Inca Empire, was rich in gold but suffered the same fate as Potosí.

3.5. Wood Exploitation

Wood exploitation is another activity that has worried government authorities and environmentalists. The demand for wood for furniture production, as well as for other domestic and industrial uses including construction, has been on the increase. This occurs not only with hard woods but all species of wood, and thus the entire forest ends up being compromised. Certain wood species are endangered. Cedar, rosewood, mahogany and the nut-tree wood are threatened with disappearance. In order to prevent this loss, many countries have established Environment Protection Areas. Many of these areas are completely preserved while others have developed a system of sustainable management. The creation of "extraction" reserves is another course of action that has achieved good results. Specialists working for government agencies teach the people living in the reserves how to achieve a better quality of life by extracting products from the forest using technologies developed at universities. This allows them to obtain products whose greater economic value means that they can be more easily marketed. This policy also encompasses the preservation of the quality and quantity of water resources as well as the fauna and flora.

4. CONCLUSIONS

We began this paper with the objective of demonstrating how nature managed the largest and richest water basin in the world. Subsequently, we showed how activities in the region affect water resources; how their development and progress was invariably irrational. Progress provided little change for the native population. The government provides no assistance to these people and they still remain poor today. Towards the end of the last millennium, humanity began to realize the importance of ecology, strongly highlighted by the Russian leader at the time, Mikhail Gorbachev.

A brighter future for the Amazon and its inhabitants will only be possible if all Amazon countries agree to adopt policies and guidelines for sustainable regional development brought about by cooperation and comprehension through "management". Brazil initiated this effort through programs such as the Center for Support to Integrated Policies in the Amazon - NAPIAm, coordinated by the Ministry of the Environment. This program was created in April 1997 with the support of UNDP/BRA/95/025 of the Center for International Cooperation in Agronomic Research for Development - CIRAD and of the Institute of Research for Development - IRD, two French organizations. There are also the PPG7 - Pilot Program for the Protection of Brazilian Rainforests and the PROECOTUR, whose objective is to make eco-tourism development possible in the region, which is funded by the Inter-American Development Bank. In addition to these programs, there is the Project for the Expansion and Consolidation of a System of Protected Areas in the Brazilian Amazon - PROAPAM. The objective of this project is to protect at least 10% of the Amazonian biome. This is equal to an area of 370 million hectares. However, these and other programs and projects will only be effective if all Amazonian countries participate and contribute to this effort.

The approach towards integration and economic development to the benefit of all is illustrated by water resource management as an element of transformation in the Amazonian society. The initial step has already been taken as several studies on this topic have already been completed. It is now important to put them into practice. This is the case with the Intermodal Integration of South America, also called Multimodal Integration, which was previously mentioned. It is evident that activities related to electric energy generation, agriculture, fishing, river transportation, waterways, mining and wood exploitation are inextricably linked to water resources, and the way these activities have been carried out makes them highly damaging to the Amazonian ecosystem. This highlights the importance of employing the concept of water resource management as an element of transformation in the Amazonian society as early as possible. Management should involve all the Amazon basin countries and be based on granting fair exploitation rights while carrying out supervision and monitoring activities. These countries should also be involved in scientific research and technical and administrative training. All countries should implement and monitor the policies for social improvement (education, health, employment creation, etc.) in a way that makes it possible for the Human Development Index to be as high and as constant as possible.

The adequate and consensual arbitrator for all Amazonian countries is the Amazon Cooperation Treaty Organization. This was decided during the 11th Ordinary Meeting of the Amazon Cooperation Council, which took place in Santa Cruz de La Sierra from November 20 to November 23, 2002. The minutes of the meeting and the Santa Cruz Charter discussed the importance of water resources and of improving the quality of life of Amazonian populations. The actuation of the Amazon Cooperation Treaty Organization in this regard is not an obstacle to individual measures or actions being taken by individual countries when considered necessary.

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10. AMAZONIAN CO-OPERATION FOR KNOWLEDGE ON WATER RESOURCES AND FOR THE SUSTAINABLE USE OF THESE RESOURCES IN THE REGION

Marco Antonio R. Dias *
Luis E. Aragón **

1. INTRODUCTION

This paper presents the combined viewpoints of two Latin American specialists. The two specialists, from Brazil and Colombia, have vast experience in the area of university co-operation, both nationally and internationally. In addition to this experience, they also know how to deal with matters of global interest. These matters concern the ethical and political aspects of environmental issues in modern times and the relevance of international co-operation in order to overcome the important obstacles that surround these issues.

The objective of this paper is not to discuss technical issues related to water, but to raise current issues that are crucial for the survival of the planet and to discuss how higher education and international co-operation can be included as part of these discussions. Based on basic information about issues related to water, and aware of the importance of this resource for humanity, questions related to the threat to humanity due to finite water re-

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sources are discussed. Water has been polluted and watercourses degraded by the careless use of this resource by human beings. There is already a water shortage in many regions of the world. This situation can cause large-scale catastrophes unless corrective measures are taken immediately. As regards these measures, higher education and international co-operation may and should play a dominant role. Therefore, the intention is to raise the most critical and controversial issues of the moment, so that the situation can be fully discussed and hopefully resolved fairly.

2. FACTS CONCERNING THE ISSUE OF WATER IN THE WORLD

The situation of the world's water resources has been discussed at various levels, and attention has been called to the problem covering a range of fields. Here are some facts:

* On May 21, 2002, a note from a French-Brazilian employee with the European Commission, Leda Guillemette, alerted under the headline, "Brazil: Great Exporter of Water!". The United Nations had already called attention to the subject and warned that if countries continued to treat water as a limitless resource, then about 2.7 billion people will encounter problems of water shortages by 2025. The note continues that there is an extraordinary increase in the demand for water in the world and points out that it is a "market whose dimension has not yet been calculated". The Amazon alone holds about 15% of the world's freshwater resources. Countries like Brazil, with large natural fresh-water reservoirs, are considered potential suppliers.

* On May 15, 2002, UNESCO distributed the "Bulletin on the Valorization of Water in the World", informing of the convening of the World Program for the Evaluation of Water Resources high-level working group in Paris. Their task was the preparation of a report to be presented at the World Summit on Sustainable Development, in Johannesburg, August 2002 (UNESCO, 2002). The bulletin also mentioned that the Third World Water Forum would be held in March 2003. The bulletin stated that UNESCO believes it is necessary to facilitate integrated views at regional and international levels that maintain the need for co-operation by countries in order to tackle the situation of freshwater resources.

* In the brochure, "Energy: If You Know How to Use It, You Will Always Have It", which was distributed through Brazilian newspapers during the electricity crisis in 2001, was reported that 92% of all Brazilian electricity is produced by hydroelectric power plants.

* The basic principles in current Brazilian legislation, based on the National Water Resources Policy, are as follows:

- Water is a public good
- Water is a limited natural resource which has economic value
- When there is a shortage of water resources, priority is given to human consumption and the provision of water to animals
- The management of water resources must always allow for the multiple uses of water
- The water basin is the territorial unit for the implementation of policies and management
- Water resource management must be decentralized and should involve the participation of the government and that of users and communities

* The UNESCO Newsletter of February 1999 dedicated an extensive dossier to water-related issues. It contained useful information on these issues (UNESCO, 1999). For instance:

- Until recently, hydrologists and engineers had ready-made answers to water-related issues. The solution was to build gigantic dams, to desalinize water and to channel water from humid zones to dry regions through aqueducts. These solutions are no longer acceptable. They are expensive in economical and ecological terms. Nowadays, the objective is to reduce the demand for water. There are those who defend the idea that to achieve this water users should be charged for the water they use. The idea of an international water market, making it possible for countries with water shortages to buy water from countries where this resource is abundant, has been discussed.
- It is estimated that in the most vulnerable regions, there are about 460 million people who have no access to water. This accounts for 8% of the world's population. This situation therefore threatens one fourth of the world's inhabitants. If urgent measures are not taken, two thirds of humanity will suffer from moderate or severe water shortages by the year 2025. In reality, the situation is already very serious. In another UNESCO publication, Lord Selborne (2002) stated that currently 1.5 billion people do not have access to freshwater.
- Inequalities are also evident regarding water consumption: an individual living in a rural area in Madagascar has access to 10 liters of water a day, in France he has access to 150 liters and a North American has access to 450 liters. The lack of water is further aggravated by pollution. In many regions, the quality of water has become so poor that water cannot even be used for industrial purposes.

- For the first time in history, there will be more people living in cities than in rural areas. Consequently, water consumption will increase. Today, 69% of all water consumed in the world is used in agriculture, 23% is used by the industrial sector and 8% is attributed to domestic consumption.
- More than 40% of riverine waters, rock-reservoir and lake waters are found in six countries: Brazil, Russia, Canada, the United States, China and India.

3. WATER COMMERCIALIZATION

The points outlined above are very clear: water is not a renewable resource, it is finite. With the increase in the number of people and the damage caused by pollution, water has become increasingly rare. Moreover, 97.5% of the earth's water is saline and freshwater, which accounts for only 2.5% of the total amount of water available, is mostly inexploitable. Only 1% of the total amount of freshwater available on earth can be easily accessed.

With this in mind, it is easy to understand why the most important current issue is whether such a rare resource should be treated as a public good, as belonging to humanity, or should it be subjected to commercial rules?

Riccardo Petrella highlights the core issue:

> "...in the end of January, 2000, the oldest of Switzerland's banks, Pictet, decided to create an international investment fund. This fund should invest 80% of its net assets in the securities of companies specializing in the water sector. This was the first time this happened in the history of finance. The bank states that current expenses for the capture and treatment of water account for only 35% to 45% of the amount necessary in the world over the next ten years" (Petrella, 2000).

The decision of the Swiss bank to invest in the water industry illustrates the economic importance of this issue. It also highlights the current thinking within the World Trade Organization. After all, the Swiss bank would not have taken this initiative if there incurred an element of risk.

There is a tendency to privatize water supply services around the world. Many justify this trend because of the limited supply of this natural resource. It is thought that individuals are more inclined to save water if they are made to pay for it. Although this idea is open to debate as concerns irrigation, the argument may be valid with regards to the commercial and industrial use of water. However, it is contentious to argue about the utilization of potable water, which is essential for the survival of mankind. After all, an individual can survive for a month with no food but less than a week without water. Proportionally, households consume only 8% of the total amount of freshwater used worldwide. For ethical reasons, access to water must be guaranteed to all, particularly the poor. It is unacceptable in the 21st century that millions of people do not have access to drinking water and that so many children die due to a lack of water or as a result of having consumed contaminated water.

In reality, access to good quality drinking water is considered more than just a need, it is our right. However, in declarations made by governments, the word "right" is frequently replaced with "necessity" as commercial restrictions often apply. The term "right" is avoided because it restricts the action of those that defend the commercialization of all aspects of life. For these, water is a merchandise and nobody can reivindicate rights over a merchandise, except the owners, the industrialists or the businessmen. For the consumers rest to pay the price fixed for the product.

The big water companies are becoming increasingly well known. They are listed on stock markets and present in every water-related sector. Vivendi, Suez-Lyonnaise, Biwater, Thames Water and Bouygues are commercial water treatment companies. On the other hand, companies such as Nestlé and Danone commercialize bottled mineral water. Companies like Coca-Cola, Pepsi and others sell bottled purified water. They claim that bottled water is better and safer than tap water. According to Ricardo Petrella (2002), the Swiss Bank, Pictet predict that over 1.6 billion people will have their water supply provided by the private sector in 2020. This translates by an increase of more than 500%, compared to the current situation.

4. THE WORLD TRADE ORGANIZATION (WHO)

The World Trade Organization also plays a part in the new ethos. However, before we begin analyzing its role, it is important to keep in mind that the objective of the General Agreement on Trade in Services, GATS, which was approved in April 1994, was to set in motion a progressive liberation of services, including educational and environment related services.

In terms of education, we had the opportunity to analyze this issue (Dias, 2002). The World Trade Organization, as well as countries that export "educational services", believe that when a country accepts to provide educational services via private institutions then these services can be qualified as commercial services and are thus subject to the general rules that regulate commercial services.

Currently, GATS comprises 134 countries whose mandate covers all services, and everything that can be defined as a service. Education is no exception, on the contrary, the WHO defines four kinds of services that are linked to education: (1) services provided across borders, (2) services consumed abroad, (3) commercial presence (which takes place, for instance, when a foreigner becomes a property owner in a country that is not his own, i.e. a hotel) and (4) the movement of natural persons across borders.

World Trade Organization regulations set out general commitments and obligations that directly and systematically apply to all members and to all sectorial commitments as a result of negotiations. Article II of GATS declares that member-states must accord "services and service suppliers from other member countries treatment no less favorable than that accorded to any other country". This should take immediate effect and with no restrictions. In other words, an agreement concerning someone or a company from one country must be equally applicable to individuals and companies from other member states. However, derogations can be made, and the states must present a list of the exceptions they wish to submit before the agreements come into force. However, these derogations are only valid for a limited period of time.

This situation is not always clearly defined in WTO documentation. All analysts, even those who fiercely defend WTO procedures, recognize that developing countries were marginalized because they did not participate in the discussions that lead or led to the decisions made by the WTO. However, it is true that commitments are mandatory at the date on which an agreement comes into force. This remains the case unless the state presents any restrictions to its enforcement. Three years after the agreement comes into force, a state can request modifications. If another country feels that as a result of the modifications it has been wronged in some way, the country in question may claim compensation. An integrated work program was adopted by GATS following the Uruguay Round completed in 1994, as not all negotiations were finalized. Member-states confirmed the commitment to engage in a series of successive negotiations to facilitate liberalization. Today, we are at the phase of opening markets for "educational services" and for environment related services and is thus an important issue.

According to a 1999 document pertaining to GATS, the WTO will encompass twelve service areas. They are as follows (WTO, 1999):

* Services companies (including professional services and computer science services)
* Communication
* Construction and related engineering services
* Distribution
* Education
* Services related to the environment
* Financial services (insurance and banking)
* Health and social services
* Services related to tourism and travel
* Entertainment, culture and sports

* Transportation services and
* Other services not included in the above list

5. CONSEQUENCES OF THE WTO REGULATION

In 2002, there were presidential elections in Ecuador, Colombia, France and Brazil. One can reasonably question the reasons behind electing a president and forming a government when large multinational companies make unilateral decisions that only take into account their own financial interests. This is a time when all government functions are influenced by organizations such as the World Bank, the International Monetary Fund, and more recently, the WTO, whose power to pass regulations is unquestionable. Decisions are often taken that depend on the expectations of these organizations. It is worth recalling Lionel Jospin's bitterness when, in September 1999, Michelin announced 7,500 job cuts. On television, he said that he believed it was no longer possible to manage the economy in such a situation.

It is evident that there is a need to tackle environmental issues in much the same way as higher education, and the implications of GATS in this matter must be analyzed. The initial objective must include every aspect related to the protection of landscapes, ecotoxicology research and above all, water catchment. Furthermore, large European companies expected to be granted the right to exploit underground water sources without the imposition of limits or restrictions. The European Commission has already analyzed probable obstacles to the activities of private water companies in order to defend the interests of European groups. According to established rules of the WTO, these obstacles must be eliminated. These include the existence of monopolies or exclusive suppliers, restrictions to legal economic activities, norms related to granting licenses or authorizations for operation and exploitation as well as restrictions concerning staff turnover.

The European delegation to the WTO elaborated a list of services related to the environment, which should be open to competition. These include the following themes: water catchment, nature, forest and landscape protection, environmental impact assessments, research-development services, public awareness programs and the support of long-term forest management.

When GATS was approved in 1994, potable water services was not an issue and was therefore not discussed. Most countries considered this matter to be the responsibility of the government. Conversely, the utilization of underground water tables was considered to be a delicate issue and understandably subjected to strict control. These issues are now being discussed in Geneva and attempts are being made to include them in the GATS framework for action.

In the past, water was considered a public good. Today, the reverse is true as people realize now the economic value of water. This tendency suggests that water is becoming an exclusively commercial commodity. What are the implications of this?

Here are two examples:

In Argentina in 1995, a branch of Vivendi Environment was granted a thirty-year concession to operate water services in Tucumán province. Substantial investments were envisaged to modernize the system and as result, the company was authorized to charge twice as much from users. In the following months, no improvements had been made. Worse still, the water turned brown. The population demonstrated their anger and the two concerned parties broke off the contract. However, in 1997, according to information issued in Paris, Vivendi Environment filed a formal accusation against the Argentinian government. The company claimed 100 million dollars as compensation for their losses. The situation was submitted for analysis to the World Bank's International Center for the Settlement of Investment Disputes.

A similar situation occurred in Cochabamba, Bolivia when Bechtel, a large San Francisco based firm, was granted a concession to operate water services. In December 1999, the firm doubled the price charged for water. The population demonstrated, which led to the death of certain demonstrators. The government revoked its water privatization legislation and Bechtel is now suing the Bolivian government for 40 million dollars.

Another example of a situation that might occur as a consequence of WTO's control of water services occurred in the Canadian province of Vancouver. Water was exported from Canada to the United States by tanker ships. However, in order to defend Canadian interests, the Canadian government ceased water exportation. Today, based on NAFTA regulations, the North American Company, Sun Belt, is suing the Canadian government for a total of 500 million dollars.

The above examples demonstrate both the economic and ethical dimensions of the water issue. In 1977, during the United Nations Water Conference, participants established that "all peoples (...) have the right to have access to drinking water in quantities and of a quality equal to their basic needs". In fact, this is a matter of human dignity: after all, there is no life without water. Thus, this precious sought-after resource must be managed, bearing in mind humanitarian solidarity, so that everyone can benefit and lead an honorable life.

6. THE AMAZON CO-OPERATION TREATY

Discussing issues related to the use of water in the Amazon demands that the role played by the Amazon Co-operation Treaty (ACT) be analyzed. It would act as an instrument for regional integration and provide a mechanism for the creation of public policies that might serve to lead development initiatives that would involve all the Amazon countries.

The ACT was signed in Brasília on July 3 1978, by the republics of Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Surinam and Venezuela. However, various analysts have considered its activities over the past 25 years as being very limited with regard to the challenges defined in Article 1:[1]

> "The Contracting Parties agree to undertake joint actions and efforts to promote the harmonious development of their respective Amazonian territories in such way that these joint actions produce equitable and mutually beneficial results and also achieve the preservation of the environment and the conservation and rational utilization of the natural resources of these territories." (Ministry of Foreign Affairs)

Following the United Nations Environment and Development Conference in 1992, the ACT implemented a few projects in the Amazon. However, little progress was made; the factors that limited the implementation of ACT projects were numerous and varied. The institutional weakness of the Treaty can be identified as one of these factors.

As its name suggests, the Treaty is simply a document signed by the Foreign Affairs Ministers of the eight Amazon countries. It is not a legally bound entity and therefore does not exist as an organization. Moreover, the Secretariat headquarters changes periodically of country.

Once those limitations were recognized, the ACT focused its efforts on strengthening the institutional nature of the Treaty, which began in 1992. During the management of the Pro-Tempore Secretariat in Peru, which immediately followed that of Ecuador, a proposal was elaborated and approved at the Ministers Council Meeting. This proposal satisfied the long-time request made by various countries: the establishment of a permanent Secretariat for the Treaty (Botto, 1999). The result of this proposal was the creation of the Amazon Co-operation Treaty Organization (ACTO), which is permanently based in Brazil. The process was presented to the parliaments of the eight countries concerned. In 2002, the last Amazonian country (Colombia) confirmed the Amendment Protocol to the Amazon Co-operation Treaty, which was approved in 1998. This Protocol established the "Amazon Co-operation Treaty Organization", which from that point on was a legally binding entity. This gave the Treaty the power to sign agreements with Contracting Parties, non-member States and other international agencies.

> *"The Permanent Secretariat of the Amazon Co-operation Treaty Organization will be based in Brasília. This Secretariat will be responsible for implementing the foreseen objectives in compliance with the resolutions made during the Meetings of Ministers of the Foreign Affairs and those of the Amazon Co-operation Council" (Ministry of Foreign Affairs, s/d: 13).*

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1 Bibliography about the ACT is wide-ranging. ACT itself published its bibliography in CD (ACT, 1999). Among the most comprehensive analysis of the Treaty see Román (1998), Aragón (1994; 2001) and Costa-Filho (2002a).

The founding of the ACTO Secretariat was set for the year 2002. The seminars carried out at both national and international levels and the consultancy services requested, in order to establish a work program for the ACTO, make it possible to envisage the challenges ahead. Furthermore, they allow us to anticipate the great opportunities ahead and to make meaningful progress in the pursuit of sustainable development in the region. ACTO represents a significant step in terms of quality and the consolidation of the Treaty. This is true because of the multilateral nature of the organization and its status as a legally bound entity, with the power to coordinate co-operation efforts and to implement projects and programs in the eight countries. Thus, ACTO is the best attempt for sub-regional integration in the history of the Amazon. It makes it possible for countries to agree on the principles that will guide the development of the region.

In 2002, preparatory meetings were held in order to identify priorities for the establishment of the ACTO Secretariat. One of the priorities identified was the water issue (Costa-Filho, 2002a). There is even a proposal for the creation of a Special Commission for Hydrology, Climatology and Water Resource Management in the Amazon (Setti, 2004). The need to strengthen regional capacity in all areas is equally important, as is the mapping of the region at a continental level by systematically updating data using modern technologies.

Nobody knows exactly how many people live in the Amazon or its demographic structure. It is therefore urgent to carry out a detailed survey of the Amazon in order to identify the actual problems facing the population. This survey would also help determine the regions where activities are to take place. This request was proposed by various specialists who were invited to take part in the last preparatory meeting for the establishment of the ACTO, which took place in Manaus (Costa-Filho, 2002 b).

ACTO shall implement programs in order to become acquainted with environmental legislation in the eight Amazon countries, particularly as concerns water-related legislation. This will guarantee that regulations are consistent in every country and that laws in one country are not annulled in another. Likewise, joint actions related to the transportation of goods and passengers shall be established. ACTO is the ideal instrument for identifying the true potential of the region and to formulate and implement programs and actions that serves the entire Amazon, and that lead to sustainable development. This can be achieved mainly through partnerships with NGOs, universities, research institutes and government organizations at all levels.

7. INTERUNIVERSITY CO-OPERATION

Universities play an important role in this field. They objectively study and analyze these issues and they develop multidisciplinary programs in the fields of environmental education and communication. Nevertheless, universities cannot act alone. It is essential to widen the co-operation among higher education institutions. Firstly, we need to identify the institutions with the means, as is the case with universities, to critically and objectively analyze the social implications of environmental issues and, in this specific case, to analyze the inclusion of environmental services, particularly water related issues, at the WTO. Which institutions would be capable of analyzing all the technological and social implications of the problems in the region?

According to the Tbilissi Conference, in 1977, environmental education should be targeted at:

* the general public (communication is essential);
* specific groups of professionals, particularly in areas of activity that directly influences the environment. These include engineers, architects, administrators and planners, industrialists, union leaders, decision-makers in political, economical and financial sectors, rural workers, teachers and journalists, and professionals in the area of communication.

Most of these professionals are university-educated. Thus, the university is a privileged institution that guarantees that all these categories of individuals receive an environmental education. Furthermore, information specific to these categories should also be acknowledged.

Which path should universities follow if they are interested in this issue?

Firstly, coordination efforts between all individuals and entities working in this field should be sought, and any actions must be undertaken in a coherent fashion. In some instances, the formation of a specific course on the environment or ecology is the objective (interdisciplinarity). Many universities are beginning to take measures to create an environmental pedagogy. This could be achieved by incorporating an environmental aspect to traditional programs and subjects that are related to the issue via the principle of multidisciplinarity. This will make it possible for a great number of issues, ranging from natural habitats to themes linked to culture, to focus on the analysis of social and economic realities.

In an effort to provide the community with services, communication is often the essential factor. There are regions where actions may be isolated, but since the theme of environment is wide-ranging, universities increasingly feel that there is a need for them to be part of a network. Occasionally, and in order for these networks to operate, complex communication systems have to be installed.

8. THE CONTRIBUTION MADE BY THE UNITED NATIONS UNIVERSITY

In the international arena, the United Nations University (www.unu.edu), based in Tokyo, seeks to develop cooperative efforts in two basic areas: a) governance, which entails actions in the fields of human rights, democracy and peace and b) sustainable development, which includes issues related to the environment, science and technology as well as issues related to hydrological systems. Water is always an integral part of these issues. A Canadian-based program is dedicated to this issue.

At the UNU, the water issue is treated in its entirety. This means that all components of the hydrological cycle are included: surface waters, underground water reservoirs, mangrove swamps and sea water. Problems involving water and border disputes have become increasingly important. Water shortages, the destruction of water springs and pollution are issues that demand to be analyzed. A few of the projects being developed within the framework of the UNU are listed below; revealing the scope of the problem:

* Water Pollution Monitoring and Governance in Coastal Areas (Asia-Pacific region),
* Governance of Transboundary Water Resources (studies are being carried out in the following river basins: Danube, Ganges, Indus, Mekong, Nile and Zambezi),
* Technological and Policy Dimensions of Arsenic Contamination in the Asian Region (an equally serious problem with arsenic contamination occuring in the Amazon) and the
* Cooperative International Research Project on Marine and Coastal Environment.

In addition to this, the UNU has sought to develop a project for a "Global Water" Library. The objective of this virtual library is to provide the developing world with global knowledge on fresh water ecosystems and their management.

Finally, the UNU has developed an international network on "Water, Environment and Health", based in Canada. All these programs can assist institutions in the Amazon. They can also strengthen the South-South Co-operation Program, developed by UNESCO, the United Nations University and the Third World Academy of Science. In addition, there is intense participation of the Association of Amazonian Universities (UNAMAZ). This program should be encouraged by the prioritization of the water issue in the Amazon and in other humid tropical areas, moreover, Amazonian institutions should be included in the above mentioned projects. Incidentally, during the World Conference on Higher Education, held in October 1998, UNU was responsible for the organization of a discussion on the theme of higher education and sustainable human development. At the Conference, the Rector of UNU, Professor Van Ginkel, presented a document, which served as the basis for the discussion theme, in which he suggested that in order to make the necessary changes concerning activities of universities, it was necessary to do the following:

a) Foster research programs and interdisciplinary education programs involving co-operation;

b) form interdisciplinary networks of environment specialists on the local, national and international level;

c) foster an environmental perspective among staff members and students, regardless of their field of study;

d) insist on the enforcement of ethical obligations.

9. EXAMPLES OF INTERUNIVERSITARY CO-OPERATION

The word "network" means being united. It implies collaboration and communication. One of the greatest obstacles of the development of international co-operation is the fact that many participants have difficulty communicating (Aragón, 1997). An idea to be reconsidered is the one that was presented in UNESCO's framework for the development of a network called GOUTTE, which stands for Global Organization of Universities for Teaching, Training and Ethics in the Field of Water.

It is very important to support the project coordinated by the Federal University of Amazonas, which established an Amazonian Center for Distance Education and Telemedicine Technology (Núcleo Amazônico para Tecnologia em Educação a Distância e Telemedicina - NATESD). The Center is the basis of a network that includes six Brazilian Federal Universities, all of which are located in the Amazon. Their objective is to gather human and material resources for collaborative action in the "virtual" field, starting with actions in the field of health. In addition to developing specific activities, this project will establish the basic conditions for the development of a comprehensive databank on the Amazon.

Among the institutions that joined the project, and whose goal is to train people in the area of human resources to use new technologies in the Amazon, are: the Federal University of Rondônia, the Federal University of Amazonas, the Federal University of Acre, the Federal University of Amapá, the Federal University of Roraima and the Federal University of Pará. These new technologies will be used to solve the health problems of people in the Amazon. Another objective is to democratize access to education. There is no doubt that such programs are necessary in order to embark on an organized fight against such serious problems as malnutrition and endemic diseases (malaria, cholera, verminosis, leprosy, tuberculosis and elephantiasis), as well as diseases brought over by western civilization. These diseases include the flu, which was fatal for the Indians, syphilis and

AIDS, among others. There is an international network (the GUS - Global University System) that provides international support to this project. The network was created in 1999 in Tampere, Finland.

Another important program to be mentioned and encouraged is the Interdisciplinary Graduate Program on Sustainable Development in the Humid Tropics (Programa de Pós-Graduação Interdisciplinar em Desenvolvimento Sustentável do Trópico Úmido - PDTU). This program integrates specialization courses and masters and doctorate degrees from the Center for Advanced Amazonian Studies of the Federal University of Pará. The UNU, UNESCO and the Organization of American States have supported specialization courses that are part of this program. Furthermore, the UNU has already begun to grant scholarships to students from other Amazonian countries so that they will have the opportunity to obtain their masters degree in Belém, Brazil. At some point, it will be important to establish a doctorate degree program that combines virtual learning and class attendance, employing the methodology developed by the Open University of Catalunya (www.uoc.edu). Several higher education institutions would participate both in the Amazon and in Ibero-America benefiting both the Brazilian states and the Amazon countries. In fact, this program can only be implemented through international co-operation.

It is also important to emphasize that the number of graduate programs comprising the environmental aspects of the Amazon, especially those of the Brazilian Amazon, has increased over the last years. Among these, the masters and doctorate degree programs on Fresh Water Biology and Interior Fishing offer great potential for expansion to all of the Brazilian Amazon and other Amazon countries. These courses are held in the National Institute for Amazonian Research in co-operation with the Federal University of Amazonas. Another example is the Masters course on Coastal Ecosystems offered at the Federal University of Pará at Bragança. This course is already consolidated and it is expected to achieve a Pan-Amazonian level. The National University of Colombia recently established a Masters course on Amazonian Studies at its campus, located in Letícia. Also, the Center for Development Studies of the Central University of Venezuela established a Masters course on health and environment based on Amazonian issues as the result of a UNAMAZ program.

It is important to acknowledge that there are certain places in the Amazon that are especially suited for the development of university transboundary co-operation. Leticia, in Colombia, borders both Peru and Brazil, it can therefore serve the population of the three countries. The Federal University of Acre developed a program called the MAP Initiative, within the sphere of the Sustainable Development in the Tri-National Frontier Program, formed as an international triangle whose vertices are the Municipality of Madre de Dios (Peru), the State of Acre (Brazil) and the Department of Pando (Bolivia). The initiative was developed through co-operation agreements with local City Halls and with the objective of implementing actions leading to the development of the region in accordance with the principles of sustainability (Costa-Filho, 2002 b). There are however other places where transboundary programs can be implemented, such as in Roraima where the Federal University of Roraima could strengthen its co-operation with institutions in Guyana and Venezuela.

In terms of research, there is the Program for Tropical Coastal Ecosystem Studies (ECOLAB), led by the Emilio Goeldi Museum in Pará. This Program gathers researchers from institutions in Surinam, French Guyana, Amapá, Pará and Maranhão. The researchers develop integrated research programs according to the ecosystems found in the Amazonian coast. Other relevant examples linked to research are: the Program "Processes of Change in the Amazon Estuary due to Anthropic Activities and Environmental Management" (MEGAM), coordinated by the Center for Advanced Amazonian Studies; the program "Management and Dynamics in Mangrove Swamp Areas in Northeasthern Pará" (MADAM), developed by the Federal University of Pará at Bragança, and the Program "Natural Resources and Anthropology of Maritime, Riverbank and Estuarine Societies - Social Organization, Development and Sustainability in Fishing Communities in the Amazon" (RENAS), coordinated by the Goeldi Museum.

10. CONCLUSIONS

The commitment to a world organization that is selfless and not based on the control of some over others is absolutely critical. It is unimaginable to live in a world whose organization is solely based on commercial interests, particularly as regards such issues as water. Environmental and sustainable development objectives cannot be dissociated, as Marie Bernard-Meunier, president of the UNESCO Executive Board said in Paris ten years ago (May 1992) "if the state of extreme poverty remains unchanged in one place, it will end up becoming universal."

As regards the water issue, inter-university co-operation in the Amazon is fundamental. One of the myths concerning this region is that the Amazon are the lungs of the Earth. This is not true according to Albert Setzer, a researcher for the National Institute for Space Research (INPE). However, he says that if the Amazon Forest is destroyed then we would face many serious problems, especially with water (Setzer, 1989). Emanuel Soares de Almeida, a researcher for the Goeldi Museum, agrees with Setzer. According to him, "the springs that feed forty percent of our large and medium rivers are located outside our borders. Therefore, if our neighbors pollute these springs with mercury and practice indiscriminate clearings in the areas where these springs are located, we will be drastically affected" (Almeida, 1989).

In December 2001, the United Nations University Council approved a program for research and training (RTP - Research and Training Program), whose objective was to carry out research and provide training in the area of human resources in the Pantanal, one of the largest humid areas on the planet. Most of the Pantanal is located in Brazil (Mato Grosso and Mato Grosso do Sul), but its area extends to the territories of Bolivia and

Paraguay. The UNU program will be implemented with the collaboration of federal government agencies and state government organizations, as well as federal and state universities of both states. In the medium term, the program should depend on the participation of institutions from Bolivia and Paraguay. It should also cooperate with organizations in other regions of the world that present a situation similar to the one in Pantanal.

Co-operation between this program and the South-South Co-operation Program is of course desirable. Water is the essential element of this program. It is believed to affect regional equilibrium as well as ensuring the presence of extraordinary fauna. Human activities can destroy the ecological balance in both these instances. The historical discussion regarding the construction of a waterway that, according to many people, would keep seasonal floods from occurring in a great part of the territory would be the key element for maintaining this balance and the survival of various species.

Finally, to recall the analyses of Professor Armando Dias Mendes, who for over thirty years defended the idea that there should be training in the area of human resources to ensure human development in the Amazon; according to Professor Mendes, the inhabitants should receive better treatment from the government and from the international agencies that operate in the region. Furthermore, the professor indicated the importance that the people living in the region should decide their own future.

With the objective of creating a university network in the region, a study was elaborated upon the request of UNESCO's Higher Education Division and of the Regional Center for the Development of Higher Education in Latin America and the Caribbean (CRESALC) based in Caracas. During the mid 1980s, Prof. Armando Mendes said, "it is necessary to warn about a possible comeback of what can be called the Hyleia Syndrome". Prof. Mendes was referring to the International Institute of the Amazonian Hyleia. In 1946, there was an attempt to create such Institute with links to UNESCO. The Brazilian Congress never approved the diplomatic instrument needed to establish the institute, nor did the Congresses of the other Amazonian countries approve it.

The creation of the institute was thus considered unworkable. The major reason for the project's failure was due to the fact that the Amazonian countries began to consider the institute as an instrument for the internationalization of the Hyleia or Pan-Amazon. In fact, the creation of an international agency, among other things to coordinate the institute jointly with a few European countries such as Great Britain, France and the Netherlands (supposedly because of the Guyanas, which were their own colonies) was proposed within UNESCO. Furthermore, according to Prof. Armando Mendes, "although these countries were not part of the region, the importance and the role they were to take outweighed the importance and the role of the Amazon countries" (Mendes, 1988).

The document elaborated by Prof. Armando Mendes was presented at the meeting that established the Association of Amazonian Universities - UNAMAZ. This document highlighted a series of basic principles for the operation of this Association. These principles are still valid, not only for UNAMAZ but also for all those who are interested in contributing to the development of the region. These principles are as follows (Mendes, 1988):

a) the principle of "amazoneidade" - this is the guarantee that the beneficiaries of any co-operative program will be Amazonian institutions by location, vocation and action;

b) the principle of "continentalidade" - the idea is to include all Amazonian countries, without the exclusion of any (therefore incorporating Guyana and Surinam to this project and its outcomes);

c) the principle of individuality - through which respect is shown for national, regional and institutional distinction in each national Amazon;

d) the principle of equality - the Centers for Amazonian Studies (CEAMs - Centros de Estudos Amazônicos) and Amazonian Universities (UNAMs) should receive equal and equitable treatment, according to their needs and possibilities. This should not depend on the national magnitude of Amazon countries, nor should it depend on how much of the Amazon is located within each country.

e) the principle of spontaneity - so that no Amazonian University or Center for Amazonian Studies should feel forced to join or not to join the Program;

f) The principle of uniqueness - this means "no duplicity". Through this principle the repetition of initiatives previously taken at Centers for Amazonian Studies or Amazonian Universities will be avoided.

The Amazon Co-operation Treaty Organization can coordinate fundamental programs for the development of the Amazon at a continental level. Certainly, the Amazon today is not the same Amazon of 1978 when the ACT was signed (Lourenço, 2001). The world has changed, as has the Amazon. Today, conditions seem ripe to forge true co-operation in the Amazon. This would involve interpreting borders as links between countries rather than boundaries that separate them.

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